

UNIVERSITÄT ZU LÜBECK

# Module Guide for the Study Path

# **Master Biophysics 2019**

Version from 14. April 2025



# biophysics

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BP4110-KP08 - theoretical biophysics (ThBP)				
Duration:	Turnus of offer:		Credit points:	
2 Semester	starts every winter semester		8	
Course of study, specific field and term: • Master Biophysics 2019 (compulsory) • Master Biophysics 2023 (compulsory)	), biophysics, 1st and 2nd se ), biophysics, 1st or 2nd sem	mester lester		
Classes and lectures: • theoretical biophysics (exercise, 1 SW • theoretical biophysics (lecture, 2 SWS) • molecular dynamics (lecture, 2 SWS) • molecular dynamics (exercise, 1 SWS	VS) S)	Workload: • 150 Hours private • 90 Hours in-classi	e studies room work	
Contents of teaching: Basic concepts of quantum mechani Intra- and intermolecular interaction Description of molecules by classical Simulation of the dynamics of molec Description of molecular dynamics w	cs s models :ules by means of Newtonia vith the help of thermodyna	n mechanics mics		
<ul> <li>Qualification-goals/Competencies:</li> <li>Students can explain how the existence mechanics.</li> <li>They can explain, within what limits</li> <li>They can sketch an algorithm with w</li> <li>They can list, which thermodynamic</li> <li>They can classify common simulation</li> </ul>	nce of atoms and molecules can be described by classica /hich the dynamics of molec concepts are to describe th n programs for large biomol	can be explained from th al models the interactions cules can be simulated. e molecular dynamics. ecules according to catego	e fundamental assumptions of quantum between atoms. ories and recognize their basics.	
Grading through: • Oral examination				
Requires: • Module part: Biophysik 1 (ME4600 C)				
<ul> <li>Responsible for this module:</li> <li>PD Dr. rer. nat. Hauke Paulsen</li> <li>Teacher: <ul> <li>Institute of Physics</li> <li>PD Dr. rer. nat. Hauke Paulsen</li> <li>Prof. Dr. rer. nat. Christian Hübner</li> </ul> </li> </ul>				
Literature: • V. Schünemann: Biophysik - Berlin: S • M. Daune: Molekulare Biophysik - Bra • Andrew R Leach: Molecular Modellin	pringer 2004 aunschweig: Vieweg 1997 g: Principles and Application	ns - Prentice Hall, 2nd edit	ion 2001	
Language: • German and English skills required				



BP4510-KP12 - experimental biophysics (ExpBP)			
Duration:	Turnus of offer:	Credit points:	
1 Semester	each summer semester	12	
Course of study, specific field and term: • Master Biophysics 2019 (compulsory) • Master Biophysics 2023 (compulsory)	, biophysics, 2nd semester , biophysics, 2nd semester		
Classes and lectures:		Workload:	
<ul> <li>Proteinbiophysics (exercise, 1 SWS)</li> <li>Proteinbiophysics (lecture, 2 SWS)</li> <li>Basics of Membrane Biophysics (lecture)</li> <li>Basics of Membrane Biophysics (exercise)</li> <li>Instrumentation in Biophysics (exercise)</li> <li>Instrumentation in Biophysics (lecture)</li> </ul>	ure, 2 SWS) cise, 1 SWS) ise, 1 SWS) e, 2 SWS)	<ul> <li>225 Hours private studies</li> <li>135 Hours in-classroom work</li> </ul>	
Contents of teaching:  Protein structure Energy landscapes Thermodynamics of protein folding Thermodynamics of protein folding Kinetics of protein folding Thermodynamics of enzymatic react Kinetics of enzymatic reactions Importance and function of cell men Basics of the membrane component Thermodynamic self-assembling of li Transmembrane and intrinsic memb Mechanical properties of lipid memb Nestigations using lipid monolayer Electrical and optical experiments us Examples for interaction mechanism Spectroscopic methods on membrane UV-VIS spectroscopy Fluorescence spectroscopy Film balance Patch clamp	ons abranes: structure, physical pids and reconstitution teo rane potentials aranes ort mechanisms ing planar lipid bilayers s between peptides/ proteines and membrane protein pranes and membrane prot	function and dynamic models chniques ins and planar membranes s teins	
Qualification-goals/Competencies: • Students will understand and be able • They can name the components of b • They can name and explain the role • They can name and explain the mecl • They can select and apply appropriate • They can identify the appropriate ins • They can further develop instrument • They can use the instruments of biop Grading through: • Oral examination Requires: • Introduction into Biophysics (LS2200	e to apply the physical prin iological membranes and e and function of membrane nanical and electrical prope te methods for the investig trumentation for a particul s of biophysics ohysics optimally -KP04, LS2200)	ciples of protein folding, protein dynamics and protein interaction. explain their structure. lipids and proteins. erties of membranes. lation of artificial and natural membranes. lar question of biophysics.	



Responsible for this module:
Prof. Dr. rer. nat. Christian Hübner
Teacher:
<ul> <li>Research Center Borstel, Leibniz Lung Center</li> <li>Institute of Physics</li> </ul>
<ul> <li>Prof. Dr. rer. nat. Christian Hübner</li> <li>PD Dr. rer. nat. Hauke Paulsen</li> <li>Prof. Dr. rer. nat. Thomas Gutsmann</li> <li>Prof. Dr. rer. nat. Andra Schromm</li> <li>Dr. Christian Nehls</li> </ul>
<ul> <li>Literature:</li> <li>Hans Frauenfelder, Shirley Chan und Winnie Chan: Physics of Proteins: An Introduction to Molecular Biophysics (Biological and Medical Physics, Biomedical Engineering) - von Springer, Berlin (Gebundene Ausgabe - 30. Dezember 2010)</li> <li>Alan Fersht: Structure &amp; Mechanism in Protein Science: Guide to Enzyme Catalysis and Protein Folding - W H Freeman &amp; Co (Gebundene Ausgabe - 15. Februar 1999)</li> <li>Meyer B. Jackson: Molecular and Cellular Biophysics - ISBN: 978-0-521-62470-1</li> <li>G. Adam, P. Läuger, G. Stark: Physikalische Chemie und Biophysik - Springer-Verlag, 4. Auflage 2003</li> <li>W. Hanke, R. Hanke: Methoden der Membranphysiologie - Spektrum Akademischer Verlag, Auflage 1997</li> <li>Ole G. Mouritsen: Life - As a Matter of Fat - Springer 2005, ISBN 987-3-540-23248-3</li> <li>Thomas Heimburg: Thermal Biophysics of Membranes - Whiley-VCH 2007, ISBN 978-3-527-40471-1</li> <li>Lukas K. Buehler: Cell Membranes - Garland Science 2016, ISBN 978-0-8153-4196-3</li> <li>Yves Dufrene (Ed.): Life at the Nanoscale - Pan Stanford Publishing 2011, ISBN 978-981-4267-96-0</li> </ul>
L <b>anguage:</b> • German and English skills required



BP51	00-KP12 - Internship	Biophysics 1 (ProPra	kBP1)
Duration:	Turnus of offer:		Credit points:
1 Semester	each semester		12 (Тур В)
Course of study, specific field and term: • Master Biophysics 2019 (compulsory • Master Biophysics 2023 (compulsory	), biophysics, 3rd semester ), biophysics, 3rd semester		
Classes and lectures: • Internship I (September-November) SWS)	(block practical course, 12	Workload: • 320 Hours work of • 40 Hours written	on project report
Contents of teaching: <ul> <li>Project management in a concrete re</li> <li>Documentation, presentation, motiv</li> <li>Strategies of literature research</li> <li>Analysis and curation of complex explanation</li> </ul>	esearch context ration in heterogeneous en perimental data	vironments	
Qualification-goals/Competencies: <ul> <li>Students can name and explain selete</li> <li>They can plan and implement exper</li> <li>They can document and present pro</li> <li>They can respond to special audience</li> <li>They can plan and implement project</li> <li>They can manage projects.</li> </ul>	cted aspects of biophysics iments in selected areas of ject results. es or time restrictions in a p cts in concrete application s	biophysics presentation. scenarios.	
Grading through: • B-Certificate (not graded)			
<ul> <li>Responsible for this module: <ul> <li>Studiengangsleitung</li> </ul> </li> <li>Teacher: <ul> <li>All Institutes and Clinics of the Unive</li> <li>Scientific facilities at the Universität : <ul> <li>Alle Dozentinnen/Dozenten der Uzi</li> </ul> </li> </ul></li></ul>	rsität zu Lübeck zu Lübeck or abroad with m L	nandatory supervision by a	n university lecturer
Literature: • is selected individually:			
Language: • German, except in case of only Engli	sh-speaking participants		
Notes: The internships can be completed in an recommended to seek a place abroad. One of the two internships can be com Both internships can be merged into o	uditorytechnology compan ppleted in a medical institut ne large internship.	ies or scientific facilities ou ion or a clinic.	itside the university as well. It is



BP5	200-KP12 - Internship	Biophysics 2 (ProPra	kBP2)
Duration:	Turnus of offer:		Credit points:
1 Semester	each semester		12 (Тур В)
Course of study, specific field and term: • Master Biophysics 2019 (compulso • Master Biophysics 2023 (compulso	y), biophysics, 3rd semester y), biophysics, 3rd semester		
Classes and lectures: • Internship I (September-November SWS)	) (block practical course, 12	Workload: • 320 Hours work ( • 40 Hours written	on project report
Contents of teaching: <ul> <li>Project management in a concrete</li> <li>Documentation, presentation, mot</li> <li>Strategies of literature research</li> <li>Analysis and curation of complex e</li> </ul>	research context ivation in heterogeneous env xperimental data	vironments	
Qualification-goals/Competencies: <ul> <li>Students can name and explain sel</li> <li>They can plan and implement expe</li> <li>They can document and present pi</li> <li>They can respond to special audier</li> <li>They can plan and implement proj</li> <li>They can manage projects.</li> </ul>	ected aspects of biophysics eriments in selected areas of roject results. nces or time restrictions in a p ects in concrete application s	biophysics. presentation. cenarios.	
Grading through: • B-Certificate (not graded)			
<ul> <li>Responsible for this module:</li> <li>Studiengangsleitung</li> <li>Teacher: <ul> <li>All Institutes and Clinics of the Universitätion</li> <li>Scientific facilities at the Universitätion</li> <li>Alle Dozentinnen/Dozenten der Universitätion</li> </ul> </li> </ul>	versität zu Lübeck t zu Lübeck or abroad with m zL	andatory supervision by a	n university lecturer
Literature: • is selected individually:			
Language: • German, except in case of only Eng	lish-speaking participants		
Notes: The internships can be completed in recommended to seek a place abroad One of the two internships can be co Both internships can be merged into	auditorytechnology compan 1. mpleted in a medical institut one large internship.	ies or scientific facilities ou ion or a clinic.	Itside the university as well. It is



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BP5990-KF	230 - Master Thesis Au	uditory Technology (E	BPMArbeit)
Duration:	Turnus of offer:		Credit points:
1 Semester	each semester		30
Course of study, specific field and term: • Master Biophysics 2023 (compulsory • Master Biophysics 2019 (compulsory	), biophysics, 4th semester ), biophysics, 4th semester		
Classes and lectures:       Workload:         • Authoring of the Master Thesis (supervised self studies, 1 SWS)       • 870 Hours private studies         • Colloquium (presentation (incl. preparation), 1 SWS)       • 30 Hours oral presentation (including preparation)			e studies sentation (including preparation)
Contents of teaching: • Independent scientific work on a cor • Scientific presentation of the problem	mplex task in biophysics an m at hand and the solutions	d its application s developed	
<ul> <li>Qualification-goals/Competencies:</li> <li>Ability to solve a preformulated mor theexperimental results within the ru</li> <li>They can plan, organise and implem</li> <li>They can present complex information</li> </ul>	e complex scientific proble ules of the UzL for GSP and ent a complex, innovative p on in written and oral form.	m in a defined period of tin the DFG-guidelines. project.	ne and to present and defende
Grading through: • Written report			
Responsible for this module: <ul> <li>Studiengangsleitung</li> </ul> Teacher: <ul> <li>All institutes of the University of Lüb</li> <li>Alle prüfungsberechtigten Dozentir</li> </ul>	eck nnen/Dozenten des Studien	iganges	
Literature: • is selected individually:			
Language: • thesis can be written in German or E	nglish		
Notes: Prerequisites for the module: - Minimum of 82 ECTS Prerequisites for admission to the writt - succesful work on the subject Module exam: - BP5990-L1: Master Thesis in BP, writte - BP5990-L2: Colloquium about the the mean of the two examinators)	en examination: en thesis, 66,66 % module g ssis in BP, oral defend, 60 m	ırade in (20 min oral presentation	n), 33,33 % module grade (the arithmetic
If the Master thesis is done externally ( second instructor who will be First Exa	outside our university) the s miner in the examination.	student has to choose a lice	ensed lecturer (see PO) of our university as a



	LS4020 A - Module part L	.S4020A: Crystallography (	StrAnaKris)	
Duration:	Turnus of offer:	Credit points:	N	Nax. group size:
1 Semester	each winter semester	3	6	0
Course of study, spe Master CLS 20. Master Infection Master Infection Master Biophy Master CLS 20 Master MLS 20 Master MLS 20	cific field and term: 23 (Module part of a compulsory module) on Biology 2018 (Module part of a compul on Biology 2012 (Module part of a compul sics 2019 (Module part of a compulsory m 16 (Module part of a compulsory module) 18 (Module part of a compulsory module) 16 (Module part of a compulsory module)	, MML with specialization in Life S sory module), Infection Biology, 1 sory module), Infection Biology, 1 nodule), biophysics, 1st semester , MML with specialization in Life S ), life sciences, 1st semester ), life sciences, 1st semester	cience, 3rd sen st semester st semester cience, 3rd sen	nester nester
Classes and lectures	:	Workload:		
• LS4021-V: Crys	tallography (lecture, 2 SWS)	<ul><li>60 Hours private</li><li>30 Hours in-class</li></ul>	studies sroom work	
<ul> <li>Contents of teaching:         <ul> <li>Crystal growth, precipitant and phase diagram, crystal morphology, symmetry and space groups, crystallogenesis</li> <li>X-rays, X-ray sources, X-ray diffraction, Bragg's law, reciprocal lattice and Ewald-sphere construction</li> <li>X-ray diffraction by electrons, Fourier analysis and synthesis</li> <li>Protein structure determination by X-ray diffraction, crystallographic phase problem, Patterson map, molecular replacement (MR), multiple isomorphous replacement (MIR), multi-wavelength anomalous diffraction (MAD)</li> <li>Crystallography and the drug discovery process: studying protein-ligand interactions</li> <li>Practical exercises employing an X-ray generator (collection of a diffraction image) and the computer (MR; calculation and interpretation of electron density maps)</li> <li>Site visit at the Synchrotron DESY (Hamburg)</li> </ul> </li> <li>Cualification-goals/Competencies:         <ul> <li>They have a general scientific competence in macromolecular X-ray diffraction analysis</li> <li>They have the methodological competence to correctly interpret (salt or protein) the diffraction image of a crystal using the Ewald Sphere construction</li> <li>They have the methodological competence to tackle the phase problem either by MR, MIR or MAD</li> <li>They have the methodological competence to carrectly maps</li> <li>They have the methodological competence to carrectly enciphere of X-ray diffraction image for a crystal using the Ewald Sphere construction</li> <li>They have the methodological competence to tackle the phase problem either by MR, MIR or MAD</li> <li>They have the methodological competence to carrectly tructure- or fragment-based techniques for lead compound identification</li> <li>They have the methodological competence, to apply structure- or fragment-ba</li></ul></li></ul>				
Grading through: • see Notes				
Responsible for this • Siehe Hauptn Teacher: • Institute of Bio • Dr. math. et di	module: nodul chemistry s. nat. Jeroen Mesters			
• Jan Drenth: Pr	inciples of Protein X-ray Crystallography -	Science+Business Media, LLC, Ne	w 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
- LS4026-KP06 start in 2023

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

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



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 CLS 2023 (Module part of a Master MLS 2018 (Module part of a Master Infection Biology 2018 (Mod Master Biophysics 2019 (Module part Master CLS 2016 (Module part of a Master MLS 2016 (Module part of a Master Infection Biology 2012 (Mod Master CLS 2010 (module part), cor Master MLS 2009 (Module part of a	compulsory module), MML v compulsory module), struct dule part of a compulsory module), art of a compulsory module), compulsory module), MML v compulsory module), struct dule part of a compulsory mo mputational life science / life compulsory module), struct	with specialization in Life So ure biology, 1st semester odule), Interdisciplinary mo biophysics, 1st semester with specialization in Life So ure biology, 1st semester odule), Interdisciplinary mo sciences, 3rd semester ure biology, 1st semester	cience, 3rd semester odules, 1st semester cience, 3rd semester odules, 1st semester
Classes and lectures:		Workload:	
NMR-Spectroscopy (lecture, 2 SWS)	)	<ul><li>60 Hours private</li><li>30 Hours in-class</li></ul>	studies room work
Contents of teaching:   Lecture topics:  Assignment of NMR spectra  Description of the NOESY experime  Chemical Exchange and Transfer-N  Multidimensional NMR spectroscop  Assignment strategy for peptides  Introduction into the product oper  Description of the COSY and of the NMR experiments for the assignme  NMR structural analysis of proteins  Experiments to probe the motions  Qualification-goals/Competencies:  Students are able to assign and anal Understanding of NMR experiment Students are able to analyze struct  Grading through:  see Notes	ent using the vector model OEs Dy ator formalism (POF) HSQC experiment using PO ent of proteins of protein alyze complex NMR spectra ts based on the product oper ure and dynamics of protein	F rator formalism s through NMR experiment	ts
Responsible for this module: • Prof. Dr. rer. nat. Ulrich Günther Teacher: • Institute of Chemistry and Metabol • Prof. Dr. rer. nat. Ulrich Günther • Dr. Alvaro Mallagaray Literature:	omics		
<ul> <li>James Keeler: Understanding NMR</li> <li>:</li> <li>Malcolm H. Levitt: Spin Dynamics -</li> <li>D. Neuhaus &amp; M. P. Williamson: The</li> <li>Timothy Claridge: High-Resolution</li> <li>: Current scientific literature</li> </ul>	Spectroscopy - Wiley Basics of Nuclear Magnetic I Nuclear Overhauser Effect i NMR Techniques in Organic	Resonance - Wiley-VCH n Structural and Conforma Chemistry - Pergamon Pre	tional Analysis - Wiley-VCH ss
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
- LS4027-KP06 start 2023

Exercises are integrated into the lectures. It is a compulsory module part for the Master MLS with a focus on structural biology.

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LS4020 C - Module part LS4020C: Single Molecule Methods (Einzelstru)			
Duration:	Turnus of offer:	Credit points:	
1 Semester	each winter semester	3	
Course of study, specific field and term: Master CLS 2023 (Module part of a co Master MLS 2018 (Module part of a co Master Infection Biology 2018 (Module Master Biophysics 2019 (Module part Master CLS 2016 (Module part of a co Master MLS 2016 (Module part of a co Master Infection Biology 2012 (Module Master CLS 2010 (module part), com Master MLS 2009 (Module part of a co	ompulsory module), compu compulsory module), struct ile part of a compulsory module), t of a compulsory module), compulsory module), MML v compulsory module), struct ile part of a compulsory module putational life science / life compulsory module), struct	utational life science / life sciences, 3rd semester ure biology, 1st semester odule), Interdisciplinary modules, 1st semester biophysics, 1st semester vith specialization in Life Science, 3rd semester ure biology, 1st semester odule), Interdisciplinary modules, 1st semester sciences, 3rd semester ure biology, 1st semester	
Classes and lectures:		Workload:	
Single Molecule Methods (lecture, 2	SWS)	<ul><li> 60 Hours private studies</li><li> 30 Hours in-classroom work</li></ul>	
Contents of teaching: <ul> <li>Physical basics of fluorescence</li> <li>Photo physics</li> <li>Microscopy techniques</li> <li>Protein labeling</li> <li>Fluorescence resonance energy tran</li> <li>Single molecule enzymology</li> <li>Single molecule protein folding</li> <li>Physical basics of optical tweezers</li> <li>Protein folding with optical tweezers</li> </ul> Qualification-goals/Competencies: <ul> <li>Understanding of the physical basics</li> <li>Understanding of the limits of single</li> </ul>	sfer s of single molecule method gle molecule methods molecule methods	ds	
Grading through: • see Notes			
Responsible for this module: <ul> <li>Siehe Hauptmodul</li> </ul> Teacher: <ul> <li>Institute of Physics</li> <li>Prof. Dr. rer. nat. Christian Hübner</li> </ul>			
Literature: • Lakowicz, Joseph R: Principles of Flue • Markus Sauer, Johan Hofkens, Jörg E Molecules - ISBN: 978-3-527-31669-4	orescence Spectroscopy - I nderlein: Handbook of Fluc	SBN 978-0-387-46312-4 prescence 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
- LS4027-KP06 start 2023

This module part is identical to LS4020 C-MIW without seminar.



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 term: Master CLS 2023 (Module part of a c Master MLS 2018 (Module part of a c Master Infection Biology 2018 (Mod Master Biophysics 2019 (Module part Master CLS 2016 (Module part of a c Master MLS 2016 (Module part of a c Master Infection Biology 2012 (Mod Master CLS 2010 (module part), corr	compulsory module), MML w compulsory module), structu ule part of a compulsory mo t of a compulsory module), compulsory module), MML w compulsory module), structu ule part of a compulsory mo uputational life science / life	vith specialization in Life So are biology, 1st semester dule), Interdisciplinary mo biophysics, 1st semester vith specialization in Life So are biology, 1st semester dule), Interdisciplinary mo sciences, 3rd semester	cience, 3rd semester dules, 1st semester cience, 3rd semester dules, 1st semester	
Classes and lectures:		Workload:		
LS4027-V Optical Methods (lecture,	2 SWS)	<ul><li>60 Hours private</li><li>30 Hours in-class</li></ul>	studies room work	
<ul> <li>Contents of teaching: <ul> <li>Basic principles of optics</li> <li>Light sources and detectors</li> <li>Classical light microscopy</li> <li>Photophysics, fluorescence microscopy</li> <li>Confocal microscopy</li> <li>Nonlinear microscopy</li> <li>Fluorescent dyes; GFP and genetically encoded fluorescent markers; live cell/intravital imaging: important experimental parameters</li> <li>Protein-protein interactions in living cells: FRET, FLIM; biosensors</li> <li>Photoactivatable/switchable fluorescent proteins; fluorescent timers</li> <li>Optogenetics: Cell manipulation by light</li> <li>Super-resolution 3D fluorescence microscopy: STED, PALM, STORM</li> <li>Optical tweezers as instrument for nanomanipulation</li> <li>Visualization and quantitative evaluation; data format and data storage media</li> <li>In vivo imaging in tissues and living animals</li> <li>Bioluminescence and optoacoustic imaging</li> <li>Flow cytometry &amp; fluorescence activated cell sorting</li> <li>High-content screening; optical sensor technology</li> </ul> </li> </ul>				
<ul> <li>Qualification-goals/Competencies:</li> <li>Students acquire professional competence in basic principles and concepts of optics.</li> <li>Students know the basics of light and fluorescence microscopy.</li> <li>They know and understand the most important methods for marking and microscopic visualization of proteins and sub-cellular structures.</li> <li>Students know the possible applications of live cell microscopy, intravital imaging, and quantitative fluorescence techniques in biological questions.</li> <li>They know basic techniques of 3-dimensional optical imaging of tissues and animals.</li> <li>Student are familiar with current research topics in the field of optical methods in the life sciences and are able to evaluate them in terms of their application maturity and potential.</li> <li>Students can classify optical methods according to their complexity and outline possible applications.</li> <li>The students have the social and communication skills to discuss given questions within group work for lecture preparation and lecture follow-up.</li> </ul>				
Grading through:				
• written exam				
Responsible for this module: • Siehe Hauptmodul				



Teacher:
Institute of Biomedical Optics
<ul> <li>Prof. Dr. rer. nat. Gereon Hüttmann</li> <li>Prof. Dr. rer. nat. Sebastian Karpf</li> <li>Dr. rer. nat. Norbert Linz</li> <li>Prof. Dr. rer. nat. Robert Huber</li> </ul>
Literaturo
<ul> <li>J. B. Pawley, ed.: Handbook of Biological Confocal Microscopy, Springer</li> <li>V. V. Tučin: Handbook of optical biomedical diagnostics, SPIE Press</li> <li>L. V. Wang, and Hi. Wu: Biomedical optics principles and imaging, Wiley</li> <li>:</li> <li>:</li> </ul>
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 - LS4026-KP06 start 2023
(Share of Institute of Biomedical Optics to this lecture is 100%)





Γ

LS4020-KP12 - Structure	e Analysis (StrAnaKP	12)
Turnus of offer:		Credit points:
each winter semester		12
n <b>d term:</b> compulsory), biophysics, 1st semester lsory), structure biology, 1st semester		
Classes and lectures:Workload:• Part of the module A: Crystallography (lecture, 2 SWS)• 240 Hours private studies• Part of the module B: NMR-Spectroscopy (lecture, 2 SWS)• 120 Hours in-classroom work• Part of the module C: Single Molecule Methods (lecture, 2 SWS)• 120 Hours in-classroom work• Part of the module D: Microscopy: techniques and applications (lecture, 2 SWS)		e studies sroom work
cies:		
ünther d Metabolomics ünther enfeld en Mesters Seeger i Hübner		
only German-speaking participants 020A-D. Te or related fields. ith all parts, each valued 25%.	Biology	
	LS4020-KP12 - Structure         Turnus of offer:         each winter semester         and term:         compulsory), biophysics, 1st semester         lsory), structure biology, 1st semester         stallography (lecture, 2 SWS)         R-Spectroscopy (lecture, 2 SWS)         gle Molecule Methods (lecture, 2 SWS)         gle Molecule Methods (lecture, 2 SWS)         croscopy: techniques and applications         cies:         d         Metabolomics         ünther         enfeld         en Mesters         Seeger         Hübner         only German-speaking participants         020A-D.         ce or related fields.         ith all parts, each valued 25%.         osen for the specialisation in Structure	LS4020-KP12 - Structure Analysis (StrAnakP         Turnus of offer: each winter semester         compulsory), biophysics, 1st semester         sompulsory), structure biology, 1st semester         stallography (lecture, 2 SWS)         R-Spectroscopy (lecture, 2 SWS)         gle Molecule Methods (lecture, 2 SWS)         gle Molecule Methods (lecture, 2 SWS)         groscopy: techniques and applications         cies:         ünther         indextors         ünther         enfeld         an Mesters         Seeger         Hübner         only German-speaking participants         020A-D.         e or related fields.         it all parts, each valued 25%.         osen for the specialisation in Structure Biology.



	ME4420-KP12, ME4420 -	Biomedical Optics (BMO)		
Duration:	Turnus of offer:	Credit points:		
2 Semester	each winter semester	12		
Course of study, specific fiel Master Biophysics 202 Master MES 2020 (com Master Entrepreneursl Master Biophysics 201 Master Entrepreneursl Master MES 2014 (com	ld and term: 3 (compulsory), biophysics, 1st and 2nd s apulsory), medical engineering science, 1 anip in Digital Technologies 2020 (advance 9 (compulsory), biophysics, 1st and 2nd s anip in Digital Technologies 2014 (advance apulsory), medical engineering science, 1	emester st and 2nd semester ed module), specific, Arbitrary semester emester ed module), specific, 1st and 2nd semester st and 2nd semester		
Classes and lectures:Workload:• ME4421 T: Module part: Biomedical Optics 1 (lecture, 2 SWS)• 135 Hours private studies• ME4422 T: Module part: Biomedical Optics 2 (lecture, 2 SWS)• 135 Hours in-classroom work• ME4423 T: Module part: Laser physics and -technologies (lecture, 2 SWS)• 55 Hours exam preparation • 30 Hours oral presentation (including preparation) • 20 Hours written report				
Contents of teaching: • as described for the m	odule parts			
Qualification-goals/Compet <ul> <li>as described for the m</li> </ul>	encies: nodule parts			
Grading through: • Oral examination				
Responsible for this module Prof. Dr. rer. nat. Robe Teacher: Institute of Biomedica Dr. rer. nat. Norbert Lin Prof. Dr. rer. nat. Gered Prof. Dr. rer. nat. Robe Dr. rer. nat. Ralf Brinkn Prof. Dr. rer. nat. Sebas	ert Huber I Optics nz on Hüttmann ert Huber nann stian Karpf			
Literature: • as listed for the modu	le parts:			
Language: • German and English sl	kills required			
Notes: Prerequisites for attendi - None Prerequisites for the exa - Examination requireme includes mandatory atte	ng the module: m: ent is the successful participation in one c indance and a 20 minute scientific preser	of the three module seminars (BMO1, BMO2, or Laser Physics). This Itation followed by discussion.		
Exam:				

- A 30 minutes oral exam about the content of the lectures BMO1, BMO2 and laser physics.



ME4421 T - Module part: Biomedical Optics 1 (BioMedOp1)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	Semester each winter semester		3	
Course of study, specific field and term: • Master MES 2020 (Module part of a of • Master Entrepreneurship in Digital T • Master Biophysics 2019 (Module part • Master Entrepreneurship in Digital T • Master MES 2014 (Module part of a of • Master Biophysics 2023 (Module part	compulsory module), medi echnologies 2020 (module t of a compulsory module) echnologies 2014 (module compulsory module), medi t of a compulsory module)	cal engineering science, 1st part), Module part, Arbitra , biophysics, 1st semester part), Module part, Arbitra cal engineering science, 1st , biophysics, 1st semester	: semester ry semester ry semester t semester	
Classes and lectures:		Workload:		
Lecture Biomedical Optics 1 (lecture	, 2 SWS)	<ul><li>40 Hours private</li><li>30 Hours in-class</li><li>20 Hours exam p</li></ul>	studies and exercises room work reparation	
Contents of teaching:				
<ul> <li>Tissue optics</li> <li>Photophysics of molecules, fluorescent markers, and targeting</li> <li>Photochemistry, photobiology, and photodynamic therapy</li> <li>Spectroscopic tissue characterization and diagnosis</li> <li>Raman spectroscopy and imaging</li> <li>Coherence of light, and implications for biomedical optics</li> <li>Generation, steering, and detection of light</li> <li>Thermal action of light on biomolecules and tissue, rate processes</li> <li>Selective treatment of ocular structures, guided by online-dosimetry</li> <li>Mechanisms of pulsed laser ablation</li> <li>Laser ablation at tissue surfaces and inside the body &amp; surgery by high-intensity focused ultrasound</li> <li>Nonlinear interactions of light and matter</li> <li>Plasma-mediated surgery, exemplified on refractive corneal surgery and cataract surgery</li> <li>Optical manipulation of microstructures (Laser scissors, tweezers, and catapults)</li> </ul>				
Qualification-goals/Competencies:  • The students are able to describe, illustrate and compare the fundamental diagnostic and therapeutic optical techniques in				
<ul> <li>The students are able to describe, inustrate and compare the fundamental diagnostic and therapeutic optical techniques in biomedicine.</li> <li>They are able to assess advantages and disadvantages of these techniques and to draw conclusions for their implementation into possible applications.</li> <li>They can explain light and tissue interactions and relate them to the optical techniques in which they are used.</li> <li>The students are able to understand and classify complex optical techniques as a whole and to analyze their constitutents.</li> <li>They have a profound understanding of scientific optical techniques in biomedicine, can apply it independently, and are able to transfer their knowledge to related tasks.</li> </ul>				
Grading through:				
<ul> <li>Is requisite for:</li> <li>Module part: Biomedical Optics 2 (ME4422 T)</li> </ul>				
Responsible for this module: • Siehe Hauptmodul Teacher: • Institute of Biomedical Optics				
Prof. Dr. rer. nat. Robert Huber				

• Prof. Dr. rer. nat. Gereon Hüttmann



- Dr. rer. nat. Ralf Brinkmann
- Dr. rer. nat. Norbert Linz

#### Literature:

- P.N. Prasad: Introduction to Biophotonics Wiley 2003
- J. Popp, V. Tuchin, A. Chiou, S.H. Heinemann: Handbook of Biophotonics Vol 1 & 2 Wiley-VCH 2011
- A.J. Welch, M. van Gemert: Optical-Thermal Response of Laser-Irradiated Tissue Plenum 1995 (zweite Auflage 2011)

#### Language:

offered only in German

#### Notes:

Prerequisites for attending the module:

- None

Prerequisites for the exam:

- Preliminary examinations can be determined at the beginning of the semester. If preliminary work has been defined, it must have been completed and positively assessed before the initial examination.



ME4422 T - Module part: Biomedical Optics 2 (BioMedOp2)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	each summer semester		3		
Course of study, specific field and term: Master MES 2020 (Module part of a Master Entrepreneurship in Digital Master Biophysics 2019 (Module part Master Entrepreneurship in Digital Master MES 2014 (Module part of a Master Biophysics 2023 (Module part)	a compulsory module), media Technologies 2020 (module art of a compulsory module), Technologies 2014 (module a compulsory module), media art of a compulsory module),	cal engineering science, 2n part), Module part, Arbitra , biophysics, 2nd semester part), Module part, Arbitra cal engineering science, 2n , biophysics, 2nd semester	id semester ry semester ry semester id semester		
Classes and lectures:		Workload:			
Biomedical Optics 2 (lecture, 2 SW	S)	<ul> <li>40 Hours private</li> <li>30 Hours in-class</li> <li>20 Hours exam p</li> </ul>	studies sroom work preparation		
Contents of teaching:					
<ul> <li>Light microscopy: geometrical opt</li> <li>Effects of incoherent and coherent</li> <li>Phase contrast and differential inte</li> <li>Marker and targeting techniques,</li> <li>Deconvolution &amp; optical sectioning</li> <li>Nanoscopy beyond the Abbe-limit</li> <li>Optical coherence tomography (O</li> <li>Opto-acoustic tomography and m</li> <li>Electron microscopy: principles an</li> </ul>	<ul> <li>Light microscopy: geometrical optics, wave optics, Fourier optics</li> <li>Effects of incoherent and coherent microscope-illumination &amp; technical realization</li> <li>Phase contrast and differential interference contrast (DIC)</li> <li>Marker and targeting techniques, GFP, quantum dots, FRET</li> <li>Deconvolution &amp; optical sectioning via structured illumination, confocal microscopy, 2-photon imaging</li> <li>Nanoscopy beyond the Abbe-limit: principles and biological applications</li> <li>Optical coherence tomography (OCT): principles, technical realization, and clinical applications</li> <li>Opto-acoustic tomography and microscopy</li> <li>Electron microscopy revisibles and biological applications of TEM_PEM_ and Cave EM</li> </ul>				
<ul> <li>The students have a profound unc describe and illustrate them, and t</li> <li>They can explain the light-tissue ir effects.</li> <li>The students are able to understar</li> <li>They are able to transfer and adoption</li> </ul>	lerstanding and knowledge o o relate them to applications nteraction relevant for the dif nd and classify complex optic ot their knowledge to related	of modern optical imaging s. fferent techniques, describ cal imaging techniques as a problems and to develop	techniques in biomedicine, are able to e them mathematically and predict their a whole and to analyze their constitutents. new concepts.		
Grading through: • exam type depends on main modu	ule				
Requires: • Module part: Biomedical Optics 1 (	ME4421 T)				
Responsible for this module: • Siehe Hauptmodul Teacher: • Institute of Biomedical Optics • Prof. Dr. rer. nat. Robert Huber • Prof. Dr. rer. nat. Gereon Hüttmanr • Prof. Dr. rer. nat. Sebastian Karpf • Dr. rer. nat. Norbert Linz • Dr. rer. nat. Ralf Brinkmann	۰				
Literature:					
<ul> <li>D. B. Murphy: Fundamentals of Lig</li> <li>J. Mertz: Optical Microscopy - Robe</li> </ul>	ht Microscopy and Electronic erts & Co. Publ. 2010	c Imaging - Wiley-Liss 2001			

• J.B. Pawley (ed): Handbook of Confocal Microscopy - Springer 2006



<ul> <li>W. Drexler, J.G. Fujimoto (eds.): Optical Coherence Tomography - Springer 2008</li> <li>L. Wang (ed): Photoacoustic Imaging and Spectroscoy - CRC Press 2009</li> </ul>	
Language:	
offered only in German	
Notes:	
Prerequisites for attending the module: - None (The competences of the required modules are required for this module, but the modules are not a prereq	uisite for admission).
Prerequisites for the exam:	

- Talk and participation in discussion



ME4423 T - Module part: Laserphysics and -technologies (LaPhyTec)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	1 Semester each winter semester		3	
Course of study, specific field and term: • Master MES 2020 (Module part of a of • Master Entrepreneurship in Digital T • Master Biophysics 2019 (Module part • Master Entrepreneurship in Digital T • Master MES 2014 (Module part of a of • Master Biophysics 2023 (Module part	compulsory module), medi echnologies 2020 (module) t of a compulsory module) echnologies 2014 (module compulsory module), medi t of a compulsory module)	cal engineering science, 1st part), Module part, Arbitrar , biophysics, 1st semester part), Module part, Arbitrar cal engineering science, 1st , biophysics, 1st semester	: semester ry semester ry semester : semester	
Classes and lectures:		Workload:		
• Lecture laser physics and -technolog	gies (lecture, 2 SWS)	<ul> <li>45 Hours private</li> <li>30 Hours in-class</li> <li>15 Hours exam p</li> </ul>	studies and exercises room work reparation	
Contents of teaching:				
<ul> <li>Understanding the laser (What is a l</li> <li>Basic properties of light, light propa</li> <li>Light and matter (radiation interacti</li> <li>Laser (Broad laser theory, rate equat</li> <li>Types of lasers (gas lasers, ion lasers</li> <li>nonlinear optics (frequency doublin</li> <li>Ultrashort light pulses</li> </ul>	aser, the laser history, laser gation (Gaussian beam res ons, stimulated and sponta ions, laser threshold, laser , solid state lasers, fiber las g and conversion)	parameters) onators, stability conditions aneous emission light ampl dynamics) ers, semiconductor lasers)	s, wavelength selective elements) ification)	
<ul> <li>They can implement concepts for not they can list the most important typ.</li> <li>They can explain the basic concepts</li> <li>They can analyze laser formally.</li> <li>They can assess the potential of lase</li> </ul>	ew laser applications. bes of lasers. of laser physics. er radiation on the basis of	the parameters.		
exam type depends on main modul	e			
Responsible for this module: <ul> <li>Siehe Hauptmodul</li> </ul> <li>Teacher: <ul> <li>Institute of Biomedical Optics</li> <li>Prof. Dr. rer. nat. Robert Huber</li> <li>Dr. rer. nat. Ralf Brinkmann</li> <li>Prof. Dr. rer. nat. Sebastian Karpf</li> </ul> </li>				
Literature:				
<ul> <li>Dieter Meschede: Optics, Light and Lasers - Wiley-VCH 2007</li> <li>Walter Koechner: Solid State Laser Engineering - Springer 1999</li> <li>Saleh/Teich: Grundlagen der Photonik - Wiley-VCH 2008</li> </ul>				
<ul> <li>Language:</li> <li>• offered only in German</li> </ul>				
Notes:				



Prerequisites for attending the module: - None

Prerequisites for the exam:

- Preliminary examinations can be determined at the beginning of the semester. If preliminary work has been defined, it must have been completed and positively assessed before the initial examination.



PS5000-KP06, PS5000 - Student Conference (ST)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	each winter semester		6 (Тур В)	
<ul> <li>Course of study, specific field and term:</li> <li>Master Psychology - Cognitive Systems 2022 (compulsory), psychology, 3rd semester</li> <li>Master Biophysics 2023 (compulsory), biophysics, 3rd semester</li> <li>Master Auditory Technology 2022 (compulsory), Auditory Technology, 3rd semester</li> <li>Master MES 2020 (compulsory), interdisciplinary competence, 3rd semester</li> <li>Master Medical Informatics 2019 (compulsory), interdisciplinary competence, 3rd semester</li> <li>Master Biophysics 2019 (compulsory), biophysics, 3rd semester</li> <li>Master Biophysics 2019 (compulsory), biophysics, 3rd semester</li> <li>Master Biophysics 2019 (compulsory), biophysics, 3rd semester</li> <li>Master Auditory Technology 2017 (compulsory), Auditory Technology, 3rd semester</li> <li>Master Interdisciplinary Courses (optional subject), Interdisciplinary modules, Arbitrary semester</li> <li>Master Robotics and Autonomous Systems 2019 (compulsory), Compulsory courses, 3rd semester</li> <li>Master Medical Informatics 2014 (compulsory), interdisciplinary competence, 3rd semester</li> <li>Master Medical Informatics 2014 (compulsory), interdisciplinary competence, 3rd semester</li> <li>Master Medical Informatics 2014 (compulsory), interdisciplinary competence, 3rd semester</li> </ul>				
Classes and lectures: • Student Conference (seminar, 4 SWS	5)	<ul> <li>Workload:</li> <li>155 Hours work of development) an</li> <li>25 Hours in-classi</li> </ul>	on an individual topic (research and d written elaboration room work	
Contents of teaching:				
<ul> <li>Preparation of a scientific publicatio</li> <li>Preparation of a scientific poster in F</li> <li>Presentation of a scientific poster in</li> <li>Talk in English based on the results</li> <li>Active participation in scientific disc</li> <li>Active participation in a scientific period</li> </ul>	n in English based on the re English based on the results German or English, based o of at least one of the project ussions er-review process	sults of at least one of the of at least one of the proje n the results of at least on internships	project internships ect internships e of the project internships	
Qualification-goals/Competencies:         • Students have experience in a comprehensive review of a scientific topic         • They are able to get an extensive overview of a complex scientific area         • They have the experience and ability to take an active part in scientific discussions         • They are able to defend one's work successfully in a scientific discourse         • They have knowledge of the peer-review process of publications         • They are able to constructively criticize in a blind peer-review process				
Grading through: • continuous, successful participation	in course			
<ul> <li>Responsible for this module:</li> <li>Prof. Dr. rer. nat. habil. Heinz Handels</li> <li>Prof. Dr. rer. nat. Thorsten Buzug</li> <li>Teacher:</li> <li>All Institutes and Clinics of the Universität zu Lübeck</li> </ul>				
Literature: • is selected individually:				
Language: • offered only in English				
Notes:				



Admission requirements for the module:

- Successful completion of at least one project internship.

- Registration for at least one project internship is required.

Admission requirements for the examination:

- Regular and successful participation

Since the content of the presentation should reflect the results of at least one of the project internships, the students will be supervised by the same university lecturer that supervised the internships. Internships can be carried out at home or abroad in medical technology companies, audiology companies and IT companies in the healthcare industry as well as hospitals and scientific institutions. The supervision by an university lecturer is obligatory.

Students for whom this course is a compulsory module have priority.

(The share of the Institute of Medical Technology in all is 75%) (Share of medical informatics in all is 25%)



CS4405 T - Module part: NeuroInformatics (NeuroInfa)					
Duration: Turn	us of offer:	Credit points:			
1 Semester each	summer semester	4			
Course of study. specific field and term:					
<ul> <li>Master Biophysics 2023 (module part), adv</li> <li>Master Computer Science 2019 (module part), computer</li> <li>Master MES 2020 (module part), computer</li> <li>Master Entrepreneurship in Digital Techno</li> <li>Master Medical Informatics 2019 (module part), adv</li> <li>Master Biophysics 2019 (module part), adv</li> <li>Master IT-Security 2019 (module part), Module</li> <li>Master Medical Informatics 2014 (module part), Master Medical Informatics 2014 (module part), computer</li> <li>Master MES 2014 (module part), computer</li> <li>Master Computer Science 2014 (module part)</li> </ul>	anced curriculum, 2nd semester art), Module part, Arbitrary semester science / electrical engineering, Arbitrary logies 2020 (module part), Module part, A part), Module part, Arbitrary semester anced curriculum, 2nd semester dule part, 1st or 2nd semester part), Module part, Arbitrary semester logies 2014 (module part), Module part, a science / electrical engineering, 2nd sem art), Module part, Arbitrary semester	y semester Arbitrary semester Arbitrary semester nester			
Classes and lectures:	Workload:				
<ul> <li>NeuroInformatics (lecture, 2 SWS)</li> <li>NeuroInformatics (exercise, 1 SWS)</li> </ul>	<ul> <li>55 Hours  </li> <li>45 Hours i</li> <li>20 Hours e</li> </ul>	private studies in-classroom work exam preparation			
Contents of teaching:					
<ul> <li>The human brain and abstract neuron more</li> <li>Learning with a single neuron:* Perceptron</li> <li>Network architectures:* Hopfield-Network</li> <li>Unxupervised Learning:* k-means, Neural</li> </ul>	dels ns* Max-Margin Classification* LDA and lo s* Multilayer-Perceptrons* Deep Learning Gas and SOMs* PCA & ICA* Sparse Codin	ogistic Regression g g			
<ul> <li>Qualification-goals/Competencies:</li> <li>The students are able to understand the p</li> <li>They know abstract neuronal models and</li> <li>They are able to derive a learning rule from</li> <li>They are able to apply (and implement) the</li> </ul>	rinciple function of a single neuron and t they are able to name practical application n a given error function. e proposed learning rules and approache	the brain as a whole. ons for the different variants. es to solve unknown practical problems.			
Grading through:					
<ul> <li>exam type depends on main module</li> </ul>					
Responsible for this module:					
Siehe Hauptmodul					
Teacher:					
<ul> <li>Institute for Neuro- and Bioinformatics</li> </ul>	Institute for Neuro- and Bioinformatics				
Prof. Dr. rer. nat. Thomas Martinetz					
Literature:					
<ul> <li>S. Haykin: Neural Networks - London: Pren</li> <li>J. Hertz, A. Krogh, R. Palmer: Introduction t</li> <li>T. Kohonen: Self-Organizing Maps - Berlin:</li> <li>H. Ritter, T. Martinetz, K. Schulten: Neurona Addison Wesley, 1991</li> </ul>	tice Hall, 1999 to the Theory of Neural Computation - Ac Springer, 1995 ale Netze: Eine Einführung in die Neuroin	ddison Wesley, 1991 formatik selbstorganisierender Netzwerke - Bonn:			
Language: • offered only in German					
Notes:					



Examination prerequisites can be defined at the beginning of the semester. If prerequisite courses are defined, they must have been completed and positively evaluated before the first examination.

(Is module part of CS4410, CS4511) (Is equal to CS4405)

Admission requirements for the module: - None

Admission requirements for the examination:

- Successful completion of exercises during the semester.

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CS4440 T - Module part: Molecular Bioinformatics (MolBioInfa)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	Semester each winter semester		4		
<ul> <li>Course of study, specific field and term:</li> <li>Master Biophysics 2023 (module part), advanced curriculum, Arbitrary semester</li> <li>Master Biophysics 2019 (module part), advanced curriculum, Arbitrary semester</li> <li>Master Computer Science 2019 (module part), Module part, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester</li> <li>Master Medical Informatics 2019 (module part), Module part, Arbitrary semester</li> <li>Master MLS 2009 (Module part of a compulsory module), interdisciplinary competence, 1st semester</li> <li>Master Medical Informatics 2014 (module part), Module part, Arbitrary semester</li> </ul>					
Classes and lectures:		Workload:			
<ul> <li>Molecular Bioinformatics (lecture, 2</li> <li>Molecular Bioinformatics (exercise, 1</li> </ul>	SWS) SWS)	<ul> <li>45 Hours private</li> <li>45 Hours in-class</li> <li>20 Hours exam p</li> </ul>	studies room work reparation		
Contents of teaching: • Methods for fast genome compariso • Analysis of data describing gene exp • Advanced usage of biological datab	n pression profiles and seque ases (for sequences, motifs,	nce variation structures, gene regulatio	n and interactions)		
Qualification-goals/Competencies: <ul> <li>The students can apply indexing bases</li> <li>They can use and design databases</li> <li>They are able to detect statistically statistically</li></ul>	sed software to Next Gener for molecularbiological rese ignificant changes in Micro	ation sequence data. earch. array data.			
Grading through: • exam type depends on main module	2				
Requires: • Introduction to Bioinformatics (CS14	00-KP04, CS1400)				
Responsible for this module:					
<ul> <li>Siehe Hauptmodul</li> <li>Teacher: <ul> <li>Institute for Neuro- and Bioinformatics</li> <li>Prof. Dr. Bernhard Haubold</li> <li>Prof. Dr. rer. nat. Thomas Martinetz</li> <li>Prof. Lars Bertram</li> <li>MitarbeiterInnen des Instituts</li> </ul> </li> </ul>					
Literature:					
<ul> <li>M. S. Waterman: Introduction to Computational Biology - London: Chapman and Hall 1995</li> <li>B. Haubold, T. Wiehe: Introduction to Computational Biology - Birkhäuser 2007</li> <li>R. Durbin, S. Eddy, A. Krogh, G. Mitchison: Biological sequence analysis. Probabilistic models - Cambridge, MA: Cambridge University Press</li> <li>J. Setubal, J. Meidanis: Introduction to computational molecular - Pacific Grove: PWS Publishing Company</li> <li>D. M. Mount: Bioinformatics - Sequence and Genome - New York: Cold Spring Harbor Press</li> </ul>					
Language: <ul> <li>offered only in German</li> </ul>					



#### Notes:

Prerequisites for attending the module:

- None (The competences of the required modules are required for this module, but the modules are not a prerequisite for admission.)

Prerequisites for the exam:

- Preliminary examinations can be determined at the beginning of the semester. If preliminary work has been defined, it must have been completed and positively assessed before the initial examination.

This modul is for Master MLS the Modulpart B of Modul LS4060 with 5 credit points.



CS4	442-KP12 - Systembiolog	gie und Bioinform	natik (SysBioInf)	
Duration:	Turnus of offer:		Credit points:	
2 Semester	starts every winter semester		12	
Course of study, specific field and to • Master Biophysics 2019 (advar	e <b>rm:</b> nced curriculum), advanced curi	riculum, 1st and 2nd s	semester	
Classes and lectures:		Workload:		
<ul> <li>Molecular Bioinformatics (lecture, 2 SWS)</li> <li>Molecular Bioinformatics (exercise, 1 SWS)</li> <li>Modelling of Biological Systems (lecture, 2 SWS)</li> <li>Modelling of Biological Systems (exercise, 1 SWS)</li> <li>Introduction to classic and translational system biology (lecture, 2 SWS)</li> <li>Introduction to classic and translational system biology (exercise, 2 SWS)</li> </ul>				
Contents of teaching: Methods for fast genome com Analysis of data describing ge Advanced usage of biological Elementary time-discrete dete Structured time-discrete popu Generating functions, Galton-1 Markov chains with application Modeling of data and data and Introduction to the genome an Networks: cellular, genetic, ge Analysis of dynamical systems Bioinformatic analysis of Omi Introduction to public databas Exercises: computer lab for an Usage, analysis and visualization Exercises for the analysis of pro-	parison ne expression profiles and sequ databases (for sequences, moti rministic models lation dynamics Watson-processes ns alysis nd proteome of cellular systems ne-regulatory networks, interac fixed points, bifurcations and f cs data ses: e.g. STRING, Gene Expressio alysis of dynamical systems and con of high-dimensional data in otein interaction networks	ience variation fs, structures, gene re s tomes feedback on Omnibus, TCGA, KE d cellular pathways in R	gulation and interactions) GG, Reactome, MSigDB R	
Qualification-goals/Competencies: <ul> <li>The students can apply indexi</li> <li>They can use and design datal</li> <li>They are able to detect statisti</li> <li>Students have knowledge of e</li> <li>They develop skills in connect</li> <li>They have competencies in data</li> <li>They develop competencies in data</li> </ul>	ng based software to Next Gene bases for molecularbiological re cally significant changes in Mic lementary time-discrete model ing ideas from different fields o ta analysis and modelling i interdisciplinary work	eration sequence dat esearch. roarray data. Is for modeling biolo <u>c</u> f mathematics	a. Jical processes	
<ul> <li>The students can explain the principles of signal transduction in the cell</li> <li>The students can relate to the genome, transcriptome, interactome and proteome</li> <li>They can analyse and characterize dynamical systems</li> <li>They know common methods to analyse high-throughput data</li> <li>Lab work will enable the students to continue studying this subject on their own</li> </ul>				
Grading through: • Oral examination				
Requires: • Stochastics 1 (MA2510-KP04, M • Analysis 2 (MA2500-KP04, MA2 • Linear Algebra and Discrete St • Introduction to Bioinformatics	/A2510) 2500) ructures 2 (MA1500-KP08, MA1 (CS1400-KP04, CS1400)	500)		



#### **Responsible for this module:** • Prof. Dr. rer. nat. Thomas Martinetz Teacher: LIED | Lübecker Institut für experimentelle Dermatologie (Lübeck Institute of Experimental Dermatology) • Institute for Mathematics • Institute for Neuro- and Bioinformatics • Prof. Dr. Bernhard Haubold • Prof. Dr. rer. nat. Thomas Martinetz • Dr. rer. nat. Kurt Fellenberg • Nachfolge von Prof. Dr. rer. nat. Karsten Keller • Prof. Dr. Hauke Busch • Dr. Axel Künstner Literature: M. S. Waterman: Introduction to Computational Biology - London: Chapman and Hall 1995 • B. Haubold, T. Wiehe: Introduction to Computational Biology - Birkhäuser 2007 • R. Durbin, S. Eddy, A. Krogh, G. Mitchison: Biological sequence analysis. Probabilistic models - Cambridge, MA: Cambridge University Press J. Setubal, J. Meidanis: Introduction to computational molecular - Pacific Grove: PWS Publishing Company • D. M. Mount: Bioinformatics - Sequence and Genome - New York: Cold Spring Harbor Press F. Braer, C. Castillo-Chavez: Mathematical Models in Population Biology and Epidemiology - New York: Springer 2000 H. Caswell: Matrix Population Modells - Sunderland: Sinauer Associates 2001 • S. N. Elaydi: An Introduction to Difference Equations - New York: Springer 1999 • B. Huppert: Angewandte Lineare Algebra - Berlin: de Gruyter 1990 • U. Krengel: Einführung in die Wahrscheinlichkeitstheorie und Statistik - Wiesbaden: Vieweg 2002 • E. Seneta: Non-negative Matrices and Markov Chains - New York: Springer 1981 • Marian Walhout, Marc Vidal, Job Dekker: Handbook of Systems Biology: Concepts and Insights - (Englisch) Gebundene Ausgabe 15. November 2012 • Edda Klipp, Wolfram Liebermeister, Christoph Wierling, Axel Kowald;: Systems Biology: A Textbook - (Englisch) Taschenbuch 20. April 2016 Yoram Vodovotz and Gary: An Translational Systems Biology, Concepts and Practice for the Future of Biomedical Research Language: German and English skills required Notes: (The module consists of CS4440 T, MA4450 T-INF and EW4170 T) (Is equal to CS4516-KP12) Prerequisites for attending the module: - None Prerequisites for the exam: - depending on the module parts



CS4510-KP12, CS4510 - Signal Analysis (SignalAna)					
Duration:	Turnus of offer:		Credit points:		
2 Semester	each year, can be started in	winter or summer semester	12		
<ul> <li>Course of study, specific field and term:</li> <li>Master Biophysics 2023 (advanced module), advanced curriculum, 1st or 2nd semester</li> <li>Master MES 2020 (advanced module), computer science / electrical engineering, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester</li> <li>Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester</li> <li>Master Biophysics 2019 (advanced module), advanced curriculum, 1st and 2nd semester</li> <li>Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester</li> <li>Master MES 2014 (advanced module), computer science / electrical engineering, 1st and/or 2nd semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (advanced module), specific, 2nd and/or 3rd semester</li> <li>Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and/or 3rd semester</li> </ul>					
Classes and lectures:		Workload:			
<ul> <li>CS5260SJ14 T: Speech and Audio Signal Processing (lecture with exercises, 3 SWS)</li> <li>CS5275 T: Selected Topics of Signal Analysis and Enhancement (lecture with exercises, 3 SWS)</li> <li>CS5194 T: Lab course (project work, 3 SWS)</li> </ul>		<ul> <li>150 Hours private studies</li> <li>90 Hours in-classroom work</li> <li>60 Hours group work</li> <li>40 Hours exam preparation</li> <li>20 Hours written report</li> </ul>			
Contents of teaching:	······				
<ul> <li>Introduction to statistical signal analysis</li> <li>Principles of feature extraction and pattern recognition</li> <li>Linear optimum filters</li> <li>Adaptive filters</li> <li>Spectrum analysis</li> <li>Basic concepts of multirate signal processing</li> <li>Applications in speech and image processing</li> <li>Realization of signal processing tasks for typical application scenarios in teamwork</li> </ul>					
Oualification-goals/Competencies:					
<ul> <li>Students are able to explain the basic elements of stochastic signal processing and optimum filtering.</li> <li>They are able to describe and apply linear estimation theory.</li> <li>Students are able to describe the concepts of adaptive signal processing.</li> <li>They are able to explain theconcepts of feature extraction and pattern recognition.</li> <li>They are able to analyze and design multirate systems.</li> <li>Students are able to explain various practical applications of signal processing algorithms.</li> <li>They are able to create and implement signal processing systems on their own and in teamwork.</li> </ul>					
Grading through: • Oral examination					
Responsible for this module: • Prof. DrIng. Markus Kallinger Teacher: • Institute for Signal Processing • Prof. DrIng. Markus Kallinger					
Literature:     • : See description of module parts					
Language: • German and English skills required					



#### UNIVERSITÄT ZU LÜBECK

# Module Guide

#### Notes:

Examination prerequisites can be defined at the beginning of the semester. If preliminary work is defined, it must have been completed and positively evaluated before the first examination.

Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s):

- CS4510-L3 (all exept Master Biophysics since 2023): Successful completion of the project assignment, seminar presentation and exercise assignments as specified at the beginning of the semester

- CS4510-L1 (only Master Biophysics since 2023): Successful completion of the exercise assignments as specified at the beginning of the semester

- CS4510-L2 (only Master Biophysics since 2023): Successful completion of the project assignment as specified at the beginning of the semester

Module Exam(s):

- CS4510-L3 (all exept Master Biophysics since 2023): Signal Analysis, oral exam, 100% of module grade

- CS4510-L1 (only Master Biophysics since 2023): partial exam Signal Analyse, oral exam, 100% of module grade
- CS4510-L2 (only Master Biophysics since 2023): partial exam Lab course Signal- and image processing, project, ungraded

(Consists of CS4220 T, CS5275 T, CS5194 T)



CS4511-KP12, CS4511 - Learning Systems (LernSys)				
Duration:	Turnus of offer:		Credit points:	
2 Semester	irregularly		12	
<ul> <li>Course of study, specific field and term:</li> <li>Master Biophysics 2023 (advanced module), advanced curriculum, 1st or 2nd semester</li> <li>Master Computer Science 2019 (optional subject), Canonical Specialization Bioinformatics and Systems Biology, Arbitrary semester</li> <li>Master MES 2020 (advanced module), computer science / electrical engineering, Arbitrary semester</li> <li>Master Computer Science 2019 (optional subject), Canonical Specialization Data Science and Al, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester</li> <li>Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester</li> <li>Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester</li> <li>Master Biophysics 2019 (advanced module), advanced curriculum, 1st and 2nd semester</li> <li>Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester</li> <li>Master MES 2014 (advanced module), computer science / electrical engineering, 1st and 2nd semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (advanced module), specific, 2nd and 3rd semester</li> <li>Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and 3rd semester</li> </ul>				
<ul> <li>Classes and lectures:</li> <li>CS4405 T: Neuro Informatics (lecture with exercises, 3 SWS)</li> <li>CS5450 T: Machine Learning (lecture with exercises, 3 SWS)</li> <li>CS5430 T: Seminar Machine Learning (seminar, 2 SWS)</li> </ul>		<ul> <li>Workload:</li> <li>180 Hours private studies</li> <li>120 Hours in-classroom work</li> <li>40 Hours exam preparation</li> <li>20 Hours work on an individual topic with written and oral presentation</li> </ul>		
Contents of teaching:     e see module parts				
Qualification-goals/Competencies: <ul> <li>see module parts</li> </ul>				
Grading through: • Oral examination				
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. Thomas Martinetz         • Prof. Dr. rer. nat. Thomas Martinetz				
Literature: • : see module parts				
Language: • German and English skills required				
Notes:				


Admission requirements for taking the module: - None

Admission requirements for participation in module examination(s):

- Successful completion of exercises and project tasks as specified at the beginning of the semester.
- Seminar lecture and elaboration according to the requirements at the beginning of the semester.

Module Exam(s):

- CS4511-L1: Learning Systems, oral exam, 100% of module grade.

(Consists of CS4405 T, CS5450 T, CS5430 T)

Only for computer science students with the application subject Bioinformatics, the course CS4405 T Neuroinformatics is replaced by CS5204 T Artificial Intelligence 2, because this group of participants must already complete Neuroinformatics as part of a required module.



CS5194 T -	Module part: Practical Project	in Signal and Image	Processing (PrSigBildv)
Duration:	Turnus of offer:		Credit points:
Semester	every second semester		4 (Тур В)
Course of study, specific field Master Biophysics 2023 Master Computer Science Master MES 2020 (modu Master Entrepreneurship Master Biophysics 2019 Master IT-Security 2019 Master MES 2014 (modu Master Entrepreneurship Master Computer Science	and term: (module part), advanced curriculum, 1 :e 2019 (module part), Module part, A ile part), computer science / electrical o in Digital Technologies 2020 (modul (module part), advanced curriculum, 7 (module part), Module part, 1st or 2nd ile part), computer science / electrical o in Digital Technologies 2014 (modul ce 2014 (module part), Module part, A	1st or 2nd semester rbitrary semester engineering, Arbitrary sem le part), Module part, Arbitr 1st or 2nd semester d semester engineering, 1st or 2nd se le part), Module part, Arbitr rbitrary semester	lester ary semester mester ary semester
Classes and lectures:		Workload:	
iRoom (practical course,	3 SWS)	<ul> <li>60 Hours group</li> <li>40 Hours privat</li> <li>20 Hours writte</li> </ul>	e studies n report
Contents of teaching: • Planning and realization	۱ of typical signal processing applicati	ons in a team	
Qualification-goals/Competer			
<ul> <li>Students will have competent</li> <li>They are able to realize</li> <li>They have the communication</li> </ul>	prehensive knowledge of using signal signal processing systems in teamwor ication competency to document and	and image processing algo rk and in a self-directed ma l present project results.	prithms in practice. nner.
Grading through: • exam type depends on a	main module		
Requires: • Signal processing (CS31 • Image processing (CS32	00-KP04) 03)		
Responsible for this module: • Siehe Hauptmodul			
Teacher:			
Institute for Signal Proce	essing		
<ul><li> Prof. DrIng. Markus Kal</li><li> MitarbeiterInnen des Ir</li></ul>	linger hstituts		
Language: • offered only in German			
Notes:			
(Part of Module CS4510)			
Prerequisites for attending - None	J the module:		
Prerequisites for the exam - The project must be com	: pleted in order to take the exam in th	ne module CS4510	
Modul Exam: - CS4510-L1: Signal Analys	is, oral exam consisting out of Pattern	n Recognition, Selected Top	ics of Signal Analysis and Enhancement ar



L

this project, 100% of module grade



CS5260SJ14 T - Module part: Speech and Audio Signal Processing (SprachA14a)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	normally each year in the	summer semester	4	
<ul> <li>Course of study, specific field and term:</li> <li>Master Computer Science 2019 (module part), Module part, Arbitrary semester</li> <li>Master Biophysics 2023 (module part), advanced curriculum, 1st and 2nd semester</li> <li>Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester</li> <li>Master Biophysics 2019 (module part), advanced curriculum, 1st or 2nd semester</li> <li>Master IT-Security 2019 (module part), Module part, Arbitrary semester</li> <li>Master Computer Science 2014 (Module part of a compulsory module), Module part, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester</li> </ul>				
Classes and lectures:		Workload:		
<ul> <li>Speech and Audio Signal Processing</li> <li>Speech and Audio Signal Processing</li> </ul>	<ul> <li>Speech and Audio Signal Processing (lecture, 2 SWS)</li> <li>Speech and Audio Signal Processing (exercise, 1 SWS)</li> <li>Speech and Audio Signal Processing (exercise, 1 SWS)</li> <li>45 Hours in-classroom work</li> <li>20 Hours exam preparation</li> </ul>			
Contents of teaching:				
<ul> <li>Speech production and human hear</li> <li>Physical models of the auditory Syste</li> <li>Dynamic compression</li> <li>Spectral analysis: Spectrum and Cep</li> <li>Spectral perception and masking</li> <li>Vocal tract models</li> <li>Linear prediction</li> <li>Coding in time and frequency doma</li> <li>Speech synthesis</li> <li>Noise reduction and echo compensa</li> <li>Source localization and spatial repro</li> <li>Basics of automatic speech recogniti</li> </ul>	<ul> <li>Speech production and human hearing</li> <li>Physical models of the auditory System</li> <li>Dynamic compression</li> <li>Spectral analysis: Spectrum and Cepstrum</li> <li>Spectral perception and masking</li> <li>Vocal tract models</li> <li>Linear prediction</li> <li>Coding in time and frequency domains</li> <li>Speech synthesis</li> <li>Noise reduction and echo compensation</li> <li>Source localization and spatial reproduction</li> </ul>			
<ul> <li>Qualification-goals/Competencies:</li> <li>Students are able to describe the ba</li> <li>They are able to describe the proces auditory perception.</li> <li>They are able to present basic knowl</li> <li>They can describe and use signal processional procession.</li> </ul>	<ul> <li>Qualification-goals/Competencies:</li> <li>Students are able to describe the basics of human speech production and the corresponding mathematical models.</li> <li>They are able to describe the process of human auditory perception and the corresponding signal processing tools for mimicing auditory perception.</li> <li>They are able to present basic knowledge of statistical speech modeling and automatic speech recognition.</li> </ul>			
exam type depends on main module				
Responsible for this module: <ul> <li>Siehe Hauptmodul</li> </ul> <li>Teacher: <ul> <li>Institute for Signal Processing</li> <li>Prof. DrIng. Markus Kallinger</li> </ul> </li>				
<ul> <li>Literature:</li> <li>L. Rabiner, BH. Juang: Fundamentals of Speech Recognition - Upper Saddle River: Prentice Hall 1993</li> <li>J. O. Heller, J. L. Hansen, J. G. Proakis: Discrete-Time Processing of Speech Signals - IEEE Press</li> </ul>				
Language: • offered only in German				



#### Notes:

Prerequisites for attending the module: - None

Prerequisites for the exam:

- Successful completion of assignments during the semester.

Module examination(s):

- see superordinate module

(Is modul part of CS4290, CS4510, RO4290-KP04) (Is the same as CS5260SJ14)



CS5275 T - Module par	CS5275 T - Module part: Selected Topics of Signal Analysis and Enhancement (AMSAVa)			
Duration:	Turnus of offer:		Credit points:	
1 Semester	each summer semester		4	
Course of study, specific field and term: Master Robotics and Autonomous Syst Master Biophysics 2023 (module part Master Computer Science 2019 (mod Master MES 2020 (module part), com Master Entrepreneurship in Digital Te Master Biophysics 2019 (module part Master IT-Security 2019 (module part Master Entrepreneurship in Digital Te Master Entrepreneurship in Digital Te Master MES 2014 (module part), com Master Computer Science 2014 (mod	ems 2019 (module part), Mo c), advanced curriculum, 2nd lule part), Module part, Arbi puter science / electrical er echnologies 2020 (module p c), advanced curriculum, 2nd c), Module part, 1st or 2nd s echnologies 2014 (module p puter science / electrical er lule part), Module part, Arbi	dule part Current Issues Rob d semester itrary semester igineering, Arbitrary semes part), Module part, Arbitrar d semester emester part), Module part, Arbitrar igineering, 1st or 2nd seme itrary semester	potics and Automation, 1st and/or 2nd semester ster y semester y semester ester	
Classes and lectures:		Workload:		
<ul> <li>Selected Topics of Signal Analysis an SWS)</li> <li>Selected Topics of Signal Analysis an 1 SWS)</li> </ul>	d Enhancement (lecture, 2 d Enhancement (exercise,	<ul> <li>55 Hours private</li> <li>45 Hours in-classi</li> <li>20 Hours exam private</li> </ul>	studies room work reparation	
Contents of teaching:				
<ul> <li>Linear optimal filters</li> <li>Adaptive filters</li> <li>Multichannel signal processing, bear</li> <li>Compressed sensing</li> <li>Basic concepts of multirate signal processing algorithm</li> <li>Nonlinear signal processing algorithm</li> <li>Application scenarios in auditory tec measurement, noise reduction, deco</li> </ul>	nforming, and source separ ocessing ns hnology, enhancement, and nvolution (listening-room c	ation d restauration of one- and compensation), inpainting	higher-dimensional signals, Sound-field	
Qualification-goals/Competencies:				
<ul> <li>Students are able to explain the basi</li> <li>They are able to describe and apply</li> <li>Students are able to describe the cor</li> <li>They are able to describe and apply</li> <li>They are able to describe the conception</li> <li>They are able to describe the conception</li> <li>They are able to analyze and design</li> <li>Students are able to explain various</li> <li>They are able to create and implement</li> </ul>	c elements of stochastic sig linear estimation theory. ncepts of adaptive signal pr the concepts of multichann of compressed sensing. multirate systems. applications of nonlinear ar nt linear optimum filters an	nal processing and optimu ocessing. el signal processing. nd adaptive signal processi nd nonlinear signal enhanc	um filtering. ng. ement techniques on their own.	
Grading through:				
exam type depends on main module				
Responsible for this module: <ul> <li>Siehe Hauptmodul</li> </ul> Teacher: <ul> <li>Institute for Signal Processing</li> <li>Prof. DrIng. Markus Kallinger</li> </ul>				
Literature:				
• A. Mertins: Signaltheorie: Grundlager	n der Signalbeschreibung, F	ilterbänke, Wavelets, Zeit-	Frequenz-Analyse, Parameter- und	



Signalschätzung - Springer-Vieweg, 3. Auflage, 2013 • S. Haykin: Adaptive Filter Theory - Prentice Hall, 1995
Language:
offered only in German
Notes:
(Part of modules CS4290, CS4510, CS5400, RO4290-KP04, CS5274-KP08) (Is equal to CS5275)
For Details see main module.
Prerequisites for attending the module: - None
Prerequisites for the exam: - Successful completion of homework assignments during the semester (at least 50%).
Modul exam in Main module: - CS5275-L1: Selected Topics of Signal Analysis and Enhancement, written or oral exam, 100% of modul grade



CS5430 T - module part: Seminar Machine Learning (SemMaschLa)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	each summer semes	ster	4	
Course of study, specific field Master Biophysics 2023 Master Computer Scier Master MES 2020 (mod Master Entrepreneursh Master Biophysics 2019 Master IT-Security 2019 Master MES 2014 (mod Master Entrepreneursh Master Computer Scier	d and term: (module part), advanced curriculu (ce 2019 (module part), Module par ule part), computer science / electr ip in Digital Technologies 2020 (mo (module part), advanced curriculu (module part), Module part, 1st or ule part), computer science / electr ip in Digital Technologies 2014 (mo ce 2014 (module part), Module par	m, 2nd semester rt, Arbitrary semester rical engineering, Arbitrary seme odule part), Module part, Arbitra m, 2nd semester 2nd semester rical engineering, 1st or 2nd sem odule part), Module part, Arbitra rt, Arbitrary semester	ester ry semester nester ry semester	
Classes and lectures: • Seminar Machine Learr	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 written and oral presentation			
Contents of teaching: • Independent study of a	a specific field of machine learning			
Qualification-goals/Compete • Students can read and • Students can present t	encies: understand scientific articles in the he contents of scientific articles in t	e field of machine learning. The field of machine learning in a	a talk.	
Grading through: • exam type depends on	main module			
Responsible for this module:         • Siehe Hauptmodul         Teacher:         • Institute for Neuro- and Bioinformatics				
<ul> <li>Prof. DrIng. Ernardt Ba</li> <li>MitarbeiterInnen des I</li> </ul>	nstituts			
<ul><li>Language:</li><li>German and English skills required</li></ul>				
Notes: Admission requirements - None	for the module:			
Admission requirements for the examination: - Examination prerequisites may be defined at the beginning of the semester. If prerequisites are defined, they must have been completed and positively evaluated prior to the initial examination.				
l (Is part of the module CS-	(Is part of the module CS4511)			





	CS5450 T - Module part: Ma	chine Learning (Masch	Lerna)	
Duration:	n: Turnus of offer:		Credit points:	
1 Semester	each winter semester		4	
Course of study, specific field an Master Biophysics 2023 (m Master Computer Science Master MES 2020 (module Master Entrepreneurship i Master Biophysics 2019 (m Master IT-Security 2019 (m Master Entrepreneurship i Master MES 2014 (module Master Computer Science	nd term: nodule part), advanced curriculum, 1 2019 (module part), Module part, Ar part), computer science / electrical of n Digital Technologies 2020 (module nodule part), advanced curriculum, 1 nodule part), Module part, 1st or 2nd n Digital Technologies 2014 (module part), computer science / electrical of 2014 (module part), Module part, Ar	st semester bitrary semester engineering, Arbitrary semeste part), Module part, Arbitrary st semester semester e part), Module part, Arbitrary engineering, 1st or 2nd semes bitrary semester	er semester semester ster	
Classes and lectures:		Workload:		
<ul> <li>Machine Learning (lecture</li> <li>Machine Learning (exercis)</li> </ul>	, 2 SWS) e, 1 SWS)	<ul> <li>55 Hours private st</li> <li>45 Hours in-classro</li> <li>20 Hours exam pre</li> </ul>	udies Jom work aparation	
<ul> <li>Representation learning, i</li> <li>Statistical learning theory</li> <li>VC dimension and suppor</li> <li>Boosting</li> <li>Deep learning</li> <li>Limits of induction and im</li> </ul> Qualification-goals/Competence <ul> <li>Students can understand</li> <li>They can explain and apple</li> <li>They can understand and</li> </ul>	ncluding manifold learning t vector machines portance of data ponderation <b>fes:</b> and explain various machine-learnin y different machine learning metho evaluate an appropriate method for explain the limits of automatic data	g problems. ds and algorithms. a particular learning problem. analysis.		
Grading through: • exam type depends on ma	in module			
Responsible for this module:         • Siehe Hauptmodul         Teacher:         • Institute for Neuro- and Bioinformatics         • Prof. DrIng. Erhardt Barth         • Prof. Dr. rer. nat. Thomas Martinetz				
Literature: • Chris Bishop: Pattern Recognition and Machine Learning - Springer ISBN 0-387-31073-8 • Vladimir Vapnik: Statistical Learning Theory - Wiley-Interscience, ISBN 0471030031 • Tom Mitchell: Machine Learning - McGraw Hill. ISBN 0-07-042807-7				
<ul> <li>Language:</li> <li>English, except in case of only German-speaking participants</li> </ul>				
Notes:				



Admission requirements for taking the module: - None

Admission requirements for participation in module examination(s): - Successful completion of exercise assignments as specified at the beginning of the semester.

Module Exam(s):

- CS5450-L1: Machine Learning, oral exam, 100% of module grade.

(Is part of the module CS4290, CS4511, CS5400, CS4251-KP08)



LS4031-KP12 - Zell- und mo	lekularbiologische Pat	homechanismen un	d Therapieansätze (ZMolPath)
Duration:	Turnus of offer:		Credit points:
2 Semester	starts every winter semester		12
Course of study, specific field and term: • Master Biophysics 2023 (advanced • Master Biophysics 2019 (advanced Classes and lectures:	module), advanced curriculu module), advanced curriculu	m, 1st or 2nd semester m, 1st and 2nd semester Workload:	
<ul> <li>Pharmakologie und Toxikologie (= LS4110 A) (lecture, 2 SWS)</li> <li>Drug Design (= LS4110 B) (lecture, 2 SWS)</li> <li>Cell Biology (= LS4010 A) (lecture, 2 SWS)</li> <li>General virology and biosafety (= LS4040) (lecture, 2 SWS)</li> </ul>		<ul> <li>240 Hours privat</li> <li>120 Hours in-cla</li> </ul>	te studies ssroom work
Contents of teaching: Similar to LS4110A, LS4110B, LS401 Pharmacodynamic Pharmacokinetics Oral Antidiabetics Pharmacology of the Renin-Angiota Cerebrovascular Pharmacology Reverse Pharmacology Pharmacology of the Blood-Brain-B Anxiolytics, Hypnotics and Sedative Antiepileptic Drugs Gene Therapy of neurological disea Pain physiology and analgetic thera Concepts in Drug Design NMR experiments for Drug Design Case Study: Omeprazole vs. Tamiflu Chemical Synthesis of Drugs - Com Drug Discovery - An Overview Target Identification and Validation X-ray Crystallography in Drug Desig Structure-based drug design - Princ Secretion in pro- and eukaryotes Structure, function biogenesis and Cellular fusion, cytokinesis and orga RNA-metabolism History of virology Virus taxonomy and structure Virus morphology in overview Viral life cycles (entry, assembly, bu Replication mechanisms Viral evolution Basic techniques in virology and me Blood-borne viruses and safety of the Biosafety classification of viruses ac Pharmacology of Thyroid Homones Serendipity in the age of rational d	0A, LS4040:Introduction into ensin-Aldosterone-System arrier ess apies binatorial Approaches in gn ciples and Methods stasis of membraneouse con anellar inheritence dding) ethods of virus diagnostics blood products cording to Gentechnikrech is rug design: a case study	p Pharmacology npartments of eukaryotes t and Biostoffverordnur	
Qualification-goals/Competencies:			
<ul> <li>Similar to the moduls LS4110A, LS4 organism (Pharmacodynamics).</li> <li>The are able to explain the time content of the time con</li></ul>	110B, LS4010A, LS4040:Stud	ents are able to explain th	ne effects of therapeutic drugs on the m (Pharmacokinetics).

- The are able to explain the mechanisms of action of various substance classes.
- The are able to explain the experimental methods in pharmacology
- The are able to explain the basic strategies of Drug Design.



- The are able to explain the the way from the target discovery to the drug. Techniques of rational Drug Design
- The are able to explain the the relationship between chemical structure and effect and the techniques for theoretical prognosis and experimental tests, particular x-ray crystallography and NMR-experiments
- The students should explain the borders of x-ray crystallography and NMR-experiments.
- Ability to link the newly communicated detailed cell biology knowledge with the already acquired knowledge and to apply it in the context of other modules.
- Ability, to recognize the connection between the cell biology of hosts and the molecular strategies of viral and other microbiological parasites.
- They can categorize viruses systematically.
- They can explain and compare viral life cycles and replication strategies.
- They can list basic practices and protocols for the virological safety of blood products.
- They can apply basics knowledge according to Gentechnikrecht and Biostoffverordnung .

#### Grading through:

• written exam

#### Responsible for this module:

- Prof. Dr. rer. nat. Enno Hartmann
- Prof. Dr. rer. nat. Thomas Peters

#### Teacher:

- Institute of Virology and Cell Biology
- Institute for Biology
- Institute of Chemistry and Metabolomics
- Institute of Experimental and Clinical Pharmacology and Toxicology
- Institute of Molecular Medicine
- Institute of Biochemistry
- Prof. Dr. rer. nat. Thomas Peters
- Prof. Dr. rer. nat. Olaf Jöhren
- Dr. rer. nat. Jan Wenzel
- Prof. Dr. rer. nat. Tobias Restle
- Prof. Dr. rer. nat. Rolf Hilgenfeld
- Prof. Dr. med. Markus Schwaninger
- Dr. med. Dirk Ridder
- Prof. Dr. rer. nat. Walter Raasch
- Prof. Dr. rer. nat. Norbert Tautz
- Dr. rer. nat. Olaf Isken
- Prof. Dr. rer. nat. Enno Hartmann
- Prof. Dr. rer. medic. Lisa Marshall
- Dr. rer. nat. Dipl.-Psych. Sonja Binder
- Prof. Dr. rer. nat. Enrico Leipold
- Dr. rer. nat. Marietta Zille
- Dr.rer.nat Sonja Petkovic
- Prof. Dr. Lars Redecke
- Dr. math. et dis. nat. Jeroen Mesters
- Dr. rer. hum. biol. Helge Müller-Fielitz
- Literature:
  - Brunton L, Knollmann B: Goodman & Gilman's The Pharmacologic Basis of Therapeutics McGraw-Hill Education; 14. Edition (1. November 2022) ISBN-10: 1264258070
  - Lüllmann H, Mohr K, Hein L, Ziegler A, Bieger D: Color Atlas of Pharmacology Thieme; 5. Edition (15. November 2017) ISBN-10: 9783132410657
  - G. Klebe: Wirkstoffdesign Spektrum-Verlag Heidelberg, 2009. ISBN 978-3-8274-2046-6
  - A. Hillisch & R. Hilgenfeld, Birkhäuser: Modern Methods in Drug Discovery Basel, Boston, Berlin 2003, ISBN 3-7643-6081-X
  - : Grundlagen- und Übersichtsartikel für beide Veranstaltungen
  - Lodish: Molecular Cell Biology
  - Alberts: Molecular Biology of the Cell
  - S.J. Flint et al.: Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses American Society Microbiology, February 2009, 3rd Ed., ISBN: 978-1-55581-443-4



#### Language:

offered only in English

#### Notes:

Similar to LS4110 A, LS4110 B, LS4010 A und LS4040-KP04 without practical course

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MA4030 T - Module part: Optimization (OptiT)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	each summer semester		8		
Course of study, specific field and term: • Master Biophysics 2023 (module pa • Master MES 2020 (module part), ma • Master Biophysics 2019 (module pa • Master MES 2014 (module part), ma	rt), advanced curriculum, 2n thematics / natural sciences rt), advanced curriculum, 2n thematics / natural sciences	nd semester 5, Arbitrary semester nd semester 5, 2nd semester			
Classes and lectures:		Workload:			
<ul> <li>Optimization (lecture, 4 SWS)</li> <li>Optimization (exercise, 2 SWS)</li> </ul>		<ul> <li>130 Hours private</li> <li>90 Hours in-class</li> <li>20 Hours exam p</li> </ul>	e studies and exercises sroom work preparation		
Contents of teaching:					
<ul> <li>Linear optimization (simplex method)</li> <li>Unconstrained nonlinear optimization</li> <li>Equality- and inquality-constrained</li> <li>Stochastic methods for machine learning</li> </ul>	d) on (gradient descent, conju nonlinear optimization (Lag ırning	gate gradients, Newton me grange multipliers, active se	ethod, Quasi-Newton methods, globalization) et methods)		
Qualification-goals/Competencies:         • Students can model real-life problems as optimization problems.         • They understand central optimization techniques.         • They can explain central optimization techniques.         • They can compare and assess central optimization techniques.         • They can implement central optimization techniques.         • They can superior central optimization techniques.         • They can sasess numerical results.         • They can select suitable optimization techniques for practical problems.         • Interdisciplinary qualifications:         • Students can transfer theoretical concepts into practical solutions.         • They are experienced in implementation.         • They can think abstractly about practical problems.         • Grading through:         • exam type depends on main module					
Is requisite for: • Non-smooth Optimization and Analysis (MA5035-KP05)					
Requires: • Linear Algebra and Discrete Structu • Analysis 2 (MA2500-KP04, MA2500)	Requires: • Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500) • Analysis 2 (MA2500-KP04, MA2500)				
Responsible for this module:         • Siehe Hauptmodul         Teacher:         • Institute of Mathematics and Image Computing         • Prof. Dr. rer. nat. Jan Modersitzki         • Prof. Dr. rer. nat. Jan Lellmann					
Literature: • J. Nocedal, S. Wright: Numerical Optimization - Springer • F. Jarre: Optimierung - Springer • C. Geiger: Theorie und Numerik restringierter Optimierungsaufgaben - Springer					



#### Language:

#### • offered only in German

#### Notes:

(Sub-module of MA4310)

Prerequisites for attending the module:

- None (Familiarity with the topics of the required modules is assumed, but the modules are not a formal prerequisite for attending the course).

Prerequisites for the exam:

- Preliminary examinations can be determined at the beginning of the semester. If preliminary work has been defined, it must have been completed and positively assessed before the first examination.



Duration:	<b>Turnus of offer:</b> starts every winter semester		Credit points:
2 Semester			12
Course of study, specific field and term: • Master MES 2020 (advanced modul • Master Biophysics 2019 (advanced • Master MES 2014 (advanced modul • Master Biophysics 2023 (advanced modul	e), mathematics / natural scio module), advanced curriculu e), mathematics / natural scio module), advanced curriculu	ences, Arbitrary semester m, 1st and 2nd semester ences, 1st and 2nd semes m, 1st or 2nd semester	iter
<ul> <li>Classes and lectures:</li> <li>MA4330 T: Module part: Biosignalar SWS)</li> <li>MA4450 T: Module part: Modellieru ECTS) (course, 4 SWS)</li> </ul>	Workload:Ilyse (4ECTS) (course, 3• 225 Hours private studies and exercisesg Biologischer Systeme (8• 105 Hours in-classroom work• 30 Hours exam preparation		te studies and exercises assroom work preparation
Contents of teaching: • see description of module parts			
Qualification-goals/Competencies: <ul> <li>see description of module parts</li> </ul>			
Grading through: • Oral examination			
<ul> <li>Responsible for this module:</li> <li>Nachfolge von Prof. Dr. rer. nat. Kar</li> <li>Teacher: <ul> <li>Institute for Mathematics</li> <li>Nachfolge von Prof. Dr. rer. nat. Kar</li> <li>Prof. Dr. rer. nat. Jürgen Prestin</li> </ul> </li> </ul>	sten Keller sten Keller		
Literature: • see literature of module parts:			
Language: • offered only in German			
Notes: Prerequisites for attending the modul - None Prerequisites for the exam:	e:		



MA4310-KP12, MA4310 - Numerical Optimization (NumOpt)				
Duration:	Turnus of offer:	Credit points:		
1 Semester	each summer semester	12		
Course of study, specific f	field and term:			
<ul> <li>Master MES 2020 (a</li> <li>Master Biophysics 2</li> <li>Master MES 2014 (a</li> <li>Master Biophysics 2</li> </ul>	dvanced module), mathematics / natural s 019 (advanced module), advanced curricu dvanced module), mathematics / natural s 2023 (advanced module), advanced curricu	ciences, Arbitrary semester lum, 2nd semester ciences, 2nd semester lum, 2nd semester		
Classes and lectures:		Workload:		
<ul> <li>MA4030 T: Module</li> <li>MA5034 T: Module Differential Equatio</li> <li>MA5032 T: Module Computing (4ECTS)</li> <li>MA4030 T: Module</li> </ul>	part: Optimization (lecture, 4 SWS) part: Calculus of Variations and Partial ns (4ECTS) (course, 3 SWS) part: Numerical Methods for Image (course, 3 SWS) part: Optimization (exercise, 2 SWS)	<ul> <li>195 Hours private studies and exercises</li> <li>135 Hours in-classroom work</li> <li>30 Hours exam preparation</li> </ul>		
Contents of teaching: • as stated in module	e parts			
Qualification-goals/Comp • as stated in module	petencies: 9 parts			
Grading through: • Written or oral exan	n as announced by the examiner			
Responsible for this mod	ule:			
• Prof. Dr. rer. nat. Jar	n Modersitzki			
Teacher:				
<ul> <li>Institute of Mathem</li> </ul>	natics and Image Computing			
<ul><li> Prof. Dr. rer. nat. Jar</li><li> Prof. Dr. rer. nat. Jar</li></ul>	ו Modersitzki ו Lellmann			
Literature:				
<ul> <li>as stated in module</li> </ul>	e parts:			
Language:				
German and English	n skills required			
Notes:				
The module MA4310: MA5034: Calculus of \	Numerical Optimization consists of the mo /ariations and Partial Differential Equations	odule MA4030: Optimization and annually alternating of the module s or the module MA5032: Numerical Methods for Image Computing.		
Prerequisites for atter - None	iding the module:			
Prerequisites for the e	exam:			

- The module includes an oral examination with duration and scope according to PVO. Exercises and presentation are preliminary examinations.





	MA4330 T - Module part:	Biosignal analysis (BioSAT)
Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4
Course of study, specific field • Master Biophysics 2023 ( • Master MES 2020 (modu • Master Biophysics 2019 ( • Master MES 2014 (modu	and term: module part), advanced curriculum, 2n le part), mathematics / natural sciences module part), advanced curriculum, 2n le part), mathematics / natural sciences	d semester , Arbitrary semester ,d semester , 2nd semester
Classes and lectures:		Workload
Biosignal analysis (lecture, 2 SWS)     Biosignal analysis (exercise, 1 SWS)     Biosignal analysis (exercise, 1 SWS)     Compared by the second		
Contents of teaching: • Hilbert spaces • Fourier series and Fourie • generalized functions • discrete wavelet tranforr • least square techniques • application to biological	er transformation nation and medical data	
Qualification-goals/Competen • Students have deepened • They master different m • They have practical skills • They have skills in worki	i <b>cies:</b> I knowledges of the mathematical back ethods of one-dimensional signal analy s in the application of these methods ng with Mathematica or MatLab	kground of signal analysis rsis
Grading through:		
exam type depends on r	nain module	
Requires:		
• Analysis 2 (MA2500-KP04	4, MA2500)	
Responsible for this module:		
Siehe Hauptmodul		
I eacher:     Institute for Mathematic	5	
<ul> <li>Nachfolge von Prof. Dr. r</li> <li>Prof. Dr. rer. nat. Jürgen</li> </ul>	er. nat. Karsten Keller Prestin	
Literature:		
<ul> <li>S. Mallat: A wavelet tour</li> <li>A. N. Kolmogorov, S.V. Fe</li> </ul>	of signal processing - Academic Press, omin: Reelle Funktionen und Funktiona	1998 Ilanalysis - Deutscher Verlag der Wissenschaften 1975
Language: • offered only in German		
Notes:		
Prerequisites for attending - None (The competences	the module: of the required modules are required fo	or this module, but the modules are not a prerequisite for admission
Prerequisites for the exam: - Preliminary examinations	can be determined at the beginning o	f the semester. If preliminary work has been defined, it must have b



completed and positively assessed before the initial examination.



MA4450 1	- Module part: Mode	ling Biological System	ms (MoBST)	
Duration:	Turnus of offer:		Credit points:	
1 Semester	each winter semester		8	
Course of study, specific field and term: • Master Biophysics 2023 (module par • Master MES 2020 (module part), ma • Master Biophysics 2019 (module part) • Master MES 2014 (module part), ma	rt), advanced curriculum, 1s thematics / natural science: rt), advanced curriculum, 1s thematics / natural science:	st semester s, Arbitrary semester st semester s, 1st semester		
Classes and lectures:		Workload:		
<ul> <li>Modeling Biological Systems (lectur</li> <li>Modeling Biological Systems (exerci</li> </ul>	<ul> <li>Modeling Biological Systems (lecture, 2 SWS)</li> <li>Modeling Biological Systems (exercise, 2 SWS)</li> </ul>			
Contents of teaching:				
<ul> <li>Elementary time-discrete determinis</li> <li>Structured time-discrete population</li> <li>Generating functions, Galton-Watso</li> <li>Modeling of data and data analysis</li> </ul>	stic models dynamics n processes			
Qualification-goals/Competencies:				
<ul> <li>Students have knowledge of element</li> <li>They develop skills in connecting id</li> <li>They have competencies in data and</li> <li>They develop competencies in inter</li> </ul>	ntary time-discrete models eas from different fields of alysis and modelling disciplinary work	for modeling biological pro mathematics	ocesses	
Grading through:				
<ul><li>Exercises</li><li>exam type depends on main modul</li></ul>	e			
Requires: • Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500) • Stochastics 1 (MA2510-KP04, MA2510) • Analysis 2 (MA2500-MML)				
Responsible for this module:				
Siene Hauptmodul     Teacher:				
Institute for Mathematics				
Nachfolge von Prof. Dr. rer. nat. Karsten Keller				
Literature:				
<ul> <li>F. Braer, C. Castillo-Chavez: Mathematical Models in Population Biology - New York: Springer 2000</li> <li>H. Caswell: Matrix Population Models - Sunderland: Sinauer Associates 2001</li> <li>S. N. Elaydi: An Introduction to Difference Equations - New York: Springer 1999</li> <li>B. Huppert: Angewandte Lineare Algebra - Berlin: de Gruyter 1990</li> <li>U. Krengel: Einführung in die Wahrscheinlichkeitstheorie und Statistik - Wiesbaden: Vieweg 2002</li> <li>E. Seneta: Non-negative Matrices and Markov Chains - New York: Springer 1981</li> </ul>				
<ul> <li>Language:</li> <li>• offered only in German</li> </ul>				
Notes:				
NO(C).				



The lecture is identical to that in module MA4450.

Prerequisites for attending the module:

- None (The competences of the required modules are required for this module, but the modules are not a prerequisite for admission.)

Prerequisites for the exam:

- Preliminary examinations can be determined at the beginning of the semester. If preliminary work has been defined, it must have been completed and positively assessed before the initial examination.



MA5032 T - Module part: Numerical Met	thods for Image	Computing (NumerikBVT)	
Duration: Turnus of offer:		Credit points:	
1 Semester every second summer se	every second summer semester		
<ul> <li>Course of study, specific field and term:</li> <li>Master Biophysics 2023 (module part), advanced curriculum, 21</li> <li>Master MES 2020 (module part), mathematics / natural science</li> <li>Master Biophysics 2019 (module part), advanced curriculum, 21</li> <li>Master MES 2014 (module part), mathematics / natural science</li> </ul>	nd semester es, Arbitrary semester nd semester es, 2nd semester		
Classes and lectures:	Workload:	winete studies and superiors	
<ul> <li>Numerical Methods for Image Computing (lecture, 2 SWS)</li> <li>Numerical Methods for Image Computing (exercise, 1 SWS)</li> </ul>	Is for Image Computing (lecture, 2 SWS)• 65 Hours private studies and exercisesIs for Image Computing (exercise, 1 SWS)• 45 Hours in-classroom work• 10 Hours exam preparation		
Contents of teaching:			
<ul> <li>Operators in spatial and frequency domain</li> <li>Discrete Fourier Transform/FFT und Anwendungen</li> <li>JPEG</li> <li>Poisson equation and finite differences discretization</li> <li>Splitting methods</li> <li>Multigrid methods</li> </ul> Qualification-goals/Competencies: <ul> <li>The students are familiar with fundamental numerical concept</li> <li>They have experience in realizing practical solutions.</li> <li>They can implement numerical algorithms on a computer.</li> <li>They understand selected methods for solving large linear syst</li> <li>They can implement selected methods for solving large linear</li> <li>Interdisciplinary qualifications:</li> <li>Students have advanced skills in modeling.</li> </ul>	ts in image computin tems. systems. s.	g.	
<ul> <li>They are experienced in implementation.</li> <li>They can think abstractly about practical problems.</li> </ul>			
• They can think abstractly about practical problems.			
<ul><li>Grading through:</li><li>exam type depends on main module</li></ul>			
Responsible for this module:			
Siehe Hauptmodul			
Teacher:			
<ul> <li>Institute of Mathematics and Image Computing</li> </ul>			
<ul><li>Prof. Dr. rer. nat. Jan Modersitzki</li><li>Prof. Dr. rer. nat. Jan Lellmann</li></ul>			
<ul><li>Language:</li><li>German and English skills required</li></ul>			
Notes:			



#### (Sub-module of MA4310)

#### Prerequisites for attending the module:

- None (Familiarity with the topics of the required modules is assumed, but the modules are not a formal prerequisite for attending the course).

#### Prerequisites for the exam:

- Preliminary examinations can be determined at the beginning of the semester. If preliminary work has been defined, it must have been completed and positively assessed before the first examination.



MA5034 T - Module pa	rt: Calculus of Variations	s and Partial Differe	ntial Equations (VariPDET	Г)
Duration:	Turnus of offer:		Credit points:	
1 Semester	every second summer semester		4	
Course of study, specific field and term • Master Biophysics 2023 (module p • Master MES 2020 (module part), r • Master Biophysics 2019 (module p • Master MES 2014 (module part), r	n: part), advanced curriculum, 2nc nathematics / natural sciences, part), advanced curriculum, 2nc nathematics / natural sciences,	l semester Arbitrary semester d semester 2nd semester		
Classes and lectures:Workload:• Calculus of Variations and Partial Differential Equations (lecture, 2 SWS)• 65 Hours pr • 45 Hours in • 10 Hours ex (exercise, 1 SWS)		Workload: • 65 Hours private • 45 Hours in-clas • 10 Hours exam	studies and exercises sroom work preparation	
Contents of teaching: Motivation and application exam Functional-analytic foundations Direct methods in the calculus of The dual space, weak convergence Optimality conditions Classification of partial differentia Fundamental solutions, maximum Finite elements for elliptical partial	ples variations ce, Sobolev spaces Il equations and typical PDEs n principle al differential equations			
Qualification-goals/Competencies: Students understand variational r They are able to formulate basic r They understand the connections They can derive optimality condit They understand the mathematic They can implement selected fun They can formulate selected prac Interdisciplinary qualifications: Students have advanced skills in They can translate theoretical cor They are experienced in impleme They can think abstractly about p	modeling. ohysical problems in a variation s between variational methods tions for energy functionals. cal theory behind selected varia damental variational problems tical problems in the variationa modeling. neepts into practical solutions. entation. practical problems.	nal setting. and partial differential eq tional problems. I setting.	juations.	
Grading through: • exam type depends on main mod Responsible for this module: • Siehe Hauptmodul Teacher: • Institute of Mathematics and Imag • Prof. Dr. rer. nat. Jan Modersitzki • Prof. Dr. rer. nat. Jan Lellmann	lule ge Computing			
Literature: • Vogel: Computational Methods for • Aubert, Kornprobst: Mathematica • Scherzer, Grasmair, Grossauer, Ha	or Inverse Methods - SIAM I Problems in Image Processing Itmeier, Lenzen: Variational Me	g: Partial Differential Equa thods in Imaging - Sprin	tions and the Calculus of Variati ger	ons - Springer
Language:				



#### German and English skills required

#### Notes:

#### (Sub-module of MA4310)

Prerequisites for attending the module:

- None (Familiarity with the topics of the required modules is assumed, but the modules are not a formal prerequisite for attending the course).

Prerequisites for the exam:

- Preliminary examinations can be determined at the beginning of the semester. If preliminary work has been defined, it must have been completed and positively assessed before the first examination.





MZ4110-KP12 - Neurowissenschaften (Neuro)			
Duration:	Turnus of offer:		Credit points:
2 Semester	starts every winter semester		12
Course of study, specific field and term: • Master Biophysics 2023 (advanced n • Master Biophysics 2019 (advanced n	nodule), advanced curriculu nodule), advanced curriculu	m, 1st and 2nd semester m, 1st and 2nd semester	
Classes and lectures: • Neuroscience 1 (lecture, 2 SWS) • Neuroscience 1 (seminar, 2 SWS) • Neurowissenschaften 2 (lecture, 2 SWS) • Neurowissenschaften 2 (seminar, 2 SWS)		<ul> <li>Workload:</li> <li>240 Hours private studies</li> <li>120 Hours in-classroom work</li> </ul>	
<ul> <li>Neurowissenschaften 2 (seminar, 2 SWS)</li> <li>Contents of teaching: <ul> <li>Electrical activity of neurons</li> <li>Electrical activity of neurons</li> <li>Channels and transporters in neurons</li> <li>Synaptic transmission</li> <li>Neurotransmitters and their receptors</li> <li>Intracellular signaling in neurons</li> <li>Plasticity and memory</li> <li>Circadian rhythms and sleep</li> <li>The visual system</li> <li>Development of the nervous system</li> <li>Alzheimer's disease</li> <li>Infections of the CNS</li> <li>Neural stem cells and neurodegenerative disease</li> <li>Neurobiology of cerebral ischemia</li> <li>Brain channelopathies: epilepsy and ataxia</li> <li>Neurogenetic disorders</li> <li>Neurometabolic disorders</li> <li>Neurometabolic disorders</li> <li>Neurometabolic disorders</li> <li>Neuropathies</li> <li>Molecular basis of Parkinson disease and other movement disorders</li> </ul> </li> </ul>			
Qualification-goals/Competencies:         • Similar to moduls MZ4115 und MZ4125:Understanding basics of neuroscience         • Understanding the structure and development of the brain         • Understanding neuronal excitation and signal transmission         • Introduction to examples of behavior and plasticity         • Introduction to neuronal stem cells         • Introduction to various neuropathological diseases         • Understanding molecular mechanisms of neuropathological diseases         • Written exam			
Responsible for this module: • Prof. Dr. rer. nat. Olaf Jöhren Teacher: • Department of Neurology • Medical Clinic I			

- Department of Neurosurgery
- Institut of Physiology



- Institute of Experimental and Clinical Pharmacology and Toxicology
- Prof. Dr. rer. nat. Olaf Jöhren
- Prof. Dr. med. Cor de Wit
- Prof. Dr. rer. nat. Henrik Oster
- Prof. Dr. med. Markus Schwaninger
- PD Dr. rer. nat. Christina Zechel
- Prof. Dr. rer. nat. Katja Lohmann
- PD Dr. Sc. Ana Westenberger
- Prof. Dr. rer. nat. Enrico Leipold
- Dr. rer. nat. Markus Krohn

#### Literature:

- Nicholls: From Neuron to Brain: A Cellular and Molecular Approach to the Function of the Nervous System ISBN-10: 0878936092, 679 Seiten, Palgrave Macmillan; 5th edition (2012
- Purves D, Augustine G, Fitzpatrick D, Hall W, LaMantia A: Neuroscience Oxford University Press; 6. Edition (25. September 2018) -ISBN-10: 160535841X
- Brady: Basic Neurochemistry: Principles of Molecular, Cellular, and Medical Neurobiology ISBN-10: 0123749476, 1096 Seiten, Academic Press; 8th Edition (2011)
- : Original publications and Reviews

• Purves: Neuroscience - ISBN-10: 0878936955, Palgrave Macmillan; 5th edition. (2011)

#### Language:

- offered only in German
- onered only in German

#### Notes:

Similar to MZ5115 and MZ4125



CS3010-KP04, CS3010 - Human-Computer-Interaction (MCI)				
Duration:	Turnus of offer: Cr		Credit points:	
1 Semester	each winter semester 4		4	
1 Semester       each winter semester       4         Course of study, specific field and term:         • Master Entrepreneurship in Digital Technologies 2020 (optional subject), interdisciplinary competence, Arbitrary semester         • Bachelor Computer Science 2019 (compulsory), foundations of computer science, 5th semester         • Bachelor Robotics and Autonomous Systems 2020 (optional subject), computer science, 5th or 6th semester         • Bachelor Medical Informatics 2019 (optional subject), computer science, 4th to 6th semester         • Master Biophysics 2019 (optional subject), Elective, 1st semester         • Master Psychology 2016 (optional subject), interdisciplinary competence, 3rd semester at the earliest         • Bachelor Computer Science 2016 (compulsory), foundations of computer science, 5th semester         • Bachelor IT-Security 2016 (compulsory), computer science, 3rd semester         • Bachelor Robotics and Autonomous Systems 2016 (optional subject), interdisciplinary computer science, 5th or 6th semester         • Bachelor Robotics and Autonomous Systems 2016 (optional subject), interdisciplinary computer science, 5th or 6th semester         • Bachelor Robotics and Autonomous Systems 2016 (optional subject), interdisciplinary computer science, 5th or 6th semester         • Bachelor Robotics and Autonomous Systems 2016 (optional subject), interdisciplinary competence, Arbitrary semester         • Bachelor Robotics and Autonomous Systems 2016 (optional subject), interdisciplinary competence, 8th semester         • Bachelor Robotics and Autonomo				
Classes and lectures:		Workload:		
<ul> <li>Human-Computer-Interaction (lecture)</li> <li>Human-Computer-Interaction (exercised)</li> </ul>	Iteraction (lecture, 2 SWS)• 55 Hours private studiesIteraction (exercise, 1 SWS)• 45 Hours in-classroom work• 20 Hours exam preparation		studies room work reparation	
Contents of teaching:				
<ul> <li>Introduction and overview of the topic area</li> <li>Norms and legal foundations</li> <li>Human information processing and processes of actions</li> <li>Models for human-computer systems and interactive media</li> <li>Input/Output devices and interaction technologies</li> <li>User-centered development process and special groups of users</li> <li>Usability Engineering</li> <li>System paradigms and corresponding system examples</li> <li>Evaluation and impact analyzes</li> <li>Innovative concepts and systems</li> </ul>				
Qualification-goals/Competencies:				
<ul> <li>The students know the principles and methods of the context-, task- and user-centered development of interactive systems.</li> <li>They have basic knowledge about human information processing and can introduce it into the design process.</li> <li>They know the basic models of interactive systems und can apply them for their analysis and evaluation.</li> <li>They have the ability to analyze and review interative systems based on criteria.</li> </ul>				
Grading through:  • written exam				
Responsible for this module:				
Prof. DrIng. Nicole Jochems				
Teacher:     Institute for Multimedia and Interactive Systems				
Prof. DrIng. Nicole Jochems				
<ul> <li>Literature:</li> <li>M. Dahm: Grundlagen der Mensch-Computer-Interaktion - Pearson Studium, 2006</li> <li>J.A. Jacko: The Human-Computer Interaction Handbook - CRC Press, 2012</li> </ul>				



#### Language:

#### • offered only in German

#### Notes:

Prerequisites for attending the module: - None

Prerequisites for the exam:

- Successful completion of homework assignments as stated in the beginning of the course

Exam(s):

- CS3010-L1 Mensch-Computer-Interaktion, Klausur, 90min, 100% der Modulnote



CS4250-KP04, CS4250 - Computer Vision (CompVision)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	each summer semester		4	
1 Semester       each summer semester       4         Course of study, specific field and term:         • Master CLS 2023 (optional subject), computer science, 2nd or 3rd semester         • Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester         • Master Computer Science 2019 (optional subject), Elective, Arbitrary semester         • Master Media Informatics 2020 (optional subject), Elective, Arbitrary semester         • Master Biophysics 2019 (optional subject), Computer science, Arbitrary semester         • Master Biomedical Engineering (optional subject), advanced curriculum, 2nd semester         • Master MES 2016 (optional subject), computer science, 2nd or 3rd semester         • Master MES 2014 (optional subject), computer science, Arbitrary semester         • Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester         • Master Computer Science 2012 (optional subject), computer science, Arbitrary semester         • Master Computer Science 2012 (optional subject), advanced curriculum imaging systems, 2nd or 3rd semester         • Master Computer Science 2012 (optional subject), advanced curriculum signal and image processing, 2nd or 3rd semester         • Master MES 2011 (advanced curriculum), imaging systems, signal and image processing, 2nd or 3rd semester         • Master Computer Science 2012 (optional subject), advanced curriculum signal and image processing, 2nd or 3rd semester         • Master Computer Science 2012 (optional subject), advanced curri				
Classes and lectures:		Workload:		
<ul> <li>Computer Vision (lecture, 2 SWS)</li> <li>Computer Vision (exercise, 1 SWS)</li> <li>Structure</li> <li>55 Hours private studies</li> <li>45 Hours in-classroom work</li> <li>20 Hours exam preparation</li> </ul>		studies room work reparation		
Contents of teaching: <ul> <li>Introduction to human and computer vision</li> <li>Sensors, cameras, optics and projections</li> <li>Image features: edges, intrinsic dimension, Hough transform, Fourier descriptors, snakes</li> <li>Range imaging and 3-D cameras</li> <li>Motion and optical flow</li> <li>Object recognition</li> <li>Example applications</li> </ul>				
<ul> <li>Qualification-goals/Competencies:</li> <li>Students can understand the basics of computer vision.</li> <li>They can explain and perform camera choice and calibration.</li> <li>They can explain and apply the basic methods for feature extraction, motion estimation, and object recognition.</li> <li>They can indicate appropriate methods for different kinds of computer-vision applications.</li> </ul>				
Grading through:     Oral examination				
Responsible for this module:         • Prof. DrIng. Erhardt Barth         Teacher:         • Institute for Neuro- and Bioinformatics         • Prof. DrIng. Erhardt Barth				
<ul> <li>Literature:         <ul> <li>Richard Szeliski: Computer Vision: Algorithms and Applications - Springer, Boston, 2011</li> <li>David Forsyth and Jean Ponce: Computer Vision: A Modern Approach - Prentice Hall. 2003</li> </ul> </li> </ul>				
Language:				



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CS4270-KP04, CS4270 - Medical Robotics (MedRob)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	each summer semester		4	
<ul> <li>Course of study, specific field and term:</li> <li>Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester</li> <li>Master Biophysics 2019 (optional subject), Elective, 2nd semester</li> <li>Master MES 2014 (optional subject), computer science / electrical engineering, Arbitrary semester</li> <li>Master Biomedical Engineering (optional subject), Interdisciplinary modules, 2nd semester</li> <li>Master Computer Science 2012 (optional subject), advanced curriculum imaging systems, 2nd or 3rd semester</li> <li>Master MES 2011 (advanced curriculum), imaging systems, signal and image processing, 2nd or 3rd semester</li> <li>Master Computer Science 2012 (compulsory), specialization field robotics and automation, 2nd semester</li> <li>Master Computer Science 2012 (optional subject) specialization field medical informatics, 2nd or 3rd semester</li> </ul>				
Classes and lectures:	Work	load:		
<ul> <li>Medical Robotics (lecture, 2 SWS)</li> <li>Medical Robotics (exercise, 1 SWS)</li> </ul>	<ul> <li>re, 2 SWS)</li> <li>ise, 1 SWS)</li> <li>55 Hours private studies</li> <li>45 Hours in-classroom work</li> <li>20 Hours exam preparation</li> </ul>		studies sroom work preparation	
Contents of teaching:				
<ul> <li>Qualification-goals/Competencies:</li> <li>Students are able to explain the concepts of forward and inverse kinematics for the examples of 3-joint and 6-joint robots.</li> <li>They are able to apply methods of medical robot systems and to simple practical applications.</li> <li>Students are able to transfer methods of motion learning to simple practical problems.</li> <li>Students are able to modify templates for dynamic calculations in order to create the calculations for their own constructions.</li> </ul>				
Grading through:     Oral examination				
Responsible for this module:         • Prof. DrIng. Achim Schweikard         Teacher:         • Institute for Robotics and Cognitive Systems         • Prof. DrIng. Achim Schweikard				
<ul> <li>Literature:</li> <li>JC. Latombe: Robot Motion Planning - Dordrecht: Kluwer 1990</li> <li>J.J. Craig: Introduction to Robotics - Pearson Prentice Hall 2002</li> <li>: lecture notes (400 pages full text)</li> </ul>				
Language: • offered only in English				
Notes:         Admission requirements for taking the module:         - None         Admission requirements for participation in module examination(s):         - Successful completion of exercise assignments as specified at the beginning of the semester				
Module Exam(s): - CS4270-L1: Medical Robotics, written exam, 90min, 100% of the module grade				



	CS5204-KP04, CS5204 -	Artificial Intellige	ence 2 (KI2)
Duration:	Turnus of offer:		Credit points:
1 Semester	each winter semester		4
Course of study, specific fie Master MES 2020 (opt Master Robotics and A Master Biophysics 201 Master MES 2014 (opt Master CLS 2016 (opti Master Computer Scie Master Computer Scie	Id and term: ional subject), computer science / elect Autonomous Systems 2019 (optional su 9 (optional subject), Elective, 1st seme ional subject), computer science / elect gineering (optional subject), Interdiscip onal subject), computer science, 3rd se ence 2012 (optional subject), advanced ence 2012 (optional subject), specializat	trical engineering, Arbi Ibject), Elective, 1st or 2 ster trical engineering, Arbi plinary modules, 2nd se emester curriculum intelligent tion field robotics and a	trary semester 2nd semester trary semester emester embedded systems, 2nd or 3rd semester automation, 3rd semester
Classes and lectures:		Workload:	
<ul> <li>Artificial Intelligence 2</li> <li>Artificial Intelligence 2</li> </ul>	<ul> <li>Artificial Intelligence 2 (lecture, 2 SWS)</li> <li>Artificial Intelligence 2 (exercise, 1 SWS)</li> <li>Structures:</li> <li>Structures:</li></ul>		
<ul> <li>Classification</li> <li>Regression</li> <li>Time-Series Prediction</li> <li>Lagrange Multipliers</li> <li>Sequential Minimal O</li> <li>Geometric Reasoning</li> </ul>	n ptimization		
Qualification-goals/Compet • The students are able • The chosen method c search of parameters learning, designed an	tencies: to choose a method for machine learn an be customized to the needs of the a and involves adjustments to the basic d implemented by the students.The sta	ing for a given applica application. The proces mathematical techniqu arting point are suppor	tion amongst a variety of such methods. s of customization goes well beyond straightforwa Jes.This leads to innovative applications for machin rt vector machines.
Grading through: <ul> <li>Oral examination</li> </ul>			
Responsible for this module	 >•		
Prof. DrIng. Achim Sci	 :hweikard		
Teacher:			
<ul> <li>Institute for Robotics a</li> </ul>	and Cognitive Systems		
Prof. DrIng. Achim Sc	hweikard		
Literature:			
P. Norvig, S. Russell: K	ünstliche Intelligenz - München: Pearso	on 2004	
Language: • offered only in English	1		
, ,			



Note: Module will not be offered in winter semester 2024/2025

Admission requirements for taking the module:

- None

Admission requirements for participation in module examination(s): - None

Module Exam(s): - CS5204-L1: Artificial Intelligence 2, written exam, 90min, 100% of the module grade



CS5410-KP04 - Artificial Life (ArtiLife)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	ester irregularly		4	
<ul> <li>Course of study, specific field and term:</li> <li>Master Biophysics 2019 (optional subject), Elective, 1st or 2nd semester</li> <li>Master CLS 2010 (optional subject), computer science, Arbitrary semester</li> <li>Master CLS 2010 (optional subject), life sciences, Arbitrary semester</li> <li>Master CLS 2010 (optional subject), life sciences, Arbitrary semester</li> <li>Master Computer Science 2012 (optional subject), specialization field robotics and automation, 3rd semester</li> <li>Master Computer Science 2012 (optional subject), specialization field bioinformatics, 3rd semester</li> </ul>				
Classes and lectures:		Workload:		
<ul> <li>Artificial Life (lecture, 2 SWS)</li> <li>Artificial Life (exercise, 1 SWS)</li> <li>Artificial Life (exercise, 1 SWS)</li> <li>45 Hours in-classroom work</li> <li>15 Hours exam preparation</li> </ul>		studies room work reparation		
Contents of teaching: • 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 • Ant algorithms				
<ul> <li>Qualification-goals/Competencies:</li> <li>Students are able to classify models of artificial life, artificial chemistry and self-replicating code.</li> <li>Students have the competence to explain the mathematical concepts of information theory.</li> <li>Students are able to implement and mathematically analyze cellular automata and complex networks.</li> <li>Students can formulate mutualistic interactions through Boolean networks and game-theoretic models and can relate them to biological or socioeconomic systems.</li> <li>Students have the methodogical competence to design evolutionary algorithms and to review them in the context of statistical mechanics and thermodynamics.</li> </ul>				
Written or oral exam as announced I	by the examiner			
Responsible for this module:         • 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				
<ul> <li>English, except in case of only German-speaking participants</li> </ul>				
Notes:				



Prerequisites for attending the module: - None

Prerequisites for the exam: - Successful completion of homework and project assignments during the semester.


CS5	440-KP04, CS5440 - Seminar N	Neuro- and Bioinformat	ics (SemNeurBio)
Duration:	Turnus of offer:		Credit points:
1 Semester	mester irregularly		4
Course of study, specific fie • Master Biophysics 201 • Master Computer Scie • Master CLS 2010 (opti	<b>ld and term:</b> 9 (optional subject), Elective, 1st or 2r nce 2012 (optional subject), specializa onal subject), computer science, Arbit	nd semester ation field bioinformatics, 3rd : rary semester	semester
Classes and lectures: <ul> <li>Seminar Neuro- and Bioinformatics (seminar, 2 SWS)</li> </ul>		<ul> <li>Workload:</li> <li>70 Hours private studies</li> <li>30 Hours in-classroom work</li> <li>20 Hours work on an individual topic with written and oral presentation</li> </ul>	
Contents of teaching: • Introduce students to	a current research topic in Neuro- and	d Bioinformatics	
<ul> <li>The students are able</li> <li>They are able to prese</li> <li>They can master basic</li> <li>They can summarize a</li> <li>They can give an intel</li> <li>They have communication</li> </ul>	to read and understand scientific pub ent orally and in a written paper the co c scientific methodology. a scientific topic in written form. ligible and concise oral presentation c ation competency to discuss a current	plications in the field of neuro- ontent of scientific publication of a current research topic. tresearch topic.	uand bioinformatics. Is in the field of neuro- and bioinformatics.
Grading through: • oral presentation • term paper			
Responsible for this module Prof. DrIng. Erhardt E Prof. Dr. rer. nat. Thon Teacher: Institute for Neuro- ar Prof. Dr. rer. nat. Thon Prof. DrIng. Erhardt E MitarbeiterInnen des	e: Barth has Martinetz d Bioinformatics has Martinetz Barth Finstituts		
Language: • English, except in case	e of only German-speaking participant	'S	
Notes: Prerequisites for attendi - None	ng the module:		



	MA2600-KP04, MA2600 - Biostatistics 2 (BioStat2)				
Duration:	Turnus of offer:		Credit points:		
1 Semester	each summer semester		4		
Course of study, specific field and t Master Medical Informatics 20 Master Biophysics 2019 (optio Master Medical Informatics 20 Master Computer Science 201 Master Computer Science 201 Master Computer Science 201 Bachelor CLS 2010 (compulsor	erm: 19 (optional subject), Medical Dat nal subject), Elective, 2nd semeste 14 (optional subject), ehealth / in 2 (optional subject), specializatior 2 (optional subject), specializatior 2 (optional subject), advanced cu y), mathematics, 4th semester	ta Science / Artificial Intel er fomatics, 1st or 2nd seme n field medical informatic n field bioinformatics, 2nd rriculum stochastics, 2nd	lligence, 1st or 2nd semester ester is, 3rd semester d or 3rd semester semester		
Classes and lectures:		Workload:			
<ul> <li>Biostatistics 2 (lecture, 2 SWS)</li> <li>Biostatistics 2 (exercise, 1 SWS)</li> </ul>		<ul> <li>45 Hours in-classroom work</li> <li>35 Hours private studies</li> <li>25 Hours programming</li> <li>15 Hours exam preparation</li> </ul>			
Contents of teaching:					
<ul> <li>Knowledge of model assumpt</li> <li>Knowledge of possible source</li> <li>Competence in independent a</li> <li>Competence in correctly inter</li> <li>Competence in parameter int</li> <li>Knowledge of model assumpt</li> <li>Competence in the independe</li> <li>Competence in correctly inter</li> </ul>	ions and mathematical foundations s of errors in the modelling analysis of a study using the linea preting study results erpretation and regression diagno ions and mathematical foundations ent analysis of a simple study with preting study results of a study w	on of model assumptions r model ostics on of the generalized linea n a dichotomous outcom rith a dichotomous outcom	for the linear model ar model e me		
<ul> <li>The students are able to enun</li> <li>The students are able to descu</li> <li>The students are able to list th</li> <li>The students are able to descu</li> <li>The students are able to calcu</li> <li>The students are able to evalu</li> <li>The students are able to inter</li> <li>The students are able to draw</li> <li>The students are able to performed</li> </ul>	nerate and explain the assumptio ibe typical applications of the cla ne differences between the linear ibe possible error sources in mod late the estimators (point and int late the graphics for regression di poret the results of studies, where and interpret Kaplan-Meier curve orm data transformations.	ns of the classical linear n ssical linear model. model and the logistic re lelling the linear model. erval estimators, residual; iagnostics in the linear mo a linear, a logistic or a Co es.	nodel. egression model. ) in the linear model by hand. odel. x regression model was applied.		
Grading through: • written exam					
Is requisite for: • Multivariate Statistics (MA494 • Interdisciplinary Seminar (MA3	4) 3300)				
Requires: • Biostatistics 1 (MA1600-KP04,	MA1600, MA1600-MML)				
Responsible for this module: • Prof. Dr. rer. biol. hum. Inke Kö Teacher: • Institute of Medical Biometry a • Prof. Dr. rer. biol. hum. Inke Kö • Dr. rer. hum. biol. Markus Sche	and Statistics anig einhardt				



#### Literature:

• Ludwig Fahrmeir, Thomas Kneib, Stefan Lang: Regression: Modelle, Methoden und Anwendungen - ISBN-13 9783540339328

Dobson, Annette J & Barnett, Adrian: An Introduction to Generalized Linear Models, 3rd ed. - Chapman & Hall/CRC: Boca Raton (FL), 2008

### Language:

### • offered only in German

#### Notes:

Prerequisites for attending the module:

- None (The competences of the required modules are required for this module, but the modules are not a prerequisite for admission.)

#### Prerequisites for the exam:

- Preliminary examinations can be determined at the beginning of the semester. If preliminary work has been defined, it must have been completed and positively assessed before the initial examination.



MA4020-KP04, MA4020 - Stochastics 2 (Stoch2)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	each winter semester		4	
Course of study, specific field a Master Biophysics 2019 (c Master MES 2011 (optiona Master Computer Science Master Computer Science Bachelor MES 2011 (optio	nd term: optional subject), Elective, 1st semest al subject), mathematics, 1st semeste 2012 (optional subject), specializatio 2012 (compulsory), advanced curric 2012 (optional subject), advanced c nal subject), mathematics, 5th semes	ter er on field bioinformatic culum stochastics, 3rd curriculum analysis, 3rd ster	s, 3rd semester semester d semester	
Classes and lectures:		Workload:		
<ul> <li>Stochastics 2 (lecture, 2 SWS)</li> <li>Stochastics 2 (exercise, 1 SWS)</li> </ul>		<ul> <li>65 Hours private studies and exercises</li> <li>45 Hours in-classroom work</li> <li>10 Hours exam preparation</li> </ul>		
<ul> <li>Lebesgue integral and Rie</li> <li>Transformations of measu</li> <li>Product measures and Fu</li> <li>Moments and dependence</li> <li>Normally distributed rance</li> </ul>	emann integral ures and integrals bini's theorem cy measures lom vectors and distributions closely	related to the norma	Il distribution	
Qualification-goals/Competence • Studends get insights into • They master techniques of • They master the treatmer • They are able to formalize	<b>:ies:</b> o basic stochastic structures of integration being relevant to stoch nt of (particularly normally distributed e complex stochastic problems	nastics d) random vectors an	d their distributions	
Grading through: • written exam • Exercises				
Is requisite for: • Modeling Biological Syste • Stochastic processes and	ms (MA4450) modeling (MA4610-KP04, MA4610)			
Requires: • Stochastics 1 (MA2510-KP • Linear Algebra and Discre • Analysis 2 (MA2500-KP04,	04, MA2510) te Structures 2 (MA1500-KP08, MA15 MA2500)	500)		
Responsible for this module: • Nachfolge von Prof. Dr. re Teacher: • Institute for Mathematics • Nachfolge von Prof. Dr. re	r. nat. Karsten Keller r. nat. Karsten Keller			
Literature: • J. Elstrodt: Maß- und Integ • M. Fisz: Wahrscheinlichke	grationstheorie - Springer itsrechnung und mathematische Sta	ıtistik - Deutscher Verl	ag der Wissenschaften	
Language: • offered only in German				



### Notes:

The lecture is identical to that in module MA4020-MML.

Prerequisites for attending the module: - None

Prerequisites for the exam:

- Successful completion of homework assignments during the semester.



MA4400-KP05 - Chaos and Complexity (ChaKomKP05)			
Duration:	Turnus of offer:		Credit points:
1 Semester irregularly			5
Course of study, specific field and term: Master CLS 2023 (optional subject), r Bachelor CLS 2023 (optional subject) Master Biophysics 2019 (optional subject) Bachelor CLS 2016 (optional subject), r	nathematics, 1st, 2nd, or 3 , mathematics, 5th or 6th s oject), Elective, 1st or 2nd s , mathematics, 5th or 6th s nathematics, 1st, 2nd, or 3	rd semester semester semester semester rd semester	
Classes and lectures: Workload:			
<ul> <li>Chaos and Complexity (lecture, 2 SWS)</li> <li>Chaos and Complexity (exercise, 1 SWS)</li> </ul>		<ul> <li>85 Hours private studies and exercises</li> <li>45 Hours in-classroom work</li> <li>20 Hours exam preparation</li> </ul>	
Contents of teaching:   • Time-discrete dynamical systems and stochastic processes  • Nonlinearity and chaos  • Ergodicity  • Symbolic dynamics  • Information-theoretic complexity measures  • Ordinal time series analysis  • Piological and medical applications in particular EEC analysis			
<ul> <li>Qualification-goals/Competencies:</li> <li>Students get insights into basic aspects of nonlinear dynamics</li> <li>They have skills in analyzing and modeling complex data and time series</li> <li>They have competencies in simulating and illustrating nonlinear dynamic phenomena</li> </ul>			
<ul><li>Grading through:</li><li>Written or oral exam as announced b</li></ul>	by the examiner		
Requires: • Stochastics 1 (MA2510-KP04, MA2510) • Analysis 1 (MA2000-KP08, MA2000)			
Responsible for this module: <ul> <li>Nachfolge von Prof. Dr. rer. nat. Karsten Keller</li> </ul> Teacher: <ul> <li>Institute for Mathematics</li> <li>Nachfolge von Prof. Dr. rer. nat. Karsten Keller</li> </ul>			
<ul> <li>Literature:</li> <li>M. Brin, G. Stuck: Introduction to Dynamical Systems - Cambridge University Press 2002</li> <li>J. M. Amigó: Permutation Complexity in Dynamical Systems - Springer 2010</li> <li>R. L. Devaney: An Introduction to Chaotic Dynamical Systems - Westview Press 2003</li> </ul>			
<ul> <li>Language:</li> <li>depends on the chosen courses</li> </ul>			
Notes:			



Admission requirements for taking the module:

- None (The competencies of the modules listed under 'Requires' are needed for this module, but are not a formal prerequisite)

Admission requirements for participation in module examination(s): - Successful completion of homework assignments as specified at the beginning of the semester

Module exam(s):

- MA4400-L1: Chaos and Complexity, oral exam, 30 min, 100 % of module grade

Lecture notes in English



RO5202-KP04 - Bio Robotics / Collective Robotics (CollRobo)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	emester each winter semester		4	
Course of study, specific field and term: • Master Biophysics 2019 (optional su	bject), Elective, 1st or 2nd s	semester		
Classes and lectures:Workload:• Collective Robotics (lecture, 2 SWS)• 65 Hours private studies• Collective Robotics (exercise, 1 SWS)• 45 Hours in-classroom wo• 10 Hours exam preparation		studies room work reparation		
Contents of teaching: • • • • • • • • • • • • •				
Grading through: • Oral examination				
Responsible for this module: <ul> <li>Prof. DrIng. Mladen Berekovic</li> </ul> <li>Teacher: <ul> <li>Institute of Computer Engineering</li> <li>Dr. rer. nat. Javad Ghofrani</li> </ul> </li> <li>Literature: <ul> <li>Bonabeau, E., Dorigo, M., Theraulaz,</li> <li>D. Flemens C. Marii - Dirimination</li> </ul></li>	G.: From Natural to Artificia	al Systems - Oxford Univ. Pr	ess, 1999	
<ul> <li>D. Floreano, C. Mattiussi: Bio-inspire</li> <li>Language:         <ul> <li>offered only in English</li> </ul> </li> <li>Notes:</li> </ul>	a artificial intelligence: the	ories, methods, and technol	ogies - The MIT Press 2008	



Admission requirements for taking the module: - None

Admission requirements for participation in module examination(s): - Successful completion of exercise assignments as specified at the beginning of the semester

Module Exam(s):

- RO5202-L1: Bio Robotics / Collective Robotics, oral exam, 100% of the module grade



RO5300-KP06 - Humanoid Robotics (HumRob)			
Duration:	Turnus of offer:		Credit points:
1 Semester	each summer semester		6
Course of study, specific field and term: Master Biophysics 2019 (optional sul Bachelor Media Informatics 2020 (op Bachelor Robotics and Autonomous Bachelor Medical Informatics 2019 (o Bachelor Medical Informatics 2014 (op Bachelor Media Informatics 2014 (op Bachelor IT-Security 2016 (optional s Bachelor Robotics and Autonomous	oject), Elective, 1st or 2nd se itional subject), Robotics and Systems 2020 (optional sub optional subject), medical co optional subject), Robotics and itional subject), Robotics and subject), Robotics and Auton Systems 2016 (optional sub	emester d Autonomous Systems, 5t oject), Robotics and Autono omputer science, 4th to 6th nd Autonomous Systems, 5t omous Systems, Arbitrary ject), Robotics and Autono	th or 6th semester omous Systems, 5th or 6th semester n semester 5th or 6th semester th or 6th semester semester omous Systems, 5th or 6th semester
Classes and lectures:		Workload:	
<ul> <li>Humanoid Robotics (lecture, 2 SWS)</li> <li>Humanoid Robotics (exercise, 2 SWS)</li> </ul>		<ul><li>100 Hours private</li><li>60 Hours in-class</li><li>20 Hours exam private</li></ul>	e studies room work reparation
<ul> <li>Contents of teaching:</li> <li>Development of humanoid robots: The special features of the kinematics of humanoid robots based on the human model are considered. Challenges and strategies for the design of humanoid robots are discussed. Mechatronic concepts for humanoid robot development are presented using examples.</li> <li>Control of humanoid walking robots: Basic concepts for the planning and control of walking movements are introduced. The characteristics of human locomotion are considered. Based on this, the motion planning and control of robotic walking is presented.</li> <li>Gripping with humanoid robot hands: Grip planning and grip synthesis with humanoid robot hands is presented. Basic characteristics of human grasping are considered. Analytical methods for planning and evaluating grasps are discussed and modern approaches for learning grasps are introduced.</li> <li>Modeling and planning: Basic concepts of modeling and planning tasks are discussed. The description of a goal-oriented action using modeling and planning tasks are discussed.</li> </ul>			
<ul> <li>Qualification-goals/Competencies:</li> <li>Students acquire the ability to independently solve application-oriented exercises from robotics, with a focus on (humanoid) robots with a mathematical background</li> <li>You have a basic understanding of the kinematic properties of humanoid robots</li> <li>They know the requirements for the design of humanoid robots and understand mechatronic concepts for the development of human-inspired robot kinematics.</li> <li>They understand the complexity of controlling humanoid robots, especially with regard to bipedal walking and gripping with five-fingered hands, including the dynamic processes</li> <li>You have gained an insight into learning methods for planning the action sequences of humanoid robots, including the dynamic processes</li> <li>You have opportion in programming humanoid robots</li> </ul>			
Grading through: <ul> <li>Oral examination</li> </ul> Responsible for this module:			
Prof. DrIng. Julia Starke			
Teacher:         • Institute for Robotics and Cognitive Systems         • Prof. DrIng. Julia Starke			
<ul> <li>Literature:</li> <li>Murray, Li and Sastry: A mathematical introduction to robotic manipulation - CRC Press 1994</li> </ul>			
Language:			



#### Notes:

Admission requirements for taking the module: - None

Admission requirements for participation in module examination(s): - Successful completion of exercise assignments as specified at the beginning of the semester

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Module Exam(s):

- RO5300-L1: Humanoid Robotics, oral exam, 100% of the module grade



	RO5600-KP06 - Soc	ial Robotics (SocRob)		
Duration:	Turnus of offer:		Credit points:	
1 Semester	not available anymore		6	
Course of study, specific field and term • Master Biophysics 2019 (optional • Master Medical Informatics 2014	<b>n:</b> subject), Elective, 1st or 2nd s (optional subject), Robotics ar	emester Id Autonomous Systems, 1	st or 2nd semester	
Classes and lectures:Workload:• Social Robotics (lecture, 2 SWS)• 100 Hours private studies• Social Robotics (exercise, 2 SWS)• 60 Hours in-classroom work• 20 Hours exam preparation		e studies room work reparation		
Contents of teaching: • • •				
Qualification-goals/Competencies: • •				
Grading through: • Written or oral exam as announce	ed by the examiner			
<ul> <li>Responsible for this module:</li> <li>Prof. DrIng. Achim Schweikard</li> <li>Teacher: <ul> <li>Institute for Robotics and Cogniti</li> <li>Prof. DrIng. Achim Schweikard</li> </ul> </li> </ul>	ive Systems			
Language: • offered only in English				



	RO5700-KP04 - Evolutio	nary Robotics (EvoRob)
Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4
Course of study, specific fie	ld and term:	
Master Biophysics 201	9 (optional subject), Elective, 1st or 2nd s	emester
Classes and lectures:		Workload:
<ul> <li>Evolutionary Robotics (lecture, 2 SWS)</li> <li>Evolutionary Robotics (exercise, 1 SWS)</li> <li>45 Hours in-classroom work</li> <li>10 Hours exam preparation</li> </ul>		<ul> <li>65 Hours private studies</li> <li>45 Hours in-classroom work</li> <li>10 Hours exam preparation</li> </ul>
Contents of teaching:		
<ul> <li>Biological basics</li> <li>Evolutionary computa</li> <li>Artificial neural network</li> <li>Conducting experime</li> <li>Robot simulators</li> <li>Concepts about (reaction)</li> <li>Nonlinear dynamic sy</li> <li>Heuristic and empirication</li> <li>Modular robotics</li> <li>State of the art (reality)</li> </ul>	ation and optimization: encoding, search s orks ents with mobile robots tive) agents stems al approach in experiments y gap, Novelty Search, etc.)	paces, genetic operators
<ul> <li>Students are able to expla</li> <li>They are able to expla</li> <li>They are able to imple robotics.</li> <li>They are able to inter</li> <li>They are able to adap</li> <li>They are able to name</li> </ul>	explain the approach of evolutionary robo ain evolutionary algorithms in their function ement and apply evolutionary algorithms pret empirical results of such simulations t parameters of the evolutionary algorithm e challenges of evolutionary robotics in it:	tics in its entirety. In as optimizers. and artificial neural networks in simulations for problems of mobile and to interpret possibly required changes in the approach. In to specific application domains. application as well as methods to resolve them.
Grading through: • Written or oral exam a	as announced by the examiner	
Responsible for this module • Prof. DrIng. Mladen F Teacher: • Institute of Computer • Dr. rer. nat. Javad Gho	erekovic Engineering frani	
Literature:		
<ul><li>Nolfi, S., Floreano, D.:</li><li>Floreano, D., Mattiuss</li></ul>	The Biology, Intelligence, and Technology i, C.: Bio-inspired artificial intelligence: the	of Self-Organizing Machines - MIT Press, 2001 ories, methods, and technologies - MIT Press, 2008
Language: • offered only in English		
Notes:		



Admission requirements for taking the module: - None

Admission requirements for participation in module examination(s): - Successful completion of exercise assignments as specified at the beginning of the semester

Module Exam(s):

- RO5700-L1: Evolutionary Robotics, oral exam, 100% of the module grade





	XM1600-KP08 - Elect	tronics and Optics (ElaOp)	
Duration:	Turnus of offer:	Credit points:	
1 Semester	each winter semester	8	
Course of study, specific fiel • Master Biophysics 2019 • Master Biomedical Eng	<b>d and term:</b> 9 (optional subject), Elective, 1st seme jineering (compulsory), compulsory m	ster odule depending on previous knowledge , 1st semester	
Classes and lectures:		Workload:	
<ul> <li>Medical Electronics [no XM1610 ] (lecture, 2 SWS)</li> <li>Medical Electronics [no XM1620] (project work, 4 SWS)</li> <li>Photonics I [no XM1630] (lecture, 2 SWS)</li> </ul>		<ul><li>120 Hours private studies</li><li>120 Hours in-classroom work</li></ul>	
Contents of teaching: • See module descriptio	n of the University of Applied Science	s Lübeck.	
Qualification-goals/Compete • See module descriptio	encies: n of the University of Applied Science	s Lübeck.	
Grading through: • written exam			
Responsible for this module • Prof. Dr. rer. nat. Dipl Teacher: • Lübeck University of A • Institute of Biomedical	: Phys. Martin Ryschka pplied Sciences Optics		
<ul> <li>Prof. Dr. rer. nat. Dipl.</li> <li>Prof. Dr. rer. nat. Gerec</li> <li>Prof. Dr. rer. nat. Sebas</li> </ul>	Priys. Martin Kyschka in Hüttmann tian Karpf		
Language: • offered only in English			