## Options B.Sc. / M.Sc. Information System Technology (PO 2023)

Module handbook FB 18 Date: 01.09.2023



TECHNISCHE UNIVERSITÄT DARMSTADT

FB 18

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Date: 01.09.2023

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## **1 Options**

## 1.1 Optional Subjects CTS: Communication Technology and Communication Systems

<b>Mo</b> Fur	Module name Fundamentals of Signal Processing					
<b>Mo</b> 18-	<b>dule nr.</b> zo-1030	<b>Credit points</b> 6 CP	Workload 180 h	Self-study 120 h	Module duration 1 Term	Module cycle Summer term
Lar Ger	<b>iguage</b> man			Module owner Prof. DrIng. Abc	lelhak Zoubir	
1	Teaching content       Prof. DrIng. Addelnak Zoubir         1       Teaching content         The course covers the following topics:       •         • The basic concepts of stochastic       •         • The sampling theorem       •         • Discrete-time noise processes and their properties       •         • Description of noise processes in the frequency domain       •         • Linear time-invariant systems: FIR and IIR filters       •         • Filtering of noise processes: AR, MA, and ARMA models       •         • The Wiener filter       •         • Properties of estimators       •         • The method of least squares       •					
2	Learning ob After success can apply th stochastic pr systems. Stu method of le	<b>ejectives</b> sful completion of the em to stochastic sign ocesses in the time a dents know the basic ast squares to proble	ne module, studer hals in the course of nd frequency dom properties of esti- ems.	nts understand the of the lecture. In pa ains and analyze t mators. They are a	basics of probability articular, students wi heir interaction with ble to design optimal	theory so that they ll be able to describe linear time-invariant filters and apply the
3	Recommend	led prerequisites fo	or participation			
4	<ul> <li>Form of examination Module exam: <ul> <li>Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS)</li> <li>The examination is a written exam (duration: 120 minutes). If less than 11 students are registered for the course, the examination will be an oral one (duration: 30 min.). The type of examination will be announced at the beginning of the lecture. </li> </ul></li></ul>					
5	<ul> <li>5 Prerequisite for the award of credit points</li> <li>Passing the final module examination</li> </ul>					
6	Grading					

	Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)					
7	<b>Usability of the</b> BSc ETiT, BSc M	<b>module</b> EC				
8	Grade bonus co	mpliant to §25 (2)				
9	References         Lecture notes and slides can be downloaded here:         • http://www.spg.tu-darmstadt.de         • Moodle platform         Further reading:         • A. Papoulis: Probability, Random Variables and Stochastic Processes. McGraw-Hill, Inc., third edition, 1991.         • P. Z. Peebles, Jr.: Probability, Random Variables and Random Signal Principles. McGraw-Hill, Inc., fourth edition, 2001.         • E. Hänsler: Statistische Signale; Grundlagen und Anwendungen. Springer Verlag, 3. Auflage, 2001.         • J. F. Böhme: Stochastische Signale. Teubner Studienbücher, 1998.         • A. Oppenheim, W. Schafer: Discrete-time Signal Processing. Prentice Hall Upper Saddle River,1999.					
Co	urses	1				
	Course nr.Course name18-zo-1030-vlFundamentals of Signal Processing					
	InstructorTypeSWSProf. DrIng. Abdelhak Zoubir2					
	Course nr.Course name18-zo-1030-ueFundamentals of Signal Processing					
	<b>Instructor</b> Prof. DrIng. Ab	delhak Zoubir		<b>Type</b> Practice	SWS 1	

Mo Mic	Module name Microwave Engineering I					
<b>Mo</b> 18-	<b>dule nr.</b> jk-1020	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module duration 1 Term	<b>Module cycle</b> Winter term
Lar Ger	<b>iguage</b> man		-	<b>Module owner</b> Prof. DrIng. Rol	f Jakoby	
1	German       Prof. DrIng. Rolf Jakoby         1       Teaching content         Electromagnetic (EM) Properties of Materials: 1.) Microscopic Scale, including energy levels and energy bands, charge carriers and conduction; 2.) Macroscopic Scale, including plane waves in homogeneous lossy media, electromagnetic properties of low-loss media (lossy dielectrics), skin effect in good conductive media (metals & alloys), penetration depth in biological tissues and specific absorption rate (SAR), oblique incidence of plane waves at a dielectric interface, mechanisms of polarization in dielectrics and its applications, losses in dielectrics, applications of (electro)ceramics; Interaction between Electromagnetic Waves and Biologica Materials (Bioelectricity, Dielectric Dispersion in Tissues, Relaxation and Resonances, Microwave Dosimetry, SAF and thermal considerations, Exposure of Body to Cell Phone and Base Station)         Passive RF Circuits with R-, L- and C-Lumped Elements: Resonant and Equivalent RLC Circuits Graphical Representation of RF Circuits with the Smith Chart, Lumped-Element Impedance Matching.         Theory and Applications of Transmission Lines: Propagation Modes in Transmission Lines, Genera Transmission Line Equations (lumped-element model, transmission-Line Parameters, wave propagation along a transmission Line); Wave Characteristics on Transmission Lines from input-port and output-port parameters o the line; Lossless Transmission Lines as Circuit Elements; Transmission-Line Terminations; Transmission-Line Impedance Matching, including quarter-wave transformer, impedance of a half-wave section and single-stub and double-stub matching; Left-Handed Metamaterial Lines and Dispersion.         Scattering-Matrix Formulation of Microwave Networks: Scattering-Matrix Formulation; Characteri zation of Microwave Networks; Input and					
	<b>N-Port Microwave Devices:</b> Power Divider and Power Combiner: Three-Port Power Divider (Lossless T-junction Power Divider, Symmetrical, Resistive T-Junction Power Divider, Wilkinson Power Divider); Four-Port Power Divider (Coupled Line Directional Coupler, The Quadrature Hybrid, The 180°-Hybrid Coupler); In-plane N-Port Compound Devices with examples of Interference-based RF Switch and Butler Matrix.					er Divider (Lossless er Divider); Four-Port d Coupler); In-plane rix.
	Equations; I Conductor L	Parallel-Plate Wavegu .osses); Microstrip Lin	uide; Rectangular nes.	Waveguide; Atter	uation in Waveguide	es (Dielectric Losses,
2	2 Learning objectives Students understand the essentials of RF engineering: passive RF components and circuits with discrete eleme and line components, line theory, application of scattering matrices to describe passive and active RF compone waveguides: theory, propagation and losses.				rith discrete elements ctive RF components,	
3	Recomment Communica	<b>ded prerequisites fo</b> tions engineering, fu	or participation ndamentals of tec	hnical electrodyna	mics	
4	<ul> <li>Form of examination Module exam:         <ul> <li>Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)</li> </ul> </li> </ul>					
5	<b>Prerequisite</b> Passing the	e for the award of c	<b>redit points</b> ation			

6	<ul><li>Grading Module exam:</li><li>Module exam (Technical examination, Examination, Weighting: 100 %)</li></ul>						
7	Usability of the BSc ETiT, Wi-ETi	module T					
8	Grade bonus compliant to §25 (2)						
9	<b>References</b> Script is in English and will be ellectronically hand out at the beginning of the letcture; Literature will be recommended in first lecture						
Coi	ırses						
	<b>Course nr.</b> 18-jk-1020-vl	<b>Course name</b> Microwave Engineering I					
	InstructorTypeSProf. DrIng. Rolf JakobyLecture3						
	Course nr.Course name18-jk-1020-ueMicrowave Engineering I						
	Instructor Prof. DrIng. Rol	f Jakoby	<b>Type</b> Practice	<b>SWS</b> 1			

Mo Info	dule name	ory I: Fundaments					
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle
Lan Eng	nguage Iguage	0 CP	180 11	Module owner Prof. Dr. techn. H	leinz Köppl	vinter terr	<u>11</u>
1	<ul> <li>Teaching content         The sector of the</li></ul>						
2	<b>Learning objectives</b> Upon completion of the module, students will have an understanding of the fundamentals of classic information theory.						
3	Recomment Basic knowle	<b>ded prerequisites fo</b> edge of probability th	or participation heory				
4	Form of exa Module exa • Modul	mination n: e exam (Technical e:	xamination, Exam	ination, Duration:	120 Min., Default	RS)	
5	Prerequisite Passing the	e for the award of c	<b>redit points</b> ation				
6	Grading Module exame Modul	n: e exam (Technical ex	xamination, Exam	ination, Weighting	: 100 %)		
7	Usability of BSc ETiT, BS	<b>the module</b> Sc iST, MSc iCE, BSc	Wi-ETiT, BSc/MS	c CE			
8	Grade bonu	s compliant to §25	(2)				
9	References						
	<ol> <li>T.M. Cover and J.A. Thomas, Elements of Information Theory, Wiley &amp; Sons, 1991.</li> <li>R. W. Yeung, Information Theory and Network Coding, Springer, 2008.</li> <li>Abbas El Gamal and Young-Han Kim, Network Information Theory, Cambrige, 2011.</li> </ol>						
<b>Co</b> ι	ırses						
	<b>Course nr.</b> 18-kp-1010-	vl Information T	heory I: Fundame	nts			1
	<b>Instructor</b> Prof. Dr. tecl	hn. Heinz Köppl, M.S	Sc. Anam Tahir		<b>Type</b> Lecture	2	<b>SWS</b> 3

<b>Course nr.</b> 18-kp-1010-ue	<b>Course name</b> Information Theory I: Fundaments		
Instructor Prof. Dr. techn. H	leinz Köppl, M.Sc. Anam Tahir	<b>Type</b> Practice	<b>SWS</b> 1

Мо	dule name							
Pro	ject Seminar (	Communication and	Sensor Systems				I	
Mo	dule nr.	Credit points	Workload	Self-study	Module o	duration	Module cy	cle
18-	pe-1041	8 CP	240 h	180 h	1 Term		Every Seme	ester
Lar	iguage			Module owner	ring Decem	nto		
Ger				PIOL DL-IIIg. Ma	rius Pesave			
	Investigating and solving specific problems concerning communication and sensor systems (Problems concerning communications engineering, microwave technology, signal processing, sensor networks etc. are possible, topics will be defined out of the recent research topics of the involved labs), working on a a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications for a given task, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions including audience.							
2	<ul> <li>2 Learning objectives Upon successful completion of the module, students will be able to: <ul> <li>the ability to apply methods of communication and sensor systems to practical problems</li> <li>deep and special knowledge in a particular field of communication and sensor systems (communications engineering), RF technology, signal processing, sensor networks <ul> <li>the skills to find, analyze and evaluate scientific reference papers for a particular topic</li> <li>the capability to summarize the achieved scientific findings in the form of a concise report</li> <li>the ability to present and discuss achieved results in the form of a presentation in front of an audience</li> </ul> </li> </ul></li></ul>							
3	Recommended prerequisites for participation Previous knowledge in chosen discipline, e.g. communication technology, signal processing, microwave technol- ogy, sensor networks							
4	Form of exa Module exar • Modul Report and/	<b>mination</b> n: e exam (Study achie or Presentation. The	vement, Oral/writ type of examinat	tten examination, I ion will be announ	Default RS) ced in the	) beginning	of the lecture	2.
5	<b>Prerequisite</b> Passing the f	e <b>for the award of c</b> inal module examina	<b>redit points</b> ation					
6	Grading Module exar • Modul	n: e exam (Study achie	vement, Oral/writ	tten examination, V	Weighting:	100 %)		
7	Usability of BSc ETiT, BS	<b>the module</b> c Wi-ETiT, BSc CE, I	BSc iST, BSc MEC					
8	Grade bonu	s compliant to §25	(2)					
9	9 References Will be announced in the lecture							
Cot	urses							
	<b>Course nr.</b> 18-pe-1041-	pj Course name Project Semina	ar Communication	and Sensor System	ns			
	Instructor Prof. DrIng	Marius Pesavento, 1	M.Sc. Yufan Fan			<b>Type</b> Project se	eminar	SWS 4

Mo Adv	dule name vanced Semin	ar on Networking, So	ecurity, Mobility, a	nd Wireless Comm	nunications	
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
Lar Ger	nguage rman/English	4 CP	120 II	<b>Module owner</b> Prof. Dr. rer. nat.	Karsten Weihe	Every 2. Semester
1	<ul> <li>Teaching content         The Advanced Seminar on Networking, Security, Mobility, and Wireless Communications covers current research that is considered highly relevant for the future development of the given topic areas. Goal of the seminar is to explore the aforementioned research area by studying, critically analyzing and discussing, summarizing, and presenting selected first-rate research articles. Deliverables are a short presentation, a final presentation, and a seminar paper.     </li> <li>The prospective topics for the advanced seminar will be derived from the current research topics of the SEEMOO group.</li> <li>Course contents:</li> </ul>					
	<ul> <li>Indepentent exploration of a topic in the area of networking, security, mobility, and wireless communications (typically in english)</li> <li>Own, enhanced literature study</li> <li>Interpretation and classification of the literature study</li> <li>Preparation of an introductory talk as well as a final talk including presentation slides</li> <li>Presentation of both talks for a heterogenous audience (experts/non-experts)</li> <li>Technical discussion after the talks</li> <li>Feedback to the speakers and the talks (including presentation skills) and technical content</li> </ul>					less communications ent
2	Learning ol After success manner. The for the inve analysis of s Students can	<b>ojectives</b> sfully attending the ey have aquired detai stigated topic area. scientific articles, and n defend their work a	course, students a led knowledge on Techniques such l the presentation against a critical te	are able to indeper selected mechanis as thoroughly sur of the obtained r echnical audience.	ndently explore new ms, methodologies as veying literature, cri esults are demonstra	topics in a scientific s well as applications itical discussion and ited by the students.
3	Recomment Successfull	<b>ded prerequisites fo</b> participation of an le	or participation cture of SEEMOO			
4	Form of exa Course relat • [20-00	amination ed exam: )-0549-se] (Study ac	hievement, Oral/v	vritten examination	n, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0549-se] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %)	)
7	Usability of	the module				

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaft B.Sc. Psychologie Joint B.A. Inform	sinformatik e in IT atik aschaft und Informatik					
	D.5C. 5portwisse	ischart und miormatik					
	Can be used in o	her degree programs.					
8	Grade bonus compliant to §25 (2)						
9	References						
	Will be announce	ed in seminar.					
Co	urses						
	Course nr.	Course name					
	20-00-0549-se	Advanced Seminar on Networking, Security, Mobility, and W	Vireless Communications	;			
	Instructor Type SWS						
	Prof. DrIng. Ma	thias Hollick	Prof. DrIng. Matthias Hollick Seminar 3				

Mo	dule name	t for Emangement Deer	nonco. Eurodomon	tala Dagion and D	uild un fuore Coustab	
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
20-	00-0780	6 CP	180 h	135 h	1 Term	Every 2. Semester
Lar Gei	<b>nguage</b> rman			Module owner Prof. Dr. rer. nat.	Eberhard Mühlhäuse	er
1	1 <b>Teaching content</b> The communication capabilities among the population is of utmost importance to respond to crises. This course will discuss how to build wireless communication systems from scratch, i.e. under the assumption that no communication infrastructure is left intact as a result of the crisis. The course introduces the theoretical basis from the fields of amateur radio as well as communication systems. It deepens these fields with the knowledge to design and build communication networks for times of crisis. The discussed technologies will span from local to global wireless communications without need of further infrastructure. Theoretical exercises as well as experimentation, the design and building of electrical circuits and the analysis of wireless technology under laboratory conditions deepen the understanding of the subject.					
	<ul> <li>Course contents:</li> <li>Signals, signal propagation, antennas, basics of electrical engineering</li> <li>Modulation schemes in analog and digital systems (OFDM, ATV/SSTV, Packet Radio, SSB,)</li> <li>System aspects for communication in times of crisis</li> <li>Design and practical realization from scratch of wireless communication systems</li> </ul>					3,)
2	2 Learning objectives After successfully attending the course, students have theoretical and practical knowledge in the area of wireless and infrastructureless communication for emergency response. They understand the most important physical and electrotechnical basics of wireless communications and know wireless transmission mechanisms in theory and practice. They are able to build a wireless communication system from scratch and operate it. The students accurate the area of amateur radia and software defined radia technology.					n the area of wireless t important physical echanisms in theory erate it. The students
3	Recomment	ded prerequisites fo	or participation			
4	Form of exa Course relat • [20-00	<b>amination</b> ed exam: )-0780-iv] (Technica	l examination, Ora	al/written examina	tion, Default RS)	
5	Prerequisite Pass exam (2	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0780-iv] (Technica	l examination, Ora	al/written examina	tion, Weighting: 100	%)
7	Usability of B.Sc. Inform M.Sc. Inform M.Sc. Wirtso B.Sc. Psycho Joint B.A. In B.Sc. Sportv	the module natik natik chaftsinformatik ologie in IT formatik vissenschaft und Info	ormatik			
	Can be used	in other degree prog	grams.			
8	Grade bonu	is compliant to §25	(2)			

	In dieser Vorlesu Novelle der APB um bis zu 1.0 fü	In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.			
9	References				
	Selected and giv	en in lecture.			
Co	urses				
	<b>Course nr.</b> 20-00-0780-iv	<b>Course name</b> Wireless Network for Emergency Response: Fundamentals, Scratch	Design, and Build-up fr	rom	
	Instructor Type SWS				
	Prof. Dr. rer. nat	Eberhard Mühlhäuser	Integrated course	3	

Mo	dule name	Notrioulia				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
18-	sm-1010	6 CP	180 h	120 h	1 Term	Summer term
Lar Ger	nguage			Module owner	f Steinmetz	
1	Toophing	antont		Tion Di ing. Ital		
	Iteaching co In this class This lecture the data lini The physica Next, error the network functionalit studied thro Detailed Top • ISO-O • Tasks • Physic • Servic • Flow co • Servic • Routir • Broad • Conge • Addre • Intern • Intern • Mobile • Servic	the technologies tha covers basic knowled k layer, the network l l layer, which is resp control, flow control c layer is discussed. It ies of the transport l oughout the class. pics are: SI and TCP/IP layer and properties of the cal layer coding techn es and protocols of th control (sliding window cations: LAN, MAN, H es of the network lay ng algorithms cast and Multicast ro estion Control ssing et protocol (IP) etworking e networking es and protocols of th JDP	t make today's cor dge about commu layer and parts of ponsible for an ac and medium acc t comprises mainly layer are discusse models physical layer hiques he data link layer ow) ligh-Speed LAN, W rer uting	nmunication netwo nication networks the transport layer. lequate transmissi ess mechanisms of y routing and conge d. This includes U	orks work are introdu and discusses in deta on across a channel the data link layer estion control algorit DP and TCP. The In	aied and discussed. ail the physical layer, , is discussed briefly. are presented. Then hms. After that basic ternet is thoroughly
2	Learning of	bjectives	unctionalities corr	ricos protocols alg	arithms and standard	s of notwork commu
	nication syst datalink lay is taught. A	er, network layer and ttendants will learn a	cquired are basic k transport layer; F about the function	nces, protocols, algo knowledge about the urthermore, basic k ality of today's net	e lower four ISO-OSI nowledge about com work technologies an	layers: physical layer, munication networks ad the Internet.
3	Recommen	ded prerequisites fo	or participation			
4	Form of exa Module exa	amination m:				
	• Modu	le exam (Technical ex	xamination, Exam	ination, Duration:	120 Min., Default RS	6)
5	5 Prerequisite for the award of credit points Passing the final module examination					
6	Grading					
	Module exame • Module	m: le exam (Technical ex	xamination, Exam	ination, Weighting	: 100 %)	

7	<b>Usability of the</b> Wi-CS, Wi-ETiT,	<b>module</b> 3Sc CS, BSc ETiT, BSc iST			
8	<b>Grade bonus compliant to §25 (2)</b> Grade improvement is achieved by solving voluntary additional assignments due weekly in writing during the lecture period. The maximum grade improvement is 1.0. For a grade improvement to be awarded, a minimum number of points (50% of the maximum achievable points) must be reached. Above this minimum number, the grade improvement increases proportionally (from 0.0 grade improvement at the minimum number to a maximum of 1.0 grade improvement at 95% of the maximum achievable points). Above 95% of the maximum achievable points, the bonus is 1.0. Components of the additional assignments can be classical exercises, answering quizzes, creating wiki articles or quizzes. Participation in these is mandatory to receive the grade improvement. The grade improvement has no influence on passing the avam				
9	References Selected chapter • Andrew S. • Andrew S. • Larry L. Pet Publishers, • Larry L. Pet Verlag, 200 • James F. Ku Edition, Pe • James F. Ku 2014 • R. Srikant, Morgan & 4 • Olivier Bo https://ww	a from the following sources: Fanenbaum: Computer Networks, 5th Edition, Prentice Hall, Fanenbaum: Computernetzwerke, 5. Auflage, Pearson Studiu erson, Bruce S. Davie: Computer Networks: A Systems Approach 2021 erson, Bruce S. Davie: Computernetze: Eine systemorientierte 7 rose, Keith W. Ross: Computer Networking: A Top-Down App arson, 2021 rose, Keith W. Ross: Computernetzwerke: Der Top-Down-App arson, 2021 rose, Keith W. Ross: Computernetzwerke: Der Top-Down-Ans Jean Walrand, Shyam Parekh: Communication Networks: A C Claypool, 2017 naventure: Computer Networking: Principles, Protoco w.computer-networking.info	2010 m, 2012 h, 6th Edition, Morgan Ka Einführung, 4. Auflage, roach Featuring the Inter atz, 6. Auflage, Pearson S oncise Introduction, 2nd ls and Practice, open	ufmann Dpunkt met, 8th Studium Edition, ebook,	
Co	ırses				
	<b>Course nr.</b> 18-sm-1010-vl	<b>Course name</b> Communication Networks I			
	<b>Instructor</b> Prof. DrIng. Ral	f Steinmetz	<b>Type</b> Lecture	<b>SWS</b> 3	
	<b>Course nr.</b> 18-sm-1010-ue	Course name Communication Networks I			
	<b>Instructor</b> Prof. DrIng. Ral	f Steinmetz	<b>Type</b> Practice	<b>SWS</b> 1	

Mo Ser	<b>dule name</b> ninar Telecoop	peration						
<b>Mo</b> 20-	<b>dule nr.</b> 00-0130	Credit points 3 CP	Workload 90 h	Self-study 60 h	Module d 1 Term	luration	Module cyc Every 2. Se	<b>cle</b> mester
Lar Eng	<b>iguage</b> glish			<b>Module owner</b> Prof. Dr. rer. nat.	Eberhard	Mühlhäuse	er	
1	<b>Teaching co</b> The TK Semi publications.	ntent inar is cycle of semin	nar where student	s are given the cha	nce to read	l and analy	yze current so	cientific
2	<ul> <li>Learning objectives         After participation in the seminar Telekooperation, students         - have been introduced to the research area of their seminar topic         - are able to critically read and analyze scientific papers         - can document and present the evaluation of such critical analysis in both written and spoken form     </li> </ul>							
3	<b>Recommend</b> General know	<b>led prerequisites fo</b> wledge within Comp	or participation outer Science base	d on Bachelor.				
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>• [20-00-0130-se] (Study achievement, Oral/written examination, Default RS)</li> </ul>							
5	Prerequisite Pass exam (1	e for the award of c	redit points					
6	Grading Course relate • [20-00	ed exam: -0130-se] (Study ac	hievement, Oral/v	vritten examination	n, Weightin	ng: 100 %)	)	
7	<ul> <li><sup>7</sup> Usability of the module         B.Sc. Informatik         M.Sc. Informatik          M.Sc. Virtschaftsinformatik          B.Sc. Psychologie in IT          Joint B.A. Informatik          B.Sc. Sportwissenschaft und Informatik          M.Sc. Sportwissenschaft und Informatik      </li> </ul>							
8	Grade bonu	s compliant to §25	(2)					
9	9 References W. Strunk, E. B. White. The Elements of Style, Pearson, ISBN 0-321-24861-9							
Cot	irses	Courses						
	20-00-0130-	se Seminar Telec	ooperation					
	Instructor					<b>Type</b> Seminar		<b>SWS</b> 2

Мо	dule name					
TK	1: Distributed	Systems and Algorit	hms	- 10 1		
<b>Mo</b>   20-	dule nr. 00-0065	Credit points 6 CP	Workload 180 h	Self-study 120 h	1 Term	<b>Module cycle</b> Every 2. Semester
Lar Eng	<b>iguage</b> glish		100 H	Module owner Prof. Dr. rer. nat.	Eberhard Mühlhäus	er
1	<ul> <li>Teaching content         <ul> <li>Objectives:                 <ul> <li>Comprehensive overview about the fundamental problems and approaches in distributed computing</li></ul></li></ul></li></ul>					
2	Learning o After succes and program algorithms distributed	<b>bjectives</b> ssful completion of th nming. They understa and programming p programming to give	ne module, studer and the fundamer aradigms. They n problems.	nts are familiar wit ital issues of distrib are able to apply	th the concepts of di- outed systems and the these classical and c	stributed algorithms classical distributed current standards of
3	Recomment Recomment	ded prerequisites for led: Computer Netwo	or participation orks and Distribut	ed Systems		
4	Form of exa Course rela • [20-00 The form of two of the f Written exa (optional: ir	amination ted exam: 0-0065-iv] (Technical the examination wil following forms is pos am (duration 60 or acluding tests).	examination, Ora l be announced at sible. 90 or 120 minut	al/written examina the beginning of t res), oral exam (c	ntion, Default RS) the course. One or a luration 15 or 30 n	combination of max. ninutes), homework
5	<b>Prerequisit</b> Pass exam (	e for the award of c 100%)	redit points			
6	<ul> <li>6 Grading Course related exam:</li> <li>• [20-00-0065-iv] (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>				) %)	
7	Usability of	f the module				

	B.Sc. Informatik M.Sc. Informatik M.Sc. Computer M.Sc. Autonome M.Sc. IT Sicherho M.Sc. IT Security	Science Systeme und Robotik eit			
	May be used in o	ther degree programs.			
8	Grade bonus compliant to §25 (2)         In dieser Veranstaltung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25(2) der 6.         Novelle der Allgemeinen Prüfungsbestimmungen der TU Darmstadt und den vom Fachbereich Informatik am         14 07 2022 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1 0 führen kann				
9	References Literature recom - George Coulour Ausgabe) 832 Se - M. Boger: Java - G. Tel: Introduc - A. Tanenbaum, 3827370574 - A. Tanenbaum: - J. Kurose, K. Ros - L. Peterson, B. I - Hammerschall,	mendations will be updated regularly, an example might be: ris, Jean Dollimore, Tim Kindberg: Distributed Systems. Con- iten, Addison Wesley; Auflage: 4th (14. Juni 2005), ISBN: 032 in verteilten Systemen, 1999, dpunkt-Verlag, Heidelberg, ISBN tion to Distributed Algorithms, 2nd Ed 2001, Cambridge Unive M.v.Steen, Verteilte Systeme: Grundlagen und Paradigmen, Computernetzwerke. 4te Auflage. Pearson Studium 2003, ISB ss: Computer Networking, 1. Ed. 2000, Adison-Wesley. ISBN: Davie, Computernetze, 1. Aufl. 2000, dpunkt Heidelberg, ISBN U.: Verteilte Systeme und Anwendungen. Pearson, München 2	ncepts and Design (Geb 21263545 1: 3932588320 ersity Press, ISBN: 05217 Pearson Studium 2003 N-10: 3827370469 0201477114 1: 393258869X 2005, ISBN: 3827370965	undene 794838 , ISBN:	
Coi	urses				
	<b>Course nr.</b> 20-00-0065-iv	<b>Course name</b> TK1: Distributed Systems and Algorithms			
	Instructor		<b>Type</b> Integrated course	SWS 4	

Mo	dule name					
Mu	ltimedia Com	munications Lab I				
<b>Mo</b>   18-	<b>dule nr.</b> sm-1020	Credit points 3 CP	Workload 90 h	Self-study 45 h	Module duration 1 Term	Module cycle Every Semester
Lar Ger	<b>nguage</b> rman/English			<b>Module owner</b> Prof. DrIng. Ral	f Steinmetz	
1	<ul> <li>1 Teaching content The course deals with cutting-edge development topics in the area of multimedia communication systems. Besides a general overview, it provides a deep insight into a special development topic. The topics are selected according to the specific working areas of the participating researchers and convey technical and basic scientific competencies in one or more of the following topics: <ul> <li>Network planning and traffic analysis</li> <li>Performance evaluation of network applications</li> <li>Discrete event simulation for network services</li> <li>Protocols for mobile ad hoc networks / sensor networks</li> <li>Infrastructure networks for mobile communication / mesh networks</li> <li>Context-aware communication and services</li> <li>Peer-to-peer systems and architectures</li> <li>Content distribution and management systems for multimedia/e-learning</li> <li>Multimedia authoring and re-authoring tools</li> <li>Web service technologies and service-oriented architectures</li> <li>Adaptive educational technologies</li> <li>Natural language processing in education</li> </ul> </li> </ul>					
2	Learning of The ability competence • Design • Impler • Applic • Preser	<b>ojectives</b> to solve simple prob s are: n of simple communic menting and testing of ation of object-orient tation of project adva	lems in the area of cation applications of software compo- red analysis and d ances and outcom	of multimedia com s and protocols onents for distribute esign techniques tes	nmunication shall be ed systems	acquired. Acquired
3	<ul> <li>3 Recommended prerequisites for participation         Keen interest to explore basic topics of cutting edge communication and multimedia technologies. Further we         expect:             <ul> <li>Basic experience in programming Java/C# (C/C++).</li> <li>Knowledge in computer communication networks. Lectures in Communication Networks I and/or Net</li></ul></li></ul>					
4	<ul> <li>Form of examination         Module exam:         <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)             Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.         </li> </ul> </li></ul>					
5	Prerequisite Passing the	e for the award of cr final module examina	redit points ation			
6	Grading					

	<ul> <li>Module exam:</li> <li>Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</li> </ul>				
7	<b>Usability of the</b> BSc ETiT, BSc/M	<b>module</b> Sc iST, MSc MEC, Wi-CS, Wi-ETiT, BSc/MSc CS			
8	Grade bonus compliant to §25 (2)				
9	References         Each topic is covered by a selection of papers and articles. In addition we recommend reading of selected chapters from following books:         • Andrew Tanenbaum: "Computer Networks". Prentice Hall PTR (ISBN 0130384887)         • Christian Ullenboom: "Java ist auch eine Insel: Programmieren mit der Java Standard Edition Version 5 / 6" (ISBN-13: 978-3898428385)         • Kent Beck: "Extreme Programming Explained - Embrace Changes" (ISBN-13: 978-0321278654)				
Coi	ırses				
	Course nr.Course name18-sm-1020-prMultimedia Communications Lab I				
	InstructorTypeSWProf. DrIng. Ralf Steinmetz, Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing.Internship3Julian Zobel, M.Sc. Fridolin Siegmund3				

Mo	Module name						
Mu	ltimedia Com	munications Project	I	[		1	
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
18- Lor	SIII-1030	8 CP	240 II	180 II	1 Ierm	Every Semester	
Ger	man/English			Prof. DrIng. Ral	f Steinmetz		
1	<b>Teaching co</b> The course Besides a ge	ontent deals with cutting-e eneral overview, it pro	dge development ovides a deep insig	topics in the area topics in the area	of multimedia com evelopment topic. Th	munication systems. ne topics are selected	
	according to competencie • Netwo	the specific working in one or more of t ork planning and traf	areas of the partic he following topic fic analysis	cipating researchers cs:	s and convey technics	al and basic scientific	
	<ul><li>Performance evaluation of network applications</li><li>Discrete event simulation for network services</li></ul>						
	• Protocols for mobile ad hoc networks / sensor networks						
	Contex	xt-aware communication	tion and services	cation / mesh netw	01K5		
	• Peer-to	o-peer systems and a	rchitectures	<b>C</b> 1.: 1: /	1 .		
	<ul><li>Conter</li><li>Multir</li></ul>	nedia authoring and	re-authoring tools	ns for multimedia/	e-learning		
	• Web se	ervice technologies a	nd service-oriente	d architectures			
	<ul> <li>Adapti</li> <li>Natura</li> </ul>	ive educational techn	ologies				
	The concret	e list of topics can be	found each seme	ster on the corresp	onding teaching web	site of KOM.	
2	<b>Learning ol</b> The ability t communicat among the f	<b>ojectives</b> o solve and evaluate tion networks and ap following:	technical problems plications using st	s in the area of desi tate of the art scien	gn and development tific methods. Acqui	of future multimedia red competences are	
	<ul><li>Search</li><li>Design</li></ul>	ning and reading of p n of communication a	project relevant lite applications and p	erature rotocols			
	<ul> <li>Implei</li> <li>Applic</li> </ul>	nenting and testing of object-orient	of software compo	onents on techniques			
	<ul> <li>Acquis</li> </ul>	sition of project mana	agement technique	es for small develop	oment teams		
	<ul> <li>Evaluation</li> <li>Writin</li> </ul>	tion and analyzing o	of technical scienti	fic experiments			
	Preser	tation of project adv	ances and outcom	ies			
3	Recomment Keen interes	<b>ded prerequisites fo</b> it to develop and expl	or participation lore challenging so	olutions and applica	ations in cutting edge	e multimedia commu-	
	Basic e	experience in program	mming Java/C# (	C/C++).			
	Basic knowledge in Object oriented analysis and design.     Knowledge in communication naturally 1 actures in Communi						
	Centri	c Systems are recom	mended.	works. Lectures in	Communication Ne	tworks I and/ of Net	
4	4 Form of examination						
	• Module example in the second	e exam (Study achie	vement, Oral/wri	tten examination, I	Default RS)		
	Report and/	or Presentation. The	type of examinat	ion will be announ	ced in the beginning	of the lecture.	
5	Prerequisit	e for the award of c	redit points				

	Passing the final	module examination				
6	<ul><li>Grading</li><li>Module exam:</li><li>Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</li></ul>					
7	<b>Usability of the module</b> BSc ETiT, BSc/MSc iST, MSc MEC, Wi-CS, Wi-ETiT, BSc/MSc CS					
8	Grade bonus compliant to §25 (2)					
9	References         Each topic is covered by a selection of papers and articles. In addition we recommend reading of selected chapters from following books:         • Andrew Tanenbaum: "Computer Networks". Prentice Hall PTR (ISBN 0130384887)         • Raj Jain: "The Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation, and Modeling" (ISBN 0-471-50336-3)         • Erich Gamma, Richard Helm, Ralph E. Johnson: "Design Patterns: Objects of Reusable Object Oriented Software" (ISBN 0-201-63361-2)         • Kent Beck: "Extreme Programming Explained - Embrace Changes" (ISBN-13: 978-0321278654)					
Coi	ırses					
	Course nr.Course name18-sm-1030-pjMultimedia Communications Project Seminar I					
	InstructorTypeS'Prof. DrIng. Ralf Steinmetz, Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing.Project seminar4Julian Zobel, M.Sc. Fridolin Siegmund4					

Mo Dig	<b>dule name</b> ital Signal Pro	ocessing						
<b>Mo</b> 18-:	<b>dule nr.</b> zo-2060	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module dura 1 Term	ation	Module cyc Winter tern	c <b>le</b> n
Lan Eng	<b>iguage</b> dish			Module owner Prof. DrIng. Abc	lelhak Zoubir			
1	<ol> <li>Teaching content         <ol> <li>Discrete-Time Signals and Linear Systems - Sampling and Reconstruction of Analog Signals</li> <li>Digital Filter Design - Filter Design Principles; Linear Phase Filters; Finite Impulse Response Filters; Implementations</li> <li>Digital Spectral Analysis - Random Signals; Nonparametric Methods for Spectrum Estimation; Parametric Spectrum Estimation; Applications;</li> <li>Kalman Filter</li> </ol> </li> </ol>							
2	Learning of Students un Furthermore the basics of analyze ther	<b>jectives</b> derstand basic prin- , they are able to an spectral estimation n with respect to the	ciples of signal pr alyze statistical si and can design n eir performance.	ocessing. They can gnals in the time an on-parametric as w	n design and a nd frequency c ell as parame	analyze domain tric spe	e FIR and IIR . The student ctral estimate	t filters. ts know ors and
3	<b>Recommend</b> Deterministi	led prerequisites for c signals and system	or participation as theory					
4	Form of exa Module exar • Module	<b>mination</b> n: e exam (Technical e	xamination, Exam	ination, Duration:	180 Min., Def	ault RS	)	
5	<b>Prerequisite</b> Passing the f	e for the award of c inal module examin	e <b>redit points</b> ation					
6	Grading Module exar • Module	n: e exam (Technical e	xamination, Exam	ination, Weighting	: 100 %)			
7	<b>Usability of</b> BSc ETiT, W	<b>the module</b> i-ETiT, MSc Medizin	technik					
8	Grade bonu	s compliant to §25	(2)					
9	<ul> <li>9 References <ul> <li>Course manuscript</li> <li>Additional References:</li> <li>A. Oppenheim, W. Schafer: Discrete-time Signal Processing, 2nd ed.</li> <li>J.F. Böhme: Stochastische Signale, Teubner Studienbücher, 1998</li> </ul> </li> </ul>							
Coι	irses	Course in a line						
	<b>Course nr.</b> 18-zo-2060-	vl Digital Signal	Processing					1
	InstructorTypeSW3M.Sc. Martin Gölz, Prof. DrIng. Abdelhak ZoubirLecture3					<b>SWS</b> 3		

	<b>Course nr.</b> 18-zo-2060-ue	<b>Course name</b> Digital Signal Processing		
	<b>Instructor</b> M.Sc. Martin Göl	z, Prof. DrIng. Abdelhak Zoubir	<b>Type</b> Practice	<b>SWS</b> 1

Мо	Module name						
Mo	bile Commun	ications				1	
<b>Mo</b>	dule nr. kl-2020	Credit points	Workload	Self-study	Module duration	Module cycle	
Lar		0.01	100 11	Module owner	1 Icilii	builder term	
Eng	glish			Prof. DrIng. Anj	a Klein		
1	<ul> <li>The lecturing content</li> <li>The lecture covers aspects of mobile communication systems with particular focus on the physical layer.</li> <li>Mobile radio systems, services, market, standardization</li> <li>Duplex and multiple access techniques, cellular concept</li> <li>Mobile radio channel, deterministic and stochastic description</li> <li>Modulation schemes</li> <li>Code division multiple access (CDMA)</li> <li>Orthogonal frequency division multiplexing (OFDM)</li> <li>Optimum and suboptimum receiver techniques</li> <li>Cellular radio capacity and spectrum efficiency</li> <li>Diversity methods</li> <li>Multiple input multiple output (MIMO) systems</li> <li>Power control and handover</li> <li>Architecture of mobile radio systems</li> </ul>						
2	<ul> <li>2 Learning objectives After completion of the module, students possess <ul> <li>a profound understanding of physical layer aspects ,e.g., transmission schemes, multiple access schemes of mobile communication systems, duplex schemes, multi carrier schemes, receiver techniques, multi antenna schemes <ul> <li>a profound understanding of signal propagation in mobile radio systems (mobile radio channel)</li> <li>the ability to understand and solve problems of the field of the physical layer</li> <li>the ability to compare, analyse and evaluate different system concepts <ul> <li>knowledge on modelling of the transmission properties of the mobile radio channel</li> </ul> </li> </ul></li></ul></li></ul>						
3	Recommend Determinist Theory, Scie	ded prerequisites for ic Signals and Syster ntific Computing	or participation ns, Communication	on Technology I, M	athematics I to III, S	Statistics/Probability	
4	Form of exa Module exa • Modul	<b>mination</b> n: e exam (Technical ex	xamination, Exam	ination, Duration:	90 Min., Default RS)		
5	Prerequisite Passing the	e <b>for the award of c</b> final module examina	<b>redit points</b> ation				
6	<ul><li>Grading</li><li>Module exam:</li><li>Module exam (Technical examination, Examination, Weighting: 100 %)</li></ul>						
7	<b>Usability of</b> MSc ETIT, M	<b>the module</b> ISc Wi-ETiT, MSc CE	, MSc iCE, MSc iS	T, MSc MEC			
8	Grade bonu	s compliant to §25	(2)				
9	References						

	will be announced in the lecture						
Co	Courses						
	Course nr.Course name18-kl-2020-vlMobile Communications						
	Instructor Prof. DrIng. Anja Klein, DrIng. Lin Xiang		<b>Type</b> Lecture	<b>SWS</b> 3			
	Course nr.Course name18-kl-2020-ueMobile Communications						
	Instructor Prof. DrIng. An	ja Klein, DrIng. Lin Xiang	<b>Type</b> Practice	<b>SWS</b> 1			

Mo	Module name Convex Ontimization in Signal Processing and Communications						
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
18-	pe-2020	6 CP	180 h	120 h	1 Term	Summer term	
Lan Eng	English			<b>Module owner</b> Prof. DrIng. Mar	rius Pesavento		
1	1 Teaching content This graduate course introduces the basic theory of convex optimization and illustrates its use with many recent applications in communication systems and signal processing. Outline: Introduction, convex sets and convex functions, convex problems and classes of convex problems (LP, QP, SOCP, SDP, GP), Lagrange duality and KKT conditions, basics of numerical algorithms and interior point methods, optimization tools, convex inner and outer approximations for non convex problems, sparse optimization, distributed optimization, discrete optimization, mixted integer linear and non-linear programming, Branch-and- Bound method, Branch-and-Cut method, customized iterative optimization, Newton method, gradient projection method, conjugate gradient method, block coordinate descent method, successive convex approximation method, BSUM method, Majorization Maximization, difference-of-convex procedure, ADMM, step size selection, optimal step size compution, applications.						
2	<b>Learning ol</b> After comple This include and mobile	<b>bjectives</b> eting the module, stuc s in particular the bas communication syste	lents will have bec sic theory of conve ms.	ome familiar with a x optimization and	dvanced topics in mo its application in dig	dern communication. ital signal processing	
3	Recomment Knowledge	<b>ded prerequisites fo</b> in linear algebra and	or participation the basic concept	s of signal processi	ng and communication	ons.	
4	Form of exa Module exam • Modul The examin less than 14 examination	amination m: le exam (Technical ex ation takes place in students register, th n will be announced i	kamination, Oral/ form of a writter the examination with n the beginning o	written examinatio n exam (duration: ill be an oral exam f the lecture.	n, Duration: 120 Mir 120 minutes). If or ination (duration: 20	n., Default RS) ne can estimate that 0 min.). The type of	
5	Prerequisite Passing the	e for the award of c	<b>redit points</b> ation				
6	Grading Module exan • Modul	m: le exam (Technical ex	xamination, Oral/	written examinatio	n, Weighting: 100 %	)	
7	<b>Usability of</b> MSc ETiT	the module					
8	Grade bonu	is compliant to §25	(2)				
9	References						
	<ul> <li>S. Boyd and L. Vandenberghe, Convex Optimization, Cambridge University Press, 2004. (online Verfügbar:http://www.stanford.edu/boyd/cvxbook/)</li> <li>D. P. Bertsekas, Nonlinear Programming, Athena Scientific, Belmont, Massachusetts, 2nd Ed., 1999.</li> <li>Daniel P. Palomar and Yonina C. Eldar, Convex Optimization in Signal Processing and Communications, Cambridge University Press, 2009.</li> </ul>						
Coι	ırses						

<b>Course nr.</b> 18-pe-2020-vl	Course name Convex Optimization in Signal Processing and Communications			
Instructor		<b>Type</b>	SWS	
Prof. DrIng. Marius Pesavento		Lecture	2	
<b>Course nr.</b> 18-pe-2020-ue	<b>Course name</b> Convex Optimization in Signal Processing and Communications			
Instructor		<b>Type</b>	<b>SWS</b>	
Prof. DrIng. Marius Pesavento		Practice	1	
<b>Course nr.</b> 18-pe-2020-pr	<b>Course name</b> Convex Optimization in Signal Processing and Communicati	ons Lab		
Instructor		<b>Type</b>	<b>SWS</b>	
Prof. DrIng. Marius Pesavento		Internship	1	

Mo MI	Module name MIMO - Communication and Space-Time-Coding						
<b>Mo</b> 18-	<b>dule nr.</b> ia-2010	Credit points 4 CP	Workload 120 h	Self-study 75 h	Module duration	Module cycle Winter term	
Lar Eng	nguage			Module owner Prof. DrIng. Vah	id Kooshkghazi		
1	<ul> <li>Teaching content         This lecture course introduces the principles of space-time and multiple-input multiple-output (MIMO) communications.         Outline: Motivation and background; overview of space-time and MIMO communications; fading MIMO channel models, MIMO information theory, receive and transmit diversity; channel estimation, MIMO detectors, Alamouti space-time block code, orthogonal space-time block codes; linear dispersion codes; coherent and non-coherent decoders, differential space-time block coding; MIMO with limited feedback, Multiantenna- and multiuser diversity, BER performance analysis, MIMO in moden wireless communication networks, multicell and multiuser MIMO (coordinated multipoint).     </li> </ul>						
2	Learning objectives Students will understand modern MIMO communications and existing space-time coding techniques.						
3	<b>Recommend</b> Knowledge o	<b>led prerequisites fo</b> of basic communicati	<b>r participation</b> on theory and bas	sic information theo	ory.		
4	<ul> <li>Form of examination Module exam: <ul> <li>Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS)</li> <li>The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 10 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be an oral examination (duration: 20 min.). The type of</li> </ul></li></ul>						
5	<b>Prerequisite</b> Passing the f	e for the award of c	r <b>edit points</b> ation				
6	Grading Module exar • Module	n: e exam (Technical ex	amination, Oral/	written examinatio	n, Weighting: 100 %	))	
7	Usability of MSc ETiT	the module					
8	Grade bonu	s compliant to §25	(2)				
9	<ul> <li>9 References</li> <li>A.B.Gershman and N.D.Sidiropoulos, Editors, Space-Time Processing for MIMO Communications, Wiley and Sons, 2005.</li> <li>E.G.Larsson and P.Stoica, Space-Time Block Coding for Wireless Communications, Cambridge University Press, 2003;</li> <li>A.Paulraj, R.Nabar, and D.Gore, Introduction to Space-Time Wireless Communications, Cambridge University Press, 2003.</li> <li>Lin Bai and Jinho Choi, Low Complexity MIMO detectors, Springer, 2012.</li> <li>Howard Huang, Constantinos B. Papadias, and Sivarama Venkatesan, MIMO Communication for Cellular Networks, Springer, 2012.</li> </ul>						
00	11363						
<b>Course nr.</b> 18-ja-2010-vl	<b>Course name</b> MIMO - Communication and Space-Time-Coding						
---------------------------------------	------------------------------------------------------------------	-------------------------	-----------------				
<b>Instructor</b> Prof. DrIng. Val	id Kooshkghazi	<b>Type</b> Lecture	<b>SWS</b> 2				
<b>Course nr.</b> 18-ja-2010-ue	<b>Course name</b> MIMO - Communication and Space-Time-Coding		•				
<b>Instructor</b> Prof. DrIng. Val	id Kooshkghazi	<b>Type</b> Practice	<b>SWS</b> 1				

Mo Ser	<b>dule name</b> ninar Smart C	ity					
<b>Mo</b> 20-	<b>dule nr.</b> 00-0619	Credit points 3 CP	Workload 90 h	Self-study 60 h	Module duration 1 Term	Module cy Every 2. Se	<b>cle</b> emester
Lar Eng	<b>iguage</b> glish		1	Module owner	I		
1	Teaching co Rapid urban to issues invo approaches t disaster prep	ntent ization presents citic olving infrastructure to cope with these di paration and manage	es with complex ch and governance. I ifferent challenges ement.	nallenges, from soc n the seminar stud , e.g. for traffic pre	io-economic and en ents will have a look diction, analysis of e	vironmental pa at different te environmental	roblems echnical data or
2	Learning of The students more, the stu	<b>jectives</b> learn fundamentals udents get a good ov	of scientific work verview of the topi	when interacting w c smart city.	ith existing Smart C	ity literature.	Further-
3	Recommend	led prerequisites fo	or participation				
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>• [20-00-0619-se] (Study achievement, Oral/written examination, Default RS)</li> </ul>						
5	Prerequisite Pass exam (1	e for the award of c	redit points				
6	Grading Course relat • [20-00	ed exam: -0619-se] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %	6)	
7	Usability of the module B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik						
8	Grade bonu	s compliant to §25	(2)				
9 Cot	References Various urses						
	<b>Course nr.</b> 20-00-0619-	se Seminar Smar	rt City				
	Instructor Prof. Dr. rer.	nat. Eberhard Müh	lhäuser		<b>Type</b> Seminar	r	<b>SWS</b> 2

Mo IoT	dule name	protocols in embedd	led systems				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle
20-	00-1064	6 CP	180 h	120 h	1 Term	Every 2. Se	mester
Lar Ger	<b>iguage</b> man			<b>Module owner</b> Prof. Dr. rer. nat. Eberhard Mühlhäuser			
1	<b>Teaching co</b> As part of the a project with The main foor on the select as well as lal	ontent e internship, student h embedded hardwa cus is on Bluetooth LE ed project topic, har poratory environmer	s become acquaint are. In addition, as E, Bluetooth Mesh, dware (microcont nt (logic analyzers	ed with IoT and ra spects of IT security LoRaWAN and com rollers, FPGAs, RF , RF analyzers, osc	dio protocols and ind y are also taken into munication via OOB transceivers, softwar illoscopes, etc.) are p	ependently ca account. channels. Dep e defined rad provided.	arry out pending io, etc.)
2	2 Learning objectives At the end of the course, students will be able to deal with complex specifications of radio protocols and transfer them into practice. Furthermore, the practical handling of embedded systems and laboratory equipment is taught.						
3	<ul> <li>Recommended prerequisites for participation</li> <li>Previous knowledge in computer networks (compulsory lecture "Computer Networks and Distributed Systems) and Embedded Systems (compulsory lectures Computer Organization and / or Data Engineering) Knowledge of the programming language C and basic knowledge of electrical engineering are helpful, as well as knowledge from relevant lectures in the field" Networks and Systems "Distributed systems "such as TK3, mobile networks or KN1</li> </ul>					ystems) edge of wledge etworks	
4	Form of exa Course relat • [20-00 Pass exam (2	<b>mination</b> ed exam: ŀ-1064-pr] (Study ac l00%)	hievement, Oral/v	vritten examination	n, Default RS)		
5	Prerequisite Passing the f	e for the award of c	<b>redit points</b> ation				
6	Grading Course relat • [20-00	ed exam: I-1064-pr] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %]	)	
7	Usability of B.Sc. Inform M.Sc. Inform May be used	<b>the module</b> atik natik in other degree pro	grams.				
8	Grade bonu	s compliant to §25	(2)				
9	References						
Co	irses						
	<b>Course nr.</b> 20-00-1064-	pr IoT and wirele	ess protocols in en	bedded systems			
	Instructor Prof. Dr. rer.	nat. Eberhard Mühl	häuser		<b>Type</b> Internshi	р	SWS 4

Mo Rot	dule name iting, Switchi	ng and Forwarding						
<b>Mo</b> 18-	<b>dule nr.</b> sm-2350	Credit points 6 CP	Workload 180 h	Self-study 105 h	Module of 1 Term	duration	<b>Module cy</b> Irregular	cle
Lar Ger	<b>iguage</b> man	1		Module owner Prof. Dr. rer. nat. Björn Scheuermann				
1	1 <b>Teaching content</b> The Modul covers in-depth knowledge about the network layer and related aspects of the link layer. For different types of networks and different requirements we consider methods for routing, for the representation of routing and switching data and for packet forwarding. The focus is on questions of protocol design with respect to robustness, stability and efficiency, also in terms of the interplay with other layers. Security aspects of the network layer are also considered, for instance firewall technologies or BGP security. The accompanying exercises in part consist of group exercise lab blocks.							
2	<ul> <li>2 Learning objectives         After taking this module, students understand the design options for routing in networks and the efficient implementation of packet forwarding in detail. They can use this knowledge to assess the effects of protocol design decisions and to analyze the expected and actual behavior of protocol designs, individually and in comparison.     </li> </ul>							
3	<b>Recommended prerequisites for participation</b> Basic knowledge in the field of communication networks, as covered for instance in the module "Communication Networks I"							
4	Form of exa Module exar • Modul The examina enroll, the ex will be anno	mination n: e exam (Technical e ation is an oral exam xamination can also unced at the beginn	xamination, Oral/ ination (duration: take the form of a ing of the course.	written examinatic 30 min.). If it is fo written exam (dura	n, Duratio reseeable t ation: 120	n: 120 Mir hat more t min.). The	n., Default RS han 30 stude type of exam	5) ents will vination
5	Prerequisite Passing the	e <b>for the award of c</b> final module examin	<b>redit points</b> ation					
6	Grading Module exan • Modul	n: e exam (Technical e:	xamination, Oral/ <sup>,</sup>	written examinatio	n, Weighti	ng: 100 %	)	
7	<b>Usability of</b> MSc etit, MS	t <b>he module</b> Sc (WI-)etit, BSc/MS	c iST					
8	Grade bonu Announcemento to accompar	<b>s compliant to §25</b> ents will be made at t by the lecture that w	(2) he beginning of the ill improve grades	e semester as to wh	ether there	e will be ho	mework assig	nments
9	9 References Technical literature will be mentioned in the course.							
Cot	urses							
	<b>Course nr.</b> 18-sm-2350	-vl Course name Routing, Swite	ching and Forward	ling	;			
	<b>Instructor</b> Prof. Dr. rer.	nat. Björn Scheuerr	nann			<b>Type</b> Lecture		<b>SWS</b> 3

-	<b>Course nr.</b> 18-sm-2350-ue	<b>Course name</b> Routing, Switching and Forwarding		
	<b>Instructor</b> Prof. Dr. rer. nat.	Björn Scheuermann	<b>Type</b> Practice	<b>SWS</b> 2

Mo Cor	<b>dule name</b> nmunication 7	Technology II					
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
18-	KI-2010	5 CP	150 h	90 h	1 Ierm	winter term	
Eng	glish			Prof. DrIng. Anj	a Klein		
1	<b>Teaching co</b> Linear and r channel capa schemes, OF	ontent nonlinear digital mo acity, channel model DM	dulation schemes s, channel estimat	, optimum receive tion and data deteo	rs for AWGN channe ction for multipath cl	els, error probability, hannels, multicarrier	
2	<ul> <li>2 Learning objectives</li> <li>After completion of the lecture, students possess: <ul> <li>the ability of comparing, evaluating, classifying an analyzing linear and nonlinear modulation schemes by means of signal space representations;</li> <li>the ability to understand, describe and analyze the influence of AWGN on the signal;</li> <li>the ability to understand and derive optimum receivers in case of AWGN channels;</li> <li>the ability to understand, describe and analyze the influence of multipath propagation on the signal;</li> <li>the ability to understand, describe and analyze the influence of multipath propagation on the signal;</li> <li>the ability to describe the influence of a multipath channel mathematically (channel model) and estimate the multipath channel at the receiver;</li> <li>the knowledge of equalizing the received signal in order to undo the influence of multipath propagation, as well as the ability to derive and design several equalizer structures;</li> <li>the ability to analyze and evaluate the properties and application areas of multicarrier transmission systems, e.g. OFDM-systems;</li> <li>the ability to design and evaluate the system parameters of multicarrier schemes for the application in realistic wireless communication scenarios;</li> <li>the ability to mathematically express and analyze all above system models in matrix-vector-notation.</li> </ul> </li> </ul>						
3	<b>Recommend</b> Deterministic	<b>ded prerequisites fo</b> sche Signale und Syst stics/Probability The	or participation teme, Communica corv. Scientific Cor	tion Technology I, E	Basics of Telecommun	ication, Mathematics	
4	Form of exa Module exar • Modul	n: e exam (Technical ex	xamination, Exam	ination, Duration:	90 Min., Default RS)		
5	<b>Prerequisite</b> Passing the f	e for the award of cr final module examina	redit points ation				
6	Grading Module exar • Modul	n: e exam (Technical ex	xamination, Exam	ination, Weighting	: 100 %)		
7	<b>Usability of</b> MSc ETIT, M	<b>the module</b> ISc Wi-ETiT, MSc CE	, MSc iCE, MSc iS	T, MSc MEC			
8	Grade bonu	s compliant to §25	(2)				
9	References           will be announced in the lecture						
Coι	ırses						

<b>Course nr.</b> 18-kl-2010-vl	<b>Course name</b> Communication Technology II		
<b>Instructor</b> Prof. DrIng. Anj	a Klein	<b>Type</b> Lecture	<b>SWS</b> 2
<b>Course nr.</b> 18-kl-2010-ue	<b>Course name</b> Communication Technology II		
Instructor Prof. DrIng. Anj	a Klein	<b>Type</b> Practice	<b>SWS</b> 2

Mo Info	dule name	y II: Networks					
<b>Mo</b> 18-	<b>dule nr.</b> pe-2010	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module durat	ion Module cy Summer te	<b>cle</b> rm
Lar Eng	<b>iguage</b> glish		1	<b>Module owner</b> Prof. DrIng. Ma	rius Pesavento		
1	Teaching contentThis lecture course is devoted to topics in network information theory. Outline: overview of Shannon capacity, outage and ergodic capacity, capacity of channels with state, capacity of Gaussian vector channels, capacity regions of multi-user channels, capacity regions of multiple-access and broadcast fading channels, interference channel, relay channel, multiuser bounds, graphical multi-hop networks, routing, network coding, capacity of MIMO multiple-access and broadcast channels, duality of MIMO multiple access and broadcast channels, dirty paper coding, multi-user diversity., wiretap channel, secrecy rate and physical layer security.						
2	Upon complet network infor	Learning objectives Upon completion of the module, students will have an understanding of the advanced concepts and strategies in network information theory.					
3	Recommend Knowledge of	ed prerequisites for basic communication	or participation ion theory				
4	<ul> <li>Form of examination Module exam:</li> <li>Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS) The examination takes place in form of a written exam (duration: 120 minutes). If apparent that less than 10 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will</li> </ul>						
5	<b>Prerequisite</b> Passing the fi	<b>for the award of c</b> nal module examin	<b>redit points</b> ation				
6	Grading Module exam • Module	: exam (Technical e:	xamination, Oral/	written examinatio	n, Weighting: 1	00 %)	
7	Usability of t MSc ETiT, BS	<b>he module</b> c iST, MSc Wi-ETiT	, MSc iCE, BSc/M	Sc CE			
8	Grade bonus	compliant to §25	(2)				
9	References						
	<ul> <li>Abbas El Gamal and Young-Han Kim, Network Information Theory, Cambrige, 2011.</li> <li>T.M. Cover and J.A. Thomas, Elements of Information Theory, Wiley Sons, 1991.</li> <li>D. Tse and P. Vishwanath, Fundamentals of Wireless Communications, Cambridge University Press, 2005.</li> </ul>						
Cot	urses						
	<b>Course nr.</b> 18-pe-2010-v	Course nameIInformation T	heory II: Network	5			1
	InstructorTypeSWSProf. DrIng. Marius PesaventoLecture3						

<b>Course nr.</b> 18-pe-2010-ue	<b>Course name</b> Information Theory II: Networks		
<b>Instructor</b> Prof. DrIng. Ma	rius Pesavento	<b>Type</b> Practice	<b>SWS</b> 1

Mo Spe	dule name ech and Audi	io Signal Processing				
Mo	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle
Lar Ger	nguage man	0.01	100 11	Module owner Prof. DrIng. Abc	lelhak Zoubir	winter term
1	1 <b>Teaching content</b> Algorithms of speech and audio signal processing: Introduction to the models of speech and audio signals and basic methods of audio signal processing. Procedures of codebook based processing and audio coding. Beamforming for spatial filtering and noise reduction for spectral filtering. Cepstral filtering and fundamental frequency estimation. Mel-filterind cepstral coefficients (MFCCs) as basis for speaker detection and speech recognition. Classification methods based on GMM (Gaussian mixture models) and speech recognition with HMM (Hidden markov models). Introduction to the methods of music signal processing, e.g. Shazam-App or beat detection.					
2	2 Learning objectives Based on the module you acquire an advanced knowledge of digital audio signal processing mainly with the help of the analysis of speech signals. You learn about different basic and advanced methods of audio signal processing, to range from the theory to practical applications. You will acquire knowledge about algorithms such as they are applied in mobile telephones, hearing aids, hands-free telephones, and man-machine-interfaces (MMI). The exercise will be organized as a talk given by each student with one self-selected topic of speech and audio processing. This will allow you to acquire the know-how to read and understand scientific literature, familiarize with an unknown topic and present your knowledge, such as it will be certainly required from you in your professional life as an engineer					
3	<b>Recommen</b> Knowlegde - but not ma	<b>ded prerequisites fo</b> about satistical signal ndatory - is knowled	or participation l processing (lectu ge about adaptive	ıre "Digital Signal I filters.	Processing"). Desired	1
4	Form of exa Module exa • Modul Seminar pre (duration 10 exam (dura	amination m: le exam (Technical ex esentation: Scientific )-15 min) or in group tion 90 min)	kamination, Oral⁄ talk about a topic s of two students	written examinatio in the field of "Spe (15-20 min) or in a	n, Duration: 90 Min. eech and Audio Signa group of 20 student	., Default RS) al Processing", single s and more a written
5	<b>Prerequisit</b> Passing the	e for the award of c final module examina	<b>redit points</b> ation			
6	Grading Module exa • Modul	m: le exam (Technical ex	kamination, Oral/	written examinatio	n, Weighting: 100 %	)
7	Usability of MSc ETiT, N	f <b>the module</b> /ISc iCE				
8	Grade bonu	is compliant to §25	(2)			
9 Co1	References Slides (for f	urther details see hor	mepage of the lect	ure)		

<b>Course nr.</b> 18-zo-2070-vl	<b>Course name</b> Speech and Audio Signal Processing		
Instructor		<b>Type</b>	<b>SWS</b>
Prof. DrIng. Henning Puder		Lecture	2
<b>Course nr.</b> 18-zo-2070-ue	<b>Course name</b> Speech and Audio Signal Processing		
Instructor		<b>Type</b>	<b>SWS</b>
Prof. DrIng. Henning Puder		Practice	1
<b>Course nr.</b> 18-zo-2070-se	<b>Course name</b> Sprach- und Audiosignalverareitung		
Instructor		<b>Type</b>	<b>SWS</b>
Prof. DrIng. Henning Puder		Seminar	1

Mo Dig	<b>dule name</b> ital Signal Pro	cessing Lab					
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle
18- Lar	zo-2030	6 CP	180 h	Module owner			
Eng	glish			Prof. DrIng. Abc	lelhak Zoubir		
1	1       Teaching content         1. Introduction to MATLAB         2. Discrete-Time Signals and Systems         3. Frequency-Domain Analysis using the DFT         4. Digital FIR Filter Design         5. IIR Filter Design using Analog Prototypes         6. Nonparametric Spectrum Estimation         7. Parametric Spectrum Estimation.						
2	2 Learning objectives The students are able to apply skills acquired in the course Digital Signal Processing. These include the design of digital FIR and IIR filters as well as non-parametric and parametric spectrum estimation. Students learn how MATLAB is used to apply theoretical concepts and to demonstrate signal processing techniques by using hands-on application examples.						
3	Recommenta Fundamenta	led prerequisites for ls of Signal Processi	ng				
4	Form of exa Module exar • Module Exam (Durat	<b>mination</b> n: e exam (Study achie ion: 120 min) and a	vement, Written e Report (Lab Repor	examination, Durat ts), Details will be	ion: 120 Min., Defau announced at the beg	llt RS) jinning of the	lecture.
5	<b>Prerequisite</b> Passing the f	<b>for the award of c</b> inal module examin	<b>redit points</b> ation				
6	Grading Module exar • Module	n: e exam (Study achie	vement, Written e	examination, Weigh	nting: 100 %)		
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> Sc iCE					
8	Grade bonu	s compliant to §25	(2)				
9 Coi	References Lab manual 1rses						
	<b>Course nr.</b> 18-zo-2030-j	or Digital Signal	Processing Lab				
	InstructorTypeSWSProf. DrIng. Abdelhak ZoubirInternship3						

Mo	Module name Multimadia Communications Lob II						
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
18-	sm-2070	6 CP	180 h	135 h	1 Term	Every Semester	
Ger	man/English			Prof. DrIng. Ral	f Steinmetz		
1	<ul> <li>1 Teaching content The course deals with cutting-edge development topics in the area of multimedia communication system. Besides a general overview, it provides a deep insight into a special development topic. The topics are selected according to the specific working areas of the participating researchers and convey technical and basic scientific competencies in one or more of the following topics: <ul> <li>Network planning and traffic analysis</li> <li>Performance evaluation of network applications</li> <li>Discrete event simulation for network services</li> <li>Protocols for mobile ad hoc networks / sensor networks</li> <li>Infrastructure networks for mobile communication / mesh networks</li> <li>Context-aware communication and services</li> <li>Peer-to-peer systems and architectures</li> <li>Content distribution and management systems for multimedia/e-learning</li> <li>Multimedia authoring and re-authoring tools</li> <li>Web service technologies and service-oriented architectures</li> <li>Adaptive educational technologies</li> <li>Natural language processing in education</li> </ul></li></ul>						
	The concrete	e list of topics can be	found each seme	ster on the correspo	onding teaching web	site of KOM.	
2	Learning ol The ability t nication net Desigr Impler Applic Acquis Writin Presen	<b>ojectives</b> o solve and evaluate works and application of complex commun nenting and testing of ation of object-orient ition of project mana g of software documo tation of project adv	problems in the at ns shall be acquire nication application of software compo- ted analysis and d agement technique entation and proje- ances and outcom	rea of design and d ed. Acquired compo- ns and protocols onents for distribute esign techniques es for small develop ect reports	evelopment of future etences are: ed systems pment teams	e multimedia commu-	
3	<ul> <li>3 Recommended prerequisites for participation         Keen interest to explore challenging topics which are cutting edge in technology and research. Further we expect:         <ul> <li>Solid experience in programming Java and/or C# (C/C++)</li> <li>Solid knowledge in object oriented analysis and design</li> <li>Solid knowledge in computer communication networks are recommended</li> <li>Lectures in Communication Networks I (II, III, or IV) are an additional plus</li> </ul> </li> </ul>					esearch. Further we	
4	<ul> <li>Form of examination         Module exam:             <ul></ul></li></ul>						
5	Prerequisite Passing the	e for the award of c final module examina	<b>redit points</b> ation				

6	<ul><li>Grading</li><li>Module exam:</li><li>Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</li></ul>					
7	<b>Usability of the</b> MSc ETiT, MSc i	<b>module</b> CE, BSc/MSc iST, Wi-ETiT, BSc/MSc CS, Wi-CS,				
8	Grade bonus co	mpliant to §25 (2)				
9	References         Each topic is covered by a selection of papers and articles. In addition we recommend reading of selected chapters from following books:         • Andrew Tanenbaum: "Computer Networks". Prentice Hall PTR (ISBN 0130384887)         • Christian Ullenboom: "Java ist auch eine Insel: Programmieren mit der Java Standard Edition Version 5 / 6" (ISBN-13: 978-3898428385)         • Joshua Bloch: "Effective Java Programming Language Guide" (ISBN-13: 978-0201310054)         • Erich Gamma, Richard Helm, Ralph E. Johnson: "Design Patterns: Objects of Reusable Object Oriented Software" (ISBN 0-201-63361-2)         • Kent Beck: "Extreme Programming Explained - Embrace Changes" (ISBN-13: 978-0321278654)					
Co	urses					
	Course nr.Course name18-sm-2070-prMultimedia Communications Lab II					
	Instructor       Type       SWS         Prof. DrIng. Ralf Steinmetz, Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing.       Internship       3         Julian Zobel M Sc. Fridolin Siegmund       Segmund       3					

Mo	Module name Multimedia Communications Desired Cominen II					
Mu Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
18-	sm-2080	6 CP	180 h	135 h	1 Term	Every Semester
Lar Gei	<b>nguage</b> rman/English			<b>Module owner</b> Prof. DrIng. Ral	f Steinmetz	
1	Teaching co	ontent		0		
	<ul> <li>The course deals with cutting edge scientific and development topics in the area of multimedia communication systems. Besides a general overview it provides a deep insight into a special scientific topic. The topics ar selected according to the specific working areas of the participating researchers and convey technical and scientific competences in one or more of the following topics: <ul> <li>Network planning and traffic analysis</li> <li>Performance evaluation of network applications</li> <li>Discrete event simulation for network services</li> <li>Protocols for mobile ad hoc networks / sensor networks</li> <li>Infrastructure networks for mobile communication / mesh networks</li> <li>Context-aware communication and services</li> <li>Peer-to-peer systems and architectures</li> <li>Content distribution and management systems for multimedia / e-learning</li> <li>Multimedia authoring and re-authoring tools</li> <li>Web service technologies and service-oriented architectures</li> <li>Applications for distributed workflows</li> </ul> </li> </ul>					
2	Learning of The ability future multi acquired. Ac • Search • Design • Impler • Applic • Acquis • Syster • Writin • Preser	bjectives to solve and evaluate imedia communicatio cquired competences ning and reading of p n of complex commun menting and testing of ation of object-orient sition of project mana natic evaluation and g of software docum- nation of project adv	e technical and sc on networks and a are: project relevant lite nication applicatio of software compo- ted analysis and d agement technique analyzing of techr entation and proje- ances and outcom	ientific problems in pplications using s erature ns and protocols onents for distribute esign techniques es for small develop nical and scientific o ect reports	n the area of design state of the art scient ed systems oment teams experiments	and development of ific methods shall be
3	<ul> <li>3 Recommended prerequisites for participation</li> <li>Keen interest to develop and explore challenging solutions and applications in cutting edge multimedia communications systems using scientific methods. Further we expect: <ul> <li>Solid experience in programming Java and/or C (C/C++)</li> <li>Solid knowledge in object oriented analysis and design</li> <li>Basic knowledge of design patterns, refactoring and project management</li> <li>Solid knowledge in computer communication networks are recommended</li> <li>Lectures in Communication Networks I (II, III, or IV) are an additional plus</li> </ul> </li> </ul>					e multimedia commu-
4	<ul> <li>Form of examination Module exam:</li> <li>Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.</li> </ul>					of the lecture.
5	Prerequisite for the award of credit points					

	Passing the final	module examination				
6	Grading Module exam: • Module exa	<ul><li>Grading</li><li>Module exam:</li><li>Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</li></ul>				
7	<b>Usability of the</b> Wi-CS, Wi-ETiT,	<b>module</b> BSc/MSc CS, MSc ETiT, MSc iST				
8	Grade bonus co	mpliant to §25 (2)				
9	References         Each topic is covered by a selection of papers and articles. In addition we recommend reading of selected chapters from following books:         • Andrew Tanenbaum: "Computer Networks". Prentice Hall PTR (ISBN 0130384887)         • Raj Jain: "The Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation, and Modeling" (ISBN 0-471-50336-3)         • Joshua Bloch: "Effective Java - Programming Language Guide" (ISBN-13: 978-0201310054)         • Erich Gamma, Richard Helm, Ralph E. Johnson: "Design Patterns: Objects of Reusable Object Oriented Software" (ISBN 0-201-63361-2)         • Martin Fowler: "Refactorings - Improving the Design of Existing Code" (ISBN-13: 978-0201485677)         • Kent Beck: "Extreme Programming Explained - Embrace Changes" (ISBN-13: 978-0321278654)					
Co	urses					
	Course nr.Course name18-sm-2080-pjMultimedia Communications Project Seminar II					
	<b>Instructor</b> Prof. DrIng. Ra Julian Zobel, M.S	lf Steinmetz, Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing. Sc. Fridolin Siegmund	<b>Type</b> Project seminar	<b>SWS</b> 3		

Mo Pro	Module name Project Seminar Wireless Communications							
Mo	dule nr.	Credit points	Workload	Self-study	Module du	uration	Module cy	cle
Lar	nguage	8 CP	240 n	Module owner	1 Ierm		Summer te	rm
Eng	English Prof. DrIng. Anja Klein							
1	1 Teaching content Solving special problems concerning wireless communications (problems concerning signal transmission and processing as well as problems concerning the network are possible, topics will be defined out of the current research topics of the lab); working on the project in teams (2-3 students); organizing and structuring of a project; dealing with scientific publications, reading up the theoretical background of the task; practical work on a complex task; scientific presentation of the results (report/presentation); defending the work in an oral discussion including an audience.							
2	<ul> <li>2 Learning objectives <ul> <li>After completion of the course, students possess</li> <li>the ability to classify and analyze special problems concerning wireless communications,</li> <li>the knowledge to plan and organize projects with temporal limitation,</li> <li>the capability to set up and test methodologies for analysis and simulation environments,</li> <li>skills to evaluate and present achieved results and achieved conclusions.</li> </ul> </li> </ul>							
3	Recomment Previous kno	<b>ded prerequisites fo</b> wledge in digital co	or participation mmunications, sig	nal processing, wir	eless comm	unication	l <b>.</b>	
4	Form of exa Module exa • Modul Report and/	<b>mination</b> n: e exam (Study achie or Presentation. The	vement, Oral/wright type of examinat	tten examination, I ion will be announ	Default RS) ced in the b	eginning	of the lecture	e.
5	<b>Prerequisite</b> Passing the f	e for the award of c	<b>redit points</b> ation					
6	Grading Module exan • Modul	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 1	100 %)		
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> ISc Wi-ETiT, MSc CE	, MSc iCE, MSc iS	T, MSc MEC				
8	Grade bonu	s compliant to §25	(2)					
9 Co1	9     References       Literature will be announced during the course.							
	<b>Course nr.</b> 18-kl-2040-1	<b>Course name</b> pj Project Semin	ar Wireless Comm	unications				
	Instructor M.Sc. Sume	dh Dongare, Prof. Dr	:-Ing. Anja Klein		•	<b>Type</b> Project se	eminar	SWS 4

Mo	dulo nomo					
Mu	ltimedia Com	munications Semina	r II			
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
18-	sm-2090	4 CP	120 h	90 h	1 Term	Every Semester
Ger	man/English			Prof. DrIng. Ral	f Steinmetz	
1	<ul> <li><b>1</b> Teaching content         This seminar deals with current and upcoming trends relevant to the future development of multimedia communication systems. The educational objective of this seminar is to gain knowledge about future research trends in different areas. To this aim, an extensive literature research will be performed, as well as the writing-up of a report and the presentation of selected, high-quality research topics from current leading magazines, newspapers and conferences in the web technologies research area.     </li> <li>Some potential topics are:         <ul> <li>Knowledge &amp; Educational Technologies</li> <li>Self organizing Systems &amp; Overlay Communication</li> <li>Mobile Systems &amp; Sensor Networking</li> <li>Service-oriented Computing</li> <li>Multimedia Technologies &amp; Serious Games</li> </ul> </li> </ul>					
2	<ul> <li>2 Learning objectives         Students shall acquire profound knowledge from current scientific publications, standards and literature on multimedia communication systems and applications which will build the future Internet. In so doing, the students will develop the following competencies:             <ul> <li>Search for and review relevant scientific literature.</li> <li>Analyse and evaluate complex technical and scientific information.</li> <li>Write technical and scientific abstracts and summary reports.</li> <li>Present technical and scientific information.</li> </ul> </li> </ul>					rds and literature on net. In so doing, the
3	Recommen Solid knowl recommend	<b>ded prerequisites fo</b> edge in computer co ed.	or participation	tworks. Lectures is	n Communication N	etworks I and II are
4	Form of exa Module exa • Modul Report and/ the lecture.	amination m: e exam (Study achie or Presentation and/o	vement, Oral/wri or Colloquium. Th	tten examination, I le type of examinat	Default RS) ion will be announce	d in the beginning of
5	Prerequisite Passing the	e for the award of c final module examina	<b>redit points</b> ation			
6	Grading Module exame • Module	m: e exam (Study achie	vement, Oral/wri	tten examination, V	Veighting: 100 %)	
7	Usability of CS, Wi-CS, I	<b>the module</b> ETiT, Wi-ETiT, MSc C	S, MSc ETiT, MSc	iST		
8	Grade bonu	is compliant to §25	(2)			
9	<b>References</b> Depending	on specific topic (sele	ected articles of ion	urnals, magazines,	and conferences).	
Cot	irses			, , ,		

<b>Course nr.</b> 18-sm-2090-se	<b>Course name</b> Multimedia Communications Seminar II		
<b>Instructor</b> Prof. DrIng. Ra Julian Zobel, M.S	lf Steinmetz, Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing. Sc. Fridolin Siegmund	<b>Type</b> Seminar	SWS 2

Mo Ada	Module name Adaptive Filters						
<b>Mo</b>	dule nr.	<b>Credit points</b>	Workload	Self-study	Module duration	Module cycle	
Lar	iguage	0.61	100 11	Module owner			
Ger	man/English			Prof. DrIng. Abc	lelhak Zoubir		
1	Teaching co Theory:	ontent					
	<ol> <li>Derivation of optimal filters for stochastic processes, e.g. Wiener filter or linear prediction filter based on suitable cost functions.</li> <li>Elaboration of adaptive procedures, which allow to iteratively approach the optimal solution for non-stationary signals in non-stationary environments. Here, the adaptive procedures such as NLMS adaptation, affine projection, and the RLS algorithm are derived and extensively analysed.</li> <li>Analysis of the adaptation behaviour and control procedures of adaptive filters based on the NLMS procedure.</li> </ol>						
	<ul> <li>4. Derivation and analysis of the Kalman filter as optimal filter for non-stationary input signals.</li> <li>5. Procedures for the decomposition of signals into sub-bands for the realization of optimal filters in the frequency domain, e.g. noise reduction procedures.</li> <li>Applications:</li> </ul>						
	Parallel to the theory, practical applications are explained. As an example for the Weiner filter, the acoustic noise reduction procedures are explained. Acoustic echo cancellation and feedback cancellation are given as examples for adaptive filters. Furthermore beamforming approaches are introduced.				er, the acoustic noise re given as examples		
	It is planned In the 4 to 5 get familiar	l to offer an excursion exercises, some cont with practical realiza	n to Siemens Audi ent of the lecture ations of the theor	iology Engineering will be implementee retical procedures.	Group in Erlangen. l in MATLAB which a	llows the students to	
2	Learning of Upon compl algorithms a the content For the admi will allow yo unknown to life as an en	<b>ojectives</b> letion of the module are derived, interpret of the lecture you are ission to the exam yo ou to acquire the know pic and present your gineer.	, students were t ted and applied to able to apply ada u give a talk about w-how to read and knowledge, such	aught the fundam o examples of speec aptive filters to real t a topic in the dom l understand scient as it will be certain	entals of adaptive fil ch, audio and video p practical application ain of adaptive filters ific literature, familia ly required from you	ters. The necessary processing. Based on us. s chosen by you. This rize yourself with an in your professional	
3	Recomment Digital Signa	<b>ded prerequisites fo</b> al Processing	or participation				
4	<ul> <li>Form of examination         Module exam:         <ul> <li>Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)</li> <li>The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 21 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture</li> </ul> </li> </ul>					, Default RS) stimate that less than type of examination	
5	<b>Prerequisite</b> Passing the f	e for the award of c final module examina	<b>redit points</b> ation				
6	<ul> <li>Grading Module exam:</li> <li>Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>						
7	Usability of	the module					

	MSc ETiT					
8	Grade bonus co	Grade bonus compliant to §25 (2)				
9	<ul> <li>References</li> <li>Slides of the lecture.</li> <li>Literature: <ul> <li>E. Hänsler, G. Schmidt: Acoustic Echo and Noise Control, Wiley, 2004 (Textbook of this course);</li> <li>S. Haykin: Adaptive Filter Theory, Prentice Hall, 2002;</li> <li>A. Sayed: Fundamentals of Adaptive Filtering, Wiley, 2004;</li> <li>P. Vary, U. Heute, W. Hess: Digitale Sprachsignalverarbeitung, Teubner, 1998 (in German)</li> </ul> </li> </ul>					
Co	ırses					
	Course nr.	Course name				
	18-zo-2010-vl	Adaptive Filters	1			
	InstructorTypeSWSProf. DrIng. Henning PuderLecture3					
	Course nr.Course name18-zo-2010-ueAdaptive Filters					
	<b>Instructor</b> Prof. DrIng. Her	nning Puder	<b>Type</b> Practice	<b>SWS</b> 1		

<b>Mo</b> Adv	Advanced Topics in Statistical Signal Processing					
<b>Mo</b> 18-:	<b>dule nr.</b> zo-2040	Credit points 8 CP	Workload 240 h	Self-studyModule durationModule cyc180 h1 TermWinter term		Module cycle Winter term
Lan Eng	i <b>guage</b> lish			Module owner Prof. DrIng. Abc	lelhak Zoubir	
1	<ul> <li><b>1</b> Teaching content         The course covers the fundamentals of detection and estimation theory. These are extended by advanced topics in statistical signal processing. Applications are typically from the following areas: Detection in Radar Applications; Robust Estimation; Prediction, Filtering, and Tracking with the Kalman Filter; Sensor Array Signal Processing, Direction of Arrival Estimation, and Source Detection; Time-Frequency Analysis. Topics may change from semester to semester.     </li> <li>The course includes a series of lectures followed by a supervised research seminar over approximately 2 months. The main topics covered are:         <ul> <li>Estimation theory</li> <li>Detection theory</li> <li>Robust estimation theory</li> <li>Seminar projects: e.g., microphone arrays/beamforming, localization and tracking, radar/ultrasonic imaging, acoustic source localization, estimation of number of sources</li> </ul> </li> </ul>					
2	Learning of After comple and reprodu	<b>ojectives</b> ting the module, stuc ce existing results. T	lents will be able to 'he students can p	o work independen resent these result	tly on advanced topics s and discuss them so	s in signal processing cientifically.
3	Recommend DSP, general	<b>ded prerequisites fo</b> l interest in signal pr	or participation ocessing			· · · ·
4	Form of exa Module exar • Modul Report and/o the lecture.	mination n: e exam (Study achie or Presentation and/o	vement, Oral/writ or Colloquium. Th	ten examination, I e type of examinat	Default RS) ion will be announced	d in the beginning of
5	<b>Prerequisite</b> Passing the f	e for the award of c	redit points ation			
6	<ul> <li>6 Grading Module exam:</li> <li>• Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</li> </ul>					
7	<b>Usability of</b> MSc ETiT, B	<b>the module</b> Sc/MSc iST, MSc iCF	E, Wi-ETiT			
8	Grade bonu	s compliant to §25	(2)			
9	References					

- Lecture slides
- Jerry D. Gibson and James L. Melsa. Introduction to Nonparametric Detection with Applications. IEEE Press, 1996.
- S. Kassam. Signal Detection in Non-Gaussian Noise. Springer Verlag, 1988.
- S. Kay. Fundamentals of Statistical Signal Processing: Estimation Theory. Prentice Hall, 1993.
- S. Kay. Fundamentals of Statistical Signal Processing: Detection Theory. Prentice Hall, 1998.
- E. L. Lehmann. Testing Statistical Hypotheses. Springer Verlag, 2nd edition, 1997.
- E. L. Lehmann and George Casella. Theory of Point Estimation. Springer Verlag, 2nd edition, 1999.
- Leon-Garcia. Probability and Random Processes for Electrical Engineering. Addison Wesley, 2nd edition, 1994.
- P. Peebles. Probability, Random Variables, and Random Signal Principles. McGraw-Hill, 3rd edition, 1993.
- H. Vincent Poor. An Introduction to Signal Detection and Estimation. Springer Verlag, 2nd edition, 1994.
  Louis L. Scharf. Statistical Signal Processing: Detection, Estimation, and Time Series Analysis. Pearson
- Education POD, 2002.Harry L. Van Trees. Detection, Estimation, and Modulation Theory, volume I,II,III,IV. John Wiley & Sons, 2003.
- A. M. Zoubir and D. R. Iskander. Bootstrap Techniques for Signal Processing. Cambridge University Press, May 2004.

## Courses

000	arbeb			
	<b>Course nr.</b> 18-zo-2040-se	<b>Course name</b> Advanced Topics in Statistical Signal Processing		
	<b>Instructor</b> Prof. DrIng. Abc	lelhak Zoubir	<b>Type</b> Seminar	SWS 4

Mo	Module name Antennas and Adaptive Beamforming						
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
18-	jk-2020	6 CP	180 h	120 h	1 Term	Winter term	
Laı Enş	<b>nguage</b> glish			Module owner Prof. DrIng. Rol	f Jakoby		
1	English       Prof. DrIng. Rolf Jakoby         1       Teaching content         Overview of most important antenna parameters types as well as their applications. Fundamental theories:         Fourier transform for far-field pattern calculations, antenna modeling techniques, antenna synthesis methods, image theory, determination of field regions of line sources, of the average radiated power density and power, directivity and gain. Antennas as key elements in power budgets of radio links, introducing the effective aperture of an antenna, deriving the relation between gain and effective aperture. Array antennas are a key hardware for beamforming and smart antenna systems: fundamentals of phased-scanning arrays, non-uniformly excited, equally spaced linear arrays, multi-dimensional planar arrays and mutual coupling effects. Wire antennas: still the most prevalent of all antenna forms, relatively simple in concept, easy to construct, very inexpensive. Antenna radiation fields and antenna parameters for different types of antennas are derived from Maxwell 's equations, applied for aperture antennas (horns, lenses or reflector antennas) and printed antennas (microstrip-patch and coplanar-slot antennas) Some basic numerical calculation methods: integral equation methods in the time and frequency domain, physical optics and uniform theory of diffraction are briefly summarized and compared for antennas and scattering problems. Smart antennas in communication and radar systems, with focus on beam						
<ul> <li>steering and adaptive beamforming.</li> <li>2 Learning objectives</li> <li>Students will know basic antenna parameters: pattern, gain, directivity, half-power beamwidth, side- lobe-efficiency and input impedance to compare, assess and evaluate different antennas for various application: operating frequencies. The antenna field regions, reactive near-field, near-field and far-field, can be different and the far-field pattern of an antenna can be determined from given current distributions along the ant by using Fourier transformation or integral solutions with distributed ideal dipoles as basic elements (ant analysis). To assess in general physical requirements, constrains and limitations of antennas, student use fundamental antenna theory: impedance matching techniques, antenna modeling and far-field pattern of a analysis, antenna synthesis, image theory and fundamental limits of electrically small antennas. After I incorporated into the different adaptive beamforming techniques, the array theory enables the student to d antenna systems that are assembled of a certain number of separate elements, feeding network, beamfor network etc. for phased-scanning or smart antennas in communications and sensing. Moreover, student able to determine, analyze and evaluate the most important classes of antennas in wireless technology for applications, operating frequencies, desired requirements or practical constrains: (1.) wire- dipole ante (2.) planar antennas (microstrip, dipole and slot antennas), (3.) aperture antennas (horn antennas, para reflector antennas, lens antennas (V antennas, biconical antennas, helical antennas, spiral and log-perented constrains, para reflector configurations), (4.) broad and frequency-independent antennas (V antennas, biconical antennas, helical antennas, spiral and log-perented constrains).</li> </ul>				idth, side- lobe-level, ious applications and can be differentiated as along the antenna c elements (antenna ennas, students can and far-field pattern ntennas. After being the student to design twork, beamforming preover, students are technology for many ire- dipole antennas, antennas, parabolic ons), (4.) broadband piral and log-periodic			
3	Recomment Fundamenta	ded prerequisites fo als of Communication	or participation as, Microwave Eng	ineering 1			
4	Form of exa Module exa • Modul	amination m: e exam (Technical ex	xamination, Exam	ination, Duration:	90 Min., Default RS)		
5	Prerequisite Passing the	e for the award of cr final module examina	redit points				
6	6 Grading						

	Module exam: • Module exa	am (Technical examination, Examination, Weighting: 100 %)				
7	Usability of the module					
8	Crede bonus compliant to \$25 (2)					
	Grade Dollas co	orade bonus compnant to 320 (2)				
9	<b>References</b> Skriptum "Antennas and Adaptive Beamforming" will be provided electronically at the beginning of the lecture.					
Co	urses					
	<b>Course nr.</b> 18-jk-2020-vl	<b>Course name</b> Antennas and Adaptive Beamforming				
	Instructor		Туре	SWS		
	Prof. DrIng. Rol	f Jakoby, M.Sc. Matthias Nickel	Lecture	3		
	Course nr.	Course name				
	18-jk-2020-ue	Antennas and Adaptive Beamforming	1			
	Instructor		Туре	SWS		
	Prof. DrIng. Rol	f Jakoby, M.Sc. Matthias Nickel	Practice	1		

Mo Mic	<b>dule name</b> crowave Engin	neering II				
<b>Mo</b> 18-	<b>dule nr.</b> jk-2130	Credit points 6 CP	<b>Workload</b> 180 h	Self-study 120 h	Module duration 1 Term	Module cycle Winter term
Lar Eng	<b>iguage</b> glish		<u> </u>	<b>Module owner</b> Prof. DrIng. Rol	f Jakoby	
1	Teaching co Part 1 Passi • Calcul- lumpe • Wave p • Smith • Design and re Part 2 Activ • Design • Gain a • Schott Part 3 Activ • FET an • Oscilla • Mixer • Materi Applications well as high Topics of go	ontent ive microwave comp ation of the two-port d elements) for MMI parameters and S-par chart and matching of and equivalent circu- esistors) re microwave compo- n and equivalent circu- nd cut-off frequencies ky contacts: function re microwave circuit mplifiers: operation, of ator design design ial choice (compound of these circuits rang- frequency sources up od scientific practice are addressed in an a	ponents: parameters of sim Cs rameters circuits with line e its of passive micr onents: uits of field effect and characteristics (main part): equivalent circuit, l semiconductor m ge from communic p to Terahertz. e, as well as socie ccompanying mar	aple passive composite elements or lumped owave components transistors (FET) a cs gain, matching cir naterial systems: pr cation systems such tal or ethical aspe-	nents and circuits (tr d elements (transmission lines, nd heterostructure tr cuit, stability and cir operties, fabrication as cell phones to sat cts of product design	ansmission lines and capacitors, inductors ransistors (HEMTs) rcuit implementation and requirements) tellite transceivers as h, optimization, and
2	Learning ol After success microwave o	<b>bjectives</b> sful completion of the components (passive	module students and active) as we	understand the phy ll as microwave circ	sics of microwave wa	veguides, resonators,
3	Recomment Introduction	<b>ded prerequisites fo</b> to Electrodynamics,	or participation Microwave Engin	eering I		
4	Form of exa Module exa • Modul	amination m: le exam (Technical ex	amination, Exam	ination, Duration:	90 Min., Default RS)	
5	<b>Prerequisite</b> Passing the	e for the award of cr final module examina	<b>redit points</b> ation			
6	Grading Module exan • Modul	m: le exam (Technical ex	amination, Exam	ination, Weighting	: 100 %)	
7	<b>Usability of</b> MSc ETiT, M	the module ISc iCE, MSc IST, Wi	-ETiT			
8	Grade bonu	is compliant to §25	(2)			
9	References Script and s	lides will be handed	out. Literature wi	ll be recommended	in the lecture.	
Coi	urses					

<b>Course nr.</b> 18-jk-2130-vl	<b>Course name</b> Microwave Engineering II		
Instructor		<b>Type</b>	<b>SWS</b>
PD DrIng. Oktay Yilmazoglu		Lecture	3
<b>Course nr.</b> 18-jk-2130-ue	<b>Course name</b> Microwave Engineering II		
Instructor		<b>Type</b>	<b>SWS</b>
PD DrIng. Oktay Yilmazoglu		Practice	1

Mo Mu	<b>dule name</b> ltimedia Com	munications Project	II					
<b>Mo</b> 18-	<b>dule nr.</b> sm-2130	Credit points 9 CP	Workload 270 h	Self-study 180 h	Module duration	Module cycle Every Semester		
Lar Ger	nguage man/English			Module owner Prof. DrIng. Ral	f Steinmetz			
1	<ul> <li>The course deals with cutting edge scientific and development topics in the area of multimedia communication systems. Besides a general overview it provides a deep insight into a special scientific topic. The topics are selected according to the specific working areas of the participating researchers and convey technical and scientific competences in one or more of the following topics:         <ul> <li>Network planning and traffic analysis</li> <li>Performance evaluation of network applications</li> <li>Discrete event simulation for network services</li> <li>Protocols for mobile ad hoc networks / sensor networks</li> <li>Infrastructure networks for mobile communication / mesh networks</li> <li>Context-aware communication and services</li> <li>Peer-to-peer systems and architectures</li> <li>Content distribution and management systems for multimedia / e-learning</li> <li>Multimedia authoring and re-authoring tools</li> <li>Web service technologies and service-oriented architectures</li> <li>Resource-based Learning</li> </ul> </li> </ul>							
2	Learning of The ability of future multi acquired. Ac • Search • Desigr • Impler • Applic • Acquis • Systen • Writin • Presen	bjectives to solve and evaluate media communicatio equired competences ning and reading of p n of complex commun menting and testing of ation of object-orient sition of project mana natic evaluation and a g of software docume tation of project adv	e technical and sc on networks and a are: roject relevant lite nication applicatio of software compo- red analysis and d agement technique analyzing of techr entation and proje ances and outcom	ientific problems in applications using s erature ns and protocols onents for distribute esign techniques es for small develop nical and scientific d ect reports les	n the area of design state of the art scient ed systems oment teams experiments	and development of ific methods shall be		
3	Recommend Keen interes nications sys Solid e Solid l Basic l Solid l Lectur	ded prerequisites for at to develop and explo- stems using scientific experience in program knowledge in object of knowledge of design knowledge in comput- tes in "Communicatio	or participation lore challenging so methods. Further nming Java and/o priented analysis a patterns, refactor ter communication n Networks I" and	plutions and applicative expect: for C# (C/C++). and design. fing and project mathematication is recom- d "Communication	ations in cutting edge nagement. nmended. Networks II" are reco	e multimedia commu-		
4	Form of exa Module exa • Modul Report (incl Colloquium beginning of	amination m: e exam (Study achie uding submission of (testate), but never f the lecture.	vement, Oral/writ programming co more than two o	tten examination, I de) and/or Preser ut of it. The type o	Default RS) ntation and/or Oral of examination will h	examination and/or be announced in the		

5	<b>Prerequisite for</b> Passing the final	the award of credit points module examination			
6	<ul><li>Grading</li><li>Module exam:</li><li>Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</li></ul>				
7	<b>Usability of the</b> MSc Wi-ETiT, BS	<b>module</b> c/MSc CS, MSc Wi-CS, MSc ETiT, MSc iST			
8	Grade bonus compliant to §25 (2)				
9	References Each topic is cov chapters from fol • Andrew Tar • Raj Jain: " Measureme • Joshua Bloo • Erich Gam Software" ( • Martin Fow • Kent Beck:	rered by a selection of papers and articles. In addition we re- lowing books: nenbaum: "Computer Networks". Prentice Hall PTR (ISBN 013) The Art of Computer Systems Performance Analysis: Techni ent, Simulation, and Modeling" (ISBN 0-471-50336-3) ch: "Effective Java - Programming Language Guide" (ISBN-13: na, Richard Helm, Ralph E. Johnson: "Design Patterns: Object ISBN 0-201-63361-2) ler: "Refactorings - Improving the Design of Existing Code" (ISBN- "Extreme Programming Explained - Embrace Changes" (ISBN-	ecommend reading of s 30384887) 3ques for Experimental 978-0201310054) cts of Reusable Object O 5BN-13: 978-020148567 -13: 978-0321278654)	elected Design, riented 77)	
Co	ırses				
	<b>Course nr.</b> 18-sm-2130-pr	<b>Course name</b> Multimedia Communications Project Lab			
	<b>Instructor</b> Prof. DrIng. Ra Julian Zobel, M.S	lf Steinmetz, Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing. Sc. Fridolin Siegmund	<b>Type</b> Internship	<b>SWS</b> 6	

Мо	dule name							
Pro	Project Seminar Communication and Sensor Systems							
Mo	dule nr.	Credit points	Workload	Self-study	Module o	duration	Module cyc	cle
18-	zo-1041	8 CP	240 h	180 h	1 Term		Every Seme	ester
Lar Ger	<b>iguage</b> man/English			Prof Dr-Ing Abc	lelhak Zou	hir		
1	<ul> <li>Teaching content</li> <li>Investigating and solving specific problems concerning communication and sensor systems (Problems concerning communications engineering, microwave technology, signal processing, sensor networks etc. are possible, topics will be defined out of the recent research topics of the involved labs), working on a a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications for a given task, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions and defending them in an oral discussion including audience.</li> </ul>							
2	<ul> <li>Learning objectives</li> <li>Upon successful completion of the module, students will be able to: <ul> <li>the ability to apply methods of communication and sensor systems to practical problems</li> <li>deep and special knowledge in a particular field of communication and sensor systems (communications engineering), RF technology, signal processing, sensor networks</li> <li>the skills to find, analyze and evaluate scientific reference papers for a particular topic</li> <li>the capability to summarize the achieved scientific findings in the form of a concise report</li> <li>the ability to present and discuss achieved results in the form of a presentation in front of an audience</li> </ul> </li> </ul>							
3	Recommended prerequisites for participation Previous knowledge in chosen discipline, e.g. communication technology, signal processing, microwave technol- ogy, sensor networks							
4	Form of exa Module exa • Modul Report and/	<b>mination</b> n: e exam (Study achie or Presentation. The	vement, Oral/wright type of examinat	tten examination, I ion will be announ	Default RS) ced in the	) beginning	of the lecture	2.
5	Prerequisite Passing the	e <b>for the award of c</b> final module examina	<b>redit points</b> ation					
6	Grading Module exan • Modul	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Veighting:	100 %)		
7	Usability of BSc ETiT, BS	<b>the module</b> Sc Wi-ETiT, BSc CE, I	BSc iST, BSc MEC					
8	Grade bonu	s compliant to §25	(2)					
9	References Will be anno	ounced in the lecture						
	<b>Course nr.</b> 18-zo-1041-	Di Project Semin	ar Communication	and Sensor System	ns			
	Instructor Prof. DrIng	. Abdelhak Zoubir				<b>Type</b> Project se	eminar	SWS 4

Mo Pro	<b>dule name</b> ject Seminar (	Communication and	Sensor Systems					
Mo	dule nr.	Credit points	Workload	Self-study	Module d	duration	Module cy	cle
18-	jk-1041	8 CP	240 h	180 h	1 Term		Every Seme	ester
Lan	iguage			Module owner	6 7 1 1			
Ger	man/English			Prof. DrIng. Rol	f Jakoby			
1	Investigating and solving specific problems concerning communication and sensor systems (Problems concerning communications engineering, microwave technology, signal processing, sensor networks etc. are possible, topics will be defined out of the recent research topics of the involved labs), working on a a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications for a given task, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions including audience.							
2	<ul> <li>Learning objectives</li> <li>Upon successful completion of the module, students will be able to: <ul> <li>the ability to apply methods of communication and sensor systems to practical problems</li> <li>deep and special knowledge in a particular field of communication and sensor systems (communications engineering), RF technology, signal processing, sensor networks</li> <li>the skills to find, analyze and evaluate scientific reference papers for a particular topic</li> <li>the capability to summarize the achieved scientific findings in the form of a concise report</li> <li>the ability to present and discuss achieved results in the form of a presentation in front of an audience</li> </ul> </li> </ul>							
3	Recommended prerequisites for participation           Previous knowledge in chosen discipline, e.g. communication technology, signal processing, microwave technology, sensor networks							
4	Form of exa Module exar • Modul Report and/	<b>mination</b> n: e exam (Study achie or Presentation. The	vement, Oral/writ type of examinat	ten examination, I ion will be announ	Default RS) ced in the l	) beginning	of the lecture	2.
5	<b>Prerequisite</b> Passing the f	e for the award of c	<b>redit points</b> ation					
6	Grading Module exar • Module	n: e exam (Study achie	vement, Oral/writ	ten examination, V	Veighting:	100 %)		
7	Usability of BSc ETiT, BS	<b>the module</b> Sc Wi-ETiT, BSc CE, I	BSc iST, BSc MEC					
8	Grade bonu	s compliant to §25	(2)					
9	<b>References</b> Will be anno	ounced in the lecture						
Coι	ırses							
	<b>Course nr.</b> 18-jk-1041-r	oi Course name	ar Communication	and Sensor System	ns			
	Instructor					Type		SWS
	DrIng. Mar	tin Schüßler, Prof. D	rIng. Rolf Jakoby	7		Project se	eminar	4

Mo Pro	<b>dule name</b> ject Seminar (	Communication and	Sensor Systems				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle
18-	kl-1041	8 CP	240 h	180 h	1 Term	Every Seme	ester
Lan Ger	<b>iguage</b> man/English			<b>Module owner</b> Prof. DrIng. Anj	a Klein		
1	Teaching co Investigating defined out o and structur summarizing conclusions a	ntent g and solving specif f the recent research ing of a seminar tasl g achieved results ar and defending them	ic problems conce topics of theresea , searching and a nd conclusions by in an oral discuss	erning communica urch group. Working nalyzing of scientif means of a written ion including audie	tion and sensor syst g on a given task by c fic reference publicat n report, presenting ence.	ems. Topics one's own, org ions for a giv achieved resu	will be anizing en task, 1lts and
2	<ul> <li>Learning objectives</li> <li>Upon successful completion of the module, students will be able to: <ul> <li>the ability to apply methods of communication and sensor systems to practical problems</li> <li>deep and special knowledge in a particular field of communication and sensor systems</li> <li>the skills to find, analyze and evaluate scientific reference papers for a particular topic</li> <li>the capability to summarize the achieved scientific findings in the form of a concise report</li> <li>the ability to present and discuss achieved results in the form of a presentation in front of an audience</li> </ul> </li> </ul>						
3	Recommended prerequisites for participation Previous knowledge in chosen discipline of communication and sensor systems						
4	Form of examination         Module exam:         • Module exam (Study achievement, Oral/written examination, Default RS)         Beport and/or Presentation. The type of examination will be appounded in the beginning of the lecture						
5	<b>Prerequisite</b> Passing the f	for the award of c	<b>redit points</b> ation				
6	Grading Module exar • Module	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 100 %)		
7	Usability of BSc ETiT, BS	<b>the module</b> c Wi-ETiT, BSc CE, I	BSc iST, BSc MEC				
8	Grade bonu	s compliant to §25	(2)				
9	<b>References</b> Will be anno	unced in the lecture					
Coi	ırses						
	<b>Course nr.</b> 18-kl-1041-p	j Course name project Semina	ar Communicatior	and Sensor System	ms		
	<b>Instructor</b> M.Sc. Sumed	lh Dongare, Prof. Dr	Ing. Anja Klein		<b>Type</b> Project se	eminar	SWS

Mo Pro	<b>dule name</b> ject Seminar (	Communication and	Sensor Systems				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle
18-	kp-1041	8 CP	240 h	180 h	1 Term	Every Seme	ester
Lan Ger	<b>iguage</b> man/English			Module owner Prof. Dr. techn. H	leinz Köppl		
1	Teaching co Investigating out of the re and structure summarizing conclusions a	ntent and solving specific cent research topic ng of a seminar tasl g achieved results an and defending them	problems concern s of the research k, searching and a nd conclusions by in an oral discuss	ing communication group. Working o nalyzing of scientif means of a writter ion including audie	and sensor systems n a given task by fic reference public n report, presentin ence.	s Topics will be one's own, org ations for a giv g achieved resu	defined anizing en task, ılts and
2	<ul> <li>2 Learning objectives</li> <li>Upon successful completion of the module, students will be able to: <ul> <li>the ability to apply methods of communication and sensor systems to practical problems</li> <li>deep and special knowledge in a particular field of communication and sensor systems</li> <li>the skills to find, analyze and evaluate scientific reference papers for a particular topic</li> <li>the capability to summarize the achieved scientific findings in the form of a concise report</li> <li>the ability to present and discuss achieved results in the form of a presentation in front of an audience</li> </ul> </li> </ul>						
3	Recommended prerequisites for participation Previous knowledge in chosen discipline of communication and sensor systems						
4	<ul> <li>Form of examination Module exam:</li> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> <li>Report and/or Presentation. The type of examination will be appounded in the beginning of the lecture.</li> </ul>						
5	<b>Prerequisite</b> Passing the f	for the award of c	<b>redit points</b> ation				
6	Grading Module exan • Module	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 100 %)		
7	Usability of BSc ETiT, BS	<b>the module</b> c Wi-ETiT, BSc CE, 1	BSc iST, BSc MEC				
8	Grade bonu	s compliant to §25	(2)				
9	<b>References</b> Will be anno	unced in the lecture					
<b>Co</b> ι	ırses						
	<b>Course nr.</b> 18-kp-1041-j	Course nameojProject Semination	ar Communicatior	and Sensor System	ns		
	<b>Instructor</b> Prof. Dr. tech	n. Heinz Köppl			<b>Type</b> Project	seminar	SWS 4

Mo Pro	<b>dule name</b> ject Seminar l	Emerging Topics in S	Sensor Array and I	Multichannel Proce	essing			
<b>Mo</b> 18-	<b>dule nr.</b> pe-2040	Credit points 8 CP	Workload 240 h	Self-study 180 h	Module du 1 Term	iration	Module cyc Winter tern	cle n
Lan Eng	<b>iguage</b> glish			<b>Module owner</b> Prof. DrIng. Ma	rius Pesavent	to		
1	<b>Teaching co</b> This project- tensor data The specific research field	ontent seminar addresses n representations. thematic focus of the d. The topics will be	ew trends in sense seminar will be a announced on th	or array and multic dapted from year to e course website w	channel proce o year accord ell in advanc	essing wi ling to th ce.	th multidime e latest trend	ensional s in the
2	<b>Learning of</b> Students wil	<b>jectives</b> l understand theory,	algorithms and a	pplications of sense	or array and	multicha	nnel system.	
3	Recommend Basic knowle	<b>led prerequisites fo</b> edge in linear algebr	or participation a.					
4	Form of exa Module exar • Modul	<b>mination</b> n: e exam (Study achie	vement, Oral exar	nination, Duration	: 40 Min., De	efault RS	)	
5	Prerequisite for the award of credit points Passing the final module examination							
6	Grading Module exar • Module	n: e exam (Study achie	vement, Oral exar	nination, Weightin	g: 100 %)			
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> Sc Wi-ETiT, MSc iCl	3					
8	Grade bonu	s compliant to §25	(2)					
9	<b>References</b> Harry L. Van Wiley & Son References in	Trees, Optimum Arr s, 2002. nclude the latest scie	ray Processing: Pa entific publications	rt IV of Detection, s, seminars and bo	Estimation, a	and Mod	ulation Theor	ry, John
Coi	urses							
	<b>Course nr.</b> 18-pe-2040-	pj Course name Project Semina	ar Emerging Topic	es in Sensor Array a	and Multicha	annel Pro	cessing	
	Instructor Prof. DrIng	. Marius Pesavento,	M.Sc. David Scher	nck	л F	<b>Гуре</b> Project se	eminar	SWS 4

Mo Inte	<b>dule name</b> ernet - Practic	al Course Telecoope	ration			
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle
Lar	nguage	0.01	100 11	Module owner	1 ICIIII	Every 2. Semester
Ger	man/English			Prof. Dr. rer. nat.	Eberhard Mühlhäuse	er
1	Teaching co The Praktiku concepts in t to implement the grades w Relevant top - Introductio - Peer-to-peet - Web cachin - Internet sta	ontent im is divided into the that part and for intro- that part and for intro- that the assignment give vill be used to determ- bics are: in to Java network pre- technologies andards	ree parts. In each oducing new mater en in the lecture. nine the total grad rogramming and H	of the parts, there v rial. After the lectur Each of the assignr le for the Praktikur HTTP	will be one lecture for re, the students will h nents will be graded n.	r reviewing the basic have roughly 4 weeks separately and all of
2	<b>Learning of</b> Students wil building bloo developing a	<b>ojectives</b> Il have aquired know cks of future-generat and integrating those	ledge on currently ion Internet servic technologies.	y evolving technolc es practically and v	ogies. Thus, students vill have gathered exj	will have used these periences with using,
3	Recomment Net Centric	<b>ded prerequisites fo</b> Systems	or participation			
4	<ul> <li>Form of examination Course related exam:</li> <li>[20-00-0131-pr] (Study achievement, Oral/written examination, Default RS)</li> </ul>					
5	Prerequisite Pass exam (2	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0131-pr] (Study ac	hievement, Oral/v	vritten examinatio	n, Weighting: 100 %)	)
7	Usability of B.Sc. Inform M.Sc. Inform M.Sc. Wirtso B.Sc. Psycho Joint B.A. In B.Sc. Sportw M.Sc. Sportw	the module natik natik chaftsinformatik ologie in IT formatik vissenschaft und Info wissenschaft und Info	ormatik ormatik			
	May be used	l in other degree pro	grams.			
8	Grade bonu	is compliant to §25	(2)			
9	References Handbook o Mühlhäuser,	of Research: Ubiquito , Dr. Iryna Gurevych,	ous Computing Te 2008, Informatio	chnology for Real <sup>-</sup> n Science Referenc	Time Enterprises edi e, ISBN-10: 1599048	ted by Prof. Dr. Max 3329
Co	urses					

<b>Course nr.</b> 20-00-0131-pr	<b>Course name</b> Internet - Practical Course Telecooperation						
Instructor		<b>Type</b> Internship	SWS 4				
Mo Mo	<b>dule name</b> bile Networki	ng					
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<b>Mo</b> 20-	<b>dule nr.</b> 00-0748	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module duration 1 Term	<b>Module cycle</b> Winter term	
LanguageModule ovEnglishProf. DrIn				Module owner Prof. DrIng. The	orsten Strufe		
1	<ul> <li>Teaching content         Mobile communications and wireless networking technology has seen a thriving development in recent years. The integrated course addresses the characteristics/principles of mobile networks in detail, and practical solutions are presented. Hereby our focus is on the network layer, which is often regarded as the glue of communication systems. In addition to describing the state of the art in technology we discuss actual research problems and learn about methodologies to approach such problems systematically. The contents of the course will be deepended by exercises.     </li> <li>Course contents:         <ul> <li>Introduction to mobile and wireless communications: Applications, history, market vision</li> <li>Overview of wireless transmission: frequencies &amp; regulations, signals, antennas, signal propagation, multiplexing, modulation, spread spectrum, cellular systems</li> </ul> </li> </ul>						
	<ul> <li>Medium access control in the wireless domain: SDMA, FDMA, CDMA TDMA (fixed, Aloha, CSMA, DAMA, PRMA, MACA, collision avoidance, polling)</li> <li>Wireless local area networks: IEEE 802.11 standard including physical layer, MAC layer and access schemes, quality of service and power management</li> <li>Wireless metropolitan area networks: Wireless mesh networks, IEEE 802.16 standard including modes of operation, medium access control, quality of service and scheduling</li> <li>Mobility at network layer: Concepts to support mobility on various layers, Mobile IP</li> <li>Ad hoc networks: Terminology, basics and applications, characteristics of ad hoc communication, ad hoc routing paradigms and protocols</li> <li>Performance evaluation of mobile networks: Overview of performance evaluation, systematic approach / common mistakes and how to avoid them, experimental design and analysis</li> <li>Mobility at transport layer: Variants of TCP (indirect TCP, snoop TCP, mobile TCP, wireless TCP)</li> </ul>						
2	<ul> <li>Mobility at application layer. Outlook: Applications for mobile networks and wireless sensor networks</li> <li>Learning objectives         After successfully attending the course, students have an in-deep knowledge on the working of mobile communication networks. They have gained insight into media access control mechanisms dedicated to wireless communication and have a thorough understanding of mechanisms based on the network and the transport layers, with a focus on ad hoc and mesh networks. Moreover, the students have acquired knowledge about the connections between the different protocol layers and are able to apply the acquired knowledge on methodological analysis of real communication systems. The students are therefore be conversant with the characteristics and basic principles of wireless and mobile communications in theory and practice. The exercise-parts of the integrated course deepen the theoretical foundations by means of exercises, which consist of literature,     </li> </ul>					rking of mobile com- ledicated to wireless rk and the transport knowledge about the edge on methodologi- th the characteristics 'he exercise-parts of consist of literature,	
3	Basic courses in Communication Networks are recommended.						
4	<ul> <li>Form of examination Course related exam:</li> <li>• [20-00-0748-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul>						
5	Prerequisite Pass exam (	e for the award of cr 100%)	redit points				
6	Grading						

	Course related ex • [20-00-074	kam: 8-iv] (Technical examination, Oral/written examination, Weig	hting: 100 %)				
7	Usability of the module						
	B.Sc. Informatik						
	M.Sc. Informatik						
	M.Sc. Wirtschaft	sinformatik					
	B.Sc. Psychologie	e in IT					
	Joint B.A. Inform	atik psehoft und Informatik					
	M Sc. Sportwisse	inschaft und Informatik					
	Can be used in o	ther degree programs.					
8	<b>Grade bonus co</b> In dieser Vorlesu Novelle der APB u um bis zu 1.0 fül	<b>mpliant to §25 (2)</b> ng findet eine Anrechnung von vorlesungsbegleitenden Leistu Ind den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsreg Iren kann.	ngen statt, die lt. 25 (2 geln zu einer Notenverbe	.) der 5. sserung			
9	References						
	Selected literatur	re, details are given in lecture.					
Co	urses						
	Course nr.	Course name					
	20-00-0748-iv	Mobile Networking	1				
	Instructor		Туре	SWS			
	Prof. DrIng. The	orsten Strufe	Integrated course	4			

Mo Pra	dule name ctical Project	Telecooperation					
<b>Mo</b> 20-	<b>dule nr.</b> 00-0485	Credit points 9 CP	Workload 270 h	Self-study 180 h	Module duration 1 Term	Module cycle Every 2. Semester	
Lar Gei	<b>nguage</b> rman/English		I	Module owner Prof. Dr. rer. nat.	Eberhard Mühlhäus	er	
1	1       Teaching content Research-related project.         The students will learn to conduct their own research given an individual research project. The topics will be defined together with the adviser.         Describle research topics						
	* Multimoda * Multitouch * Proactive S * Sensor Fus	lle Interaction Support System Sion					
2	Learning of After success idea to writt solve these p	<b>ojectives</b> sfully attending the o ten paper. They unde problems. They are a	course, students an rstand how to bre ble to evaluate the	re familiar with the eak down complex eir system and writ	e process of conductin research questions in te a report based on t	ng research from first to sub-problems and heir findings.	
3	Recomment	ded prerequisites fo	or participation				
4	Form of exa Course relat • [20-00	a <b>mination</b> ed exam: )-0485-pr] (Study ac	hievement, Oral/v	written examinatio	n, Default RS)		
5	Prerequisite Pass exam (2	e for the award of c 100%)	redit points				
6	Grading Course relat • [20-00	ed exam: )-0485-pr] (Study ac	hievement, Oral/v	written examinatio	n, Weighting: 100 %	)	
7	<ul> <li>7 Usability of the module <ul> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> <li>M.Sc. Wirtschaftsinformatik</li> <li>B.Sc. Psychologie in IT</li> <li>Joint B.A. Informatik</li> <li>B.Sc. Sportwissenschaft und Informatik</li> <li>M.Sc. Sportwissenschaft und Informatik</li> <li>Can be used in other degree programs</li> </ul> </li> </ul>						
8	Grade bonu	is compliant to §25	(2)				
9	<b>References</b> Various						
Co	Courses						

<b>Course nr.</b> 20-00-0485-pr	Course name Practical Project Telecooperation		
<b>Instructor</b> Prof. Dr. rer. nat.	Eberhard Mühlhäuser	<b>Type</b> Internship	<b>SWS</b> 6

Mo Net	<b>dule name</b> work, Traffic	and Quality Manage	ment for Internet	Services				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle		
Lar	nguage	3 CP	90 11	Module owner	1 Ierm	Every 2. Semester		
Eng	glish			Prof. Dr. rer. nat.	Eberhard Mühlhäus	er		
1	<b>Teaching content</b> Introduction into management of Internet service provider (ISP-)networks for integrating IP service platforms with their quality and traffic profiles.							
2	<ul> <li>With their quarty and traffic profiles.</li> <li>2 Learning objectives Course Content: Requirements and measures to ensure Quality-of-Service (QoS) <ul> <li>criteria from the application &amp; user perspective (QoE: Quality of Experience).</li> <li>QoS Architecture in IP Networks: Differentiated &amp; Integrated Services</li> <li>QoS support &amp; impact per application in IP traffic mix (video streaming, VoIP, web browsing, downloads, social networking etc.) Quality Assurance for Internet Services in ISP Network Infrastructures <ul> <li>Network and Transport Layer Impact: Routing (OSPF, BGP), Multiprotocol Label Switching (MPLS), TCP with protection against errors and failures.</li> <li>measurement, monitoring, optimization of IP traffic regarding QoS</li> <li>Quality assurance in service overlays and at application level</li> <li>Content Delivery Networks (CDN), Clouds and Peer-to-Peer Networks (P2P) incl. distributed caches, transport path optimization, scalability</li> <li>-IETF Standardization (CDN Interconnection, ALTO: Appl. Layer Traffic Opt.)</li> </ul></li></ul></li></ul>							
3	Recommen Recommend Prerequisite Kommunika	<b>ded prerequisites fo</b> led: es: Basic knowledge tionsnetze I and II ar	or participation in computer science re recommended.	nce and Internet a	applications is requir	red. The courses on		
4	Form of exa Course relat • [20-00 The form of two of the for Written exa	amination red exam: D-0056-vl] (Technical the examination wil ollowing forms is pos um (duration 60 or	examination, Ora l be announced at sible. 90 or 120 minut	al/written examina the beginning of t tes), oral exam (d	tion, Default RS) he course. One or a luration 15 or 30 n	combination of max. ninutes), homework		
5	Prerequisit	e for the award of c	redit points					
6	Grading         Course related exam:         • [20-00-0056-vl] (Technical examination, Oral/written examination, Weighting: 100 %)							
7	<ul> <li><sup>7</sup> Usability of the module</li> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> </ul>							
8	Grade bonu	in other degree prog	(2)					
1		1 0 0 0 0 - 0						

9	References					
	Will be given in	lecture.				
Co	urses					
	Course nr.	Course name				
	20-00-0056-vl	Network, traffic and quality management for Internet service	es			
	Instructor		Туре	SWS		
			Lecture	2		

Mo Mu	<b>dule name</b> ltimedia Com	munications Seminar	r I				
<b>Mo</b>	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
Lar	nguage man/English	401	120 11	Module owner Prof. DrIng. Rali	f Steinmetz	Every Semester	
1	Teaching content         The seminar investigates current and upcoming topics in multimedia communication systems, which are expected to be of utmost importance for the future evolution of the Internet and information technology in goal. The goal is to learn more about multimedia communication systems by studying, summarizing, and presenting top quality papers from recent high quality networking research journals, magazines, or conferences. The selection of topics corresponds to the research area of participating researchers.         Possible topics are:       • Knowledge & Educational Technologies         • Self organizing Systems & Overlay Communication         • Mobile Systems & Sensor Networking         • Service-oriented Computing         • Multimedia Technologies & Serious Games						
2	Learning objectives         The students are actively studying cutting edge scientific articles, standards, and books about multimedia communication systems and applications, which are expected to be of utmost important for the future of the Internet.         Students acquire competences in the following areas:         • Searching and reviewing of relevant scientific literature         • Analysis and evaluation of complex technical and scientific information         • Writing of technical and scientific summaries and short papers         • Presentation of complex technical and scientific information						
3	Recommen	ded prerequisites fo	or participation				
4	Form of exa Module exa • Modul Report and/ the lecture.	amination m: e exam (Study achie or Presentation and/o	vement, Oral/writ or Colloquium. Th	tten examination, I le type of examinat	Default RS) ion will be announce	d in the beginning of	
5	Prerequisite Passing the	e for the award of c final module examina	redit points ation				
6	Grading         Module exam:         • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)						
7	Usability of CS, WiCS, E	the module TiT, Wi-ETiT, BSc/M	Sc iST				
8	Grade bonu	is compliant to §25	(2)				
9 Coi	References Depending o 1rses	on specific topic (sele	ected articles of jou	urnals, magazines,	and conferences).		

<b>Course nr.</b> 18-sm-2300-se	<b>Course name</b> Multimedia Communications Seminar I		
<b>Instructor</b> Prof. DrIng. Ra Julian Zobel, M.S	lf Steinmetz, Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing. Sc. Fridolin Siegmund	<b>Type</b> Seminar	SWS 2

Mo Sof	<b>dule name</b> tware Defined	Networking						
<b>Mo</b> 18-	<b>dule nr.</b> sm-2280	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module 1 Term	duration	Module cyc Winter tern	c <b>le</b> n
Lar Ger	LanguageModule ownerGerman/EnglishProf. DrIng. Ralf Steinmetz							
1	Teaching content         The course deals with topics in the area of software defined networking:         • SDN Data Plane         • SDN Control Plane         • SDN Application Plane         • Network Function Virtualization         • Network Virtualization and Slicing         • QoS and QoE in Software Defined Networks							
2	Learning ob Upon comple as well as ba	<b>jectives</b> etion of the module, sic technologies and	students will have applications.	gained in-depth in	sights into	o Software	Defined Netw	vorking,
3	Recommende Basic courses recommende	led prerequisites for s of the first 4 semested.	or participation ters are required.	Knowledge of lectu	res Comm	unication I	Networks I an	d II are
4	Form of exa Module exam • Module The examina 15 students r will be annou	mination n: e exam (Technical ex tion takes place in fo register, the examina unced in the beginni	xamination, Oral/ orm of a written ex tion will be an ora ing of the lecture.	written examinatio am (duration: 90 n al examination (dur	n, Duratic ninutes). If ration: 20	on: 90 Min. f one can es min.). The	, Default RS) stimate that le type of exam	ess than vination
5	<b>Prerequisite</b> Passing the f	e <b>for the award of c</b> inal module examina	<b>redit points</b> ation					
6	Grading Module exan • Module	n: e exam (Technical ez	xamination, Oral/	written examinatio	n, Weight	ing: 100 %	))	
7	<b>Usability of</b> MSc ETiT, BS	<b>the module</b> Sc/MSc iST, MSc Wi	-ETiT, CS, Wi-CS					
8	Grade bonu	s compliant to §25	(2)					
9	9 References Textbooks as indicated. Slides and paper copies as necessary.							
Cot	ırses	I						
	<b>Course nr.</b> 18-sm-2280-	vl Software Defin	ned Networking					
	<b>Instructor</b> DrIng. Rali Scheuerman	f Kundel, Prof. Dr. n, M.Ed. Benjamin E	Boris Koldehofe, Becker	Prof. Dr. rer. na	ıt. Björn	<b>Type</b> Lecture		SWS 2

<b>Course nr.</b> 18-sm-2280-ue	<b>Course name</b> Software Defined Networking		
<b>Instructor</b> DrIng. Ralf Ku Scheuermann, M	ndel, Prof. Dr. Boris Koldehofe, Prof. Dr. rer. nat. Björn .Ed. Benjamin Becker	<b>Type</b> Practice	SWS 2

Mo Ubi	dule name	outing in business pro	ocesses				
<b>Mo</b> 20-	<b>dule nr.</b> 00-0121	Credit points 3 CP	Workload 90 h	Self-study 60 h	Module duration	Module cycle Every 2. Semester	
Lar Ger	<b>nguage</b> rman/English			<b>Module owner</b> Prof. Dr. rer. nat.	Eberhard Mühlhäus	er	
1	Teaching content- Learning how state-of-the-art ubiquitous computing technologies can be utilized in enterprise business processes and in the context of smart city services- Identifying technologies' economic potential for business processes and in the context of smart cities- Understanding underlying technologies, their benefits, challenges, and corresponding business cases- Technologies considered will be RFID technology and its integration with business processes, other smart items (e.g., smart shelfs), etc Demonstration of how integration works between the real world and the virtual world as it is represented in enterprise software systems today - Hands-on experience and live demonstrations						
2	<b>Learning objectives</b> After participation in this course, students will have aquired knowledge about implications of ubiquitous computing on business to business processes and in the context of smart city services in conjunction with basic concepts.						
3	Recommen	ded prerequisites fo	or participation				
4	Form of exa Course relat • [20-00	amination ted exam: D-0121-vl] (Technical	l examination, Ora	al/written examina	tion, Default RS)		
5	<b>Prerequisit</b> Pass exam (	e for the award of c 100%)	redit points				
6	Grading Course relat • [20-00	ted exam: D-0121-vl] (Technical	l examination, Ora	al/written examina	tion, Weighting: 100	%)	
7	Usability of the moduleB.Sc. InformatikM.Sc. InformatikM.Sc. VirtschaftsinformatikB.Sc. Psychologie in ITJoint B.A. InformatikB.Sc. Sportwissenschaft und InformatikM.Sc. Sportwissenschaft und InformatikMay be used in other degree programs.						
8	Grade bonu	is compliant to §25	(2)				
9	References						

- Mühlhäuser, M.; Gurevych, I. (Eds.): Ubiquitous Computing Technology for Real Time Enterprises Information Science Reference, Dezember, 2007

- Finkenzeller, K: RFID-Handbuch. Grundlagen und praktische Anwendungen von Transpondern, kontaktlosen Chipkarten und NFC. Hanser Fachbuch; Auflage: 5., aktual. u. erw. Aufl. (1. Oktober 2008)

- Fleisch, E.; Mattern, F. (Hrsg.): Das Internet der Dinge: Ubiquitous Computing und RFID in der Praxis, Springer, Berlin, Heidelberg, New York 2005

- Österle, H.; Fleisch, E.; Alt, R.: Business Networking - Shaping Collaboration between Enterprises, Springer
- Callaway, E.H.: Wireless Sensor Networks: Architectures and Protocols, Auerbach Publications

<b>Course nr.</b> 20-00-0121-vl	<b>Course name</b> Ubiquitous computing in business processes		
Instructor		<b>Type</b> Lecture	SWS 2

Mo Rac	Module name Radar Techniques							
<b>Mo</b> 18-	<b>dule nr.</b> jk-2040	Credit points 3 CP	Workload 90 h	Self-study 60 h	Module of 1 Term	duration	Module cyc Winter tern	c <b>le</b> n
Lar Ger	nguage man			<b>Module owner</b> Prof. DrIng. Rol	f Jakoby			
1	1 <b>Teaching content</b> First, there will be an introduction of different radar techniques, describing their concepts and principles, their applications and the operating frequency ranges. In a historical survey, the radar ranges and propagation effects will be dealt with. In the second part, various primary and secondary radar techniques will be investigated in detail, including specific techniques of radar signal processing and -analysis.							
2	<b>Learning of</b> Students wil and range of processing.	<b>bjectives</b> l know about concep f objects. They lear They will understand	ts and principles t n about the funct l the major physic	o detect objects as ional principles of al propagation effe	well as to various ra ects.	determine adar syster	the angular p ns, including	position g signal
3	<b>Recommend</b> Fundamenta	led prerequisites for ls of Communication	or participation ns, Microwave Eng	ineering I				
4	Form of exa Module exar • Modul	<b>mination</b> n: e exam (Technical ex	amination, Oral e	examination, Durat	ion: 30 Mi	n., Default	t RS)	
5	<b>Prerequisite</b> Passing the f	e for the award of c	redit points ation					
6	<b>Grading</b> Module exar • Modul	n: e exam (Technical ez	amination, Oral e	examination, Weigl	nting: 100	%)		
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> ISc iCE, MSc Wi-ETi	ſ					
8	Grade bonu	s compliant to §25	(2)					
9	9 References Slides, Latest Publications and Books							
Co	Courses							
	<b>Course nr.</b> 18-jk-2040-v	Course name Radar Techniq	ues					_
	InstructorTypeSWSPD Dr. habil. Holger Maune2							

Mo	Module name						
Mo	dule nr	Credit points	Workload	Self-study	Module duration	Module cycle	
20-	00-0016	5 CP	150 h	105 h	1 Term	Summer term	
Lar Ger	<b>nguage</b> rman			<b>Module owner</b> Prof. Dr. phil. nat	. Marc Fischlin		
1	1       Teaching content         Overview of Net-Centric Computing (NCC), a basic element of modern computer science. Fundamental network concepts of modeling, planning and evaluating net-centric systems         - Foundations: Service, protococols, connection, layer model         - protocol mechanisms for media access, routing, broad-/multicast         - Multimedia Data Handling         - Aspects of continuous data streams and their processing         - Quality of service: definition and mechanisms         - Multimedia - Synchronisation: Basics         - Compression procedures;						
2	<ul> <li>2 Learning objectives         <ul> <li>Overview knowledge of relevant areas and basic problems of net-centric computing (NCC)</li> <li>Reproducible comprehension of selected, elementary algorithms, protocols and procedures used in the internet</li> <li>Applicable methodological knowledge of widely applied elements of the modeling and engineering of NCC-systems</li> </ul> </li> <li>NCC is, in this context, understood as "internet technology in the broadcast sense". It covers, in particular, themes of the "classical areas" constituted by computer networks, distributed systems, multimedia and mobile communication/ mobile computing, as those from "modern areas", such as ubiquitous/pervasive computing, peer-to-peer-computing or ambient intelligence. The canonical lecture "Introduction to NCS" focusses on the area of computer networks, the understanding of which is fundamental for all other listed areas;</li> </ul>						
3	Recomment Recomment Funktionale teme", "Ein mierung".	<b>ded prerequisites fo</b> led: und objektorientiert führung in den Com	or participation te Programmierko ppilerbau", "Rech	nzepte", "Algorith nerorganisation" u	men und Datenstruk nd "Systemnahe and	turen", "Betriebssys- d parallele Program-	
4	<ul> <li>Form of examination Course related exam:</li> <li>• [20-00-0016-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul>						
5	5 Prerequisite for the award of credit points Pass exam (100%)						
6	<ul> <li>6 Grading Course related exam:</li> <li>• [20-00-0016-iv] (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>					)%)	
7	7 Usability of the module						

	<ul> <li>B.Sc. Informatik</li> <li>B.Sc. Wirtschaftsinformatik</li> <li>B.Sc. Psychologie in IT</li> <li>Joint B.A. Informatik</li> <li>B.Sc. Sportwissenschaft und Informatik</li> <li>M.Sc. Sportwissenschaft und Informatik</li> <li>B.Sc. Informationssystemtechnik</li> <li>May be used in other degree programs.</li> </ul>				
8	<b>Grade bonus compliant to §25 (2)</b> In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.				
9	ReferencesMain literature:- A. Tanenbaum, D. Wetherall: Computernetzwerke, 5te Aufl., Pearson Studium 2012- (englisch: Computer Networks, 5th Ed., Prentics Hall 2010)- J. Kurose, K. Ross: Computernetzwerke; Pearson Studium 2012 (also in english by Prentice Hall)				
	Selected chapters of: - G. Coulouris, J. Dollimore, T. Kindberg: Distributed Systems - Concept and Design, Pearson Studium - G. Krüger, D. Reschke: "Lehr- und Übungsbuch Telematik" - L. Kleinrock: Queueing Systems, vol. 1 (Wiley) - W.B. Stevens: Unix Network Programming, Volume 1: The Sockets Networking API (Addison Wesley)				
Coi	ırses				
	Course nr.Course name20-00-0016-ivComputer Networks and distributed Systems				
	Instructor		<b>Type</b> Integrated course	<b>SWS</b> 3	

Mo	dulo nomo					
Hui	nan Compute	er Interaction				
Мо	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
20-	00-0535	3 CP	90 h	60 h	1 Term	Every 2. Semester
Lan	iguage			Module owner	hists	
Ger				Prol. Dr. Bernt Sc	intele	
1	<ul> <li>Teaching content The course presents fundamental concepts, models, and theories in the area of Human Computer Interaction (HCI). More specifically, it contains the following topics: <ul> <li>Theoretical foundation on psychology and interaction design as basis for the design of intuitive user interfaces</li> <li>Overview of the different types of user interfaces</li> <li>Command line interfaces</li> <li>Graphical user interfaces (MacOS, Windows,)</li> <li>Interactive surfaces (Tabletops, Multitouch,)</li> <li>Mobile user interfaces (iOS, Android,)</li> <li>Pen-based user interfaces (electronic pens)</li> <li>Tangible user interfaces, organic user interfaces</li> <li>Speech-based user interfaces</li> <li>User studies</li> <li>Quantitative evaluation</li> <li>Qualitative evaluation</li> </ul></li></ul>					
2	Learning of After perticip - an understa - know meth - aquired an - learnt to kn	ojectives pation in this course, anding of the psycho ods of the user-centr overview on commo now and how to use t	, students will hav logic foundations ic design process n UI concepts techniques for the	e of the design of us evaluation of user	er interfaces interfaces	
3	Recommend	ded prerequisites fo	or participation			
4	<ul> <li>Form of examination Course related exam:         <ul> <li>[20-00-0535-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul> </li> </ul>					
5	<b>Prerequisite</b> Pass exam (1	e for the award of c 100%)	redit points			
6	<ul> <li>6 Grading Course related exam:</li> <li>• [20-00-0535-iv] (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>					
7	7 Usability of the module					

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik					
	M.Sc. Sportwisse	nschaft und Informatik				
	Can be used in o	her degree programs.				
8	Grade bonus compliant to §25 (2)					
9	<ul> <li>References         Literature recommendations will be updated regularly, an example might be:         Selected chapters out of:         <ul> <li>Donald Norman: The Design of Everyday Things</li> <li>Alan Dix, Janet Finlay, Gregory Abowd and Russel Beale: Human-Computer Interaction</li> <li>Jenny Preece, Yvonne Rogers and Helen Sharp: Interaction Design: Beyond Human-Computer Interaction</li> </ul> </li> </ul>					
Cot	Courses					
	Course nr.Course name20-00-0535-ivHuman Computer Interaction					
	Instructor		<b>Type</b> Integrated course	SWS 2		

Mo	dule name							
Sen	Sensor Array Processing and Adaptive Beamforming							
18	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle		
10- 1.07	pe-2000	4 GP	120 11	/JII	1 Ieim	Summer term		
Eng	glish			Prof. DrIng. Ma	rius Pesavento			
1	1 <b>Teaching content</b> This lecture course introduces the principles of modern sensor array processing and adaptive beamforming. Outline: Motivation and background; applications, narrowband and wideband signal model <u>Direction-of-arrival estimation (DoA):</u> traditional methods based on beamforming, super resolution methods, Maximum-Likelihood methods, Subspace based methods, MUSIC, ESPRIT, MODE, root-MUSIC, multidimensional source localization, approximate Maxi- mum Likelihood methods, Expectation Maximization (EM) algorithm, partial relaxation method, beamspace processing, array interpolation, partly calibrated arrays, wideband DOA estimation, spatial smoothing, forward- backward averaging, redundancy averaging, correlated sources, minimum redundancy arrays, compressed sensing and sparse reconstruction based DoA estimation, performance bounds Adaptive beamforming: Point-source model, covariance model, Wiener-Hopf equation, Minimum Variance Distortionless Response (MVDR) beamformer, Capon Beamformer, sample matrix inversion, signal self-nulling effect, robust adaptive beamforming, Hung-Turner projection beamformer, Generalized Sidelobe canceller beamformer, Eigenspace- based beamformer, non-stationary environments, modern convex optimization based beamforming, worst-case based beamforming.							
2	<b>Learning ol</b> Upon compl Sensor-Arry	<b>ojectives</b> etion of the module, s and Tensor data.	tudents will have l	earned the applicati	on of theory and algo	rithms for processing		
3	Recommen Knowledge	<b>ded prerequisites fo</b> in linear algebra.	or participation					
4	Form of exa Module exa • Modul The examin less than 10 examination	amination m: e exam (Technical ex ation takes place in students register, th a will be announced i	kamination, Oral/ form of a written he examination with n the beginning o	written examinatio 1 exam (duration: ill be an oral exam f the lecture.	n, Duration: 120 Mir 120 minutes). If or ination (duration: 2	n., Default RS) ne can estimate that 0 min.). The type of		
5	<b>Prerequisit</b> Passing the	e for the award of c	<b>redit points</b> ation					
6	<ul> <li>6 Grading Module exam:</li> <li>• Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>					))		
7	7 Usability of the module BSc / MSc etit, BSc / MSc WI-etit, MSc MEC, MSc iST, MSc iCE							
8	Grade bonu	is compliant to §25	(2)					
9	References							

- 1. Academic Press Library in Signal Processing: Volume 3 Array and Statistical Signal Processing Edited by Rama Chellappa and Sergios Theodoridis, Section 2, Edited by Mats Viberg, Pages 457-967 (2014) a) Chapter 12 - Adaptive and Robust Beamforming, Sergiy A. Vorobyov, Pages 503-552
  - b) Chapter 14 DOA Estimation Methods and Algorithms, Pei-Jung Chung, Mats Viberg, Jia Yu, Pages
  - 599-650
  - c) Chapter 15 Subspace Methods and Exploitation of Special Array Structures, Martin Haardt, Marius Pesavento, Florian Roemer, Mohammed Nabil El Korso, Pages 651-717
- 2. Spectral Analysis of Signals, Petre Stoica, Randolph Moses, Prentice Hall, April 2005Optimum Array Processing: Part IV of Detection, Estimation, and Modulation Theory, Harry L. Van Trees, Wiley Online, 2002.

#### C 11700

CO	Lourses					
	<b>Course nr.</b> 18-pe-2060-vl	<b>Course name</b> Sensor Array Processing and Adaptive Beamforming				
	<b>Instructor</b> Prof. DrIng. Ma	rius Pesavento	<b>Type</b> Lecture	<b>SWS</b> 2		
	<b>Course nr.</b> 18-pe-2060-ue	<b>Course name</b> Sensor Array Processing and Adaptive Beamforming				
	<b>Instructor</b> Prof. DrIng. Ma	rius Pesavento	<b>Type</b> Practice	<b>SWS</b> 1		

Mo Dat	Module name Data-driven Modeling - Machine Learning						
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
Lar Eng	nguage	6 CP	180 h	Module owner Prof. Dr. techn. H	l lerm Jeinz Köppl	Summer term	
1	1       Teaching content         1       Teaching content         The module provides an introduction to the emerging field of machine learning from an engineering perspective Important models and learning methods are presented and exemplified through problems from information and communication technology.         •       Fundamentals of probability theory and multivariate statistics         •       Taxonomy of machine learning problems and models (supervised, unsupervised, generative, discriminative         •       Regression and classification: theory, methods and ICT applications         •       Dimensionality reduction, clustering and big data analytics: methods and application in communication and signal processing         •       Probabilistic graphical models: categories, inference and parameter estimation         •       Fundamentals of Bayesian inference, Monte Carlo methods, Bayesian non-parametrics         •       Fundamentals of convex optimization: Solution methods and application in communications         •       Approximate algorithms for scalable Bayesian inference; application in signal processing and information theory (e.g. decoding of LDPC codes)         •       Hidden Markov models (HIMM): Theory, Algorithms and ICT applications (e.g. Viterbi decoding o convolutional codes)         •       High-dimensional statistics ("large p small n" setting), learning dependency structure in high-dimensiona data, learning causality relations from observational data.         •       Sparse estimation, random projections, compres						
2	Learning of Students ar machine lea They are a mine suitab	<b>bjectives</b> the able to interpret and arning problems. ble to reduce such le solution methods f	nd categorize spec problems to star for them.	tific engineering pr ndard machine lea	roblems from the ICT arning problems and	f domain in terms of d are able to deter-	
	They are able to implement all necessary algorithms from scratch, but they are also familiar with th state-of-the-art libraries in machine learning. They are able to determine the involved computational complexity of a method and choose an appropriate solution algorithms based on application constraints.					d choose an appro- alysis in biomedical	
3	<ul> <li>engineering, analysis of social network data, etc.</li> <li><b>Recommended prerequisites for participation</b> Good command of Matlab (for instance knowledge from course 18-st-2030 Matlab Grundkurs) and engineeri</li> </ul>				urs) and engineering		
4	mathematics         4       Form of examination         Module exam:       • Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS)         The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate th less than 10 students register, the examination will be an oral examination (duration: 30 min.). The type examination will be announced in the beginning of the lecture.				n., Default RS) ne can estimate that 0 min.). The type of		

5	<b>Prerequisite for the award of credit points</b> Passing the final module examination						
6	<ul><li>Grading</li><li>Module exam:</li><li>Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</li></ul>						
7	<b>Usability of the</b> MSc etit, BSc/M	<b>module</b> Sc iST, MSc iCE, MSc CE					
8	Grade bonus co	mpliant to §25 (2)					
9	<ul> <li>References</li> <li>Kevin P. Murphy. Machine Learning - A probabilistic perspective, MIT Press, 2012</li> <li>Christopher M. Bishop. Pattern recognition and Machine Learning, Springer, 2006</li> <li>Peter Bühlmann und Sara van de Geer. Statistics of high-dimensional data - Methods, theory and applications, Springer, 2011</li> </ul>						
Co	Course nr.	Course name					
	<b>Instructor</b> Prof. Dr. techn. I	Heinz Köppl, Prof. DrIng. Anja Klein	<b>Type</b> Lecture	<b>SWS</b> 2			
	Course nr.Course name18-kp-2110-ueData-driven Modeling - Machine Learning						
	InstructorTypeSWSProf. Dr. techn. Heinz Köppl, Prof. DrIng. Anja KleinPractice1						
	Course nr. 18-kp-2110-prCourse name Data-driven Modeling - Machine Learning Lab						
	Instructor Prof. Dr. techn. I	Heinz Köppl, Prof. DrIng. Anja Klein	<b>Type</b> Internship	<b>SWS</b> 1			

Mo TK3	Module name TK3: Ubiquitous / Mobile Computing						
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
20- Lar	00-0120	6 CP	180 h	120 n Module owner	1 Ierm	Summer term	
Ger	rman			Prof. Dr. rer. nat.	Eberhard Mühlhäus	er	
1	<ul> <li>Provide the second se</li></ul>						
	Course Cont	ent:					
	<ul> <li>Introduction to Ubiquitous Computing</li> <li>Mobile Communication</li> <li>Internet of Things: RFID and Smart Items</li> <li>Service Discovery &amp; Cloudlets</li> <li>Context- and Location-aware Computing</li> <li>Human Computer Interaction</li> <li>Privacy and Trust in Ubiquitous Computing</li> </ul>						
2	Learning ob After success They unders these challer	<b>jectives</b> sfully attending the c tand the fundaments nges. They are able t	ourse, students ar al challenge of ub o apply their know	e familiar with the iquitous computing vledge to build ubi	technical basis of mo g. They know current quitous computing sy	bbile communication. approaches to solve ystems.	
3	Recomment Computer N	<b>led prerequisites fo</b> etzwerke and Distrib	or participation outed Systems				
4	Form of exa Course relate • [20-00	<b>mination</b> ed exam: -0120-iv] (Technical	examination, Ora	al/written examina	tion, Default RS)		
5	Prerequisite Pass exam (1	e for the award of c 100%)	redit points				
6	<ul> <li>6 Grading Course related exam:</li> <li>• [20-00-0120-iv] (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>					%)	
7	<ul> <li>7 Usability of the module</li> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> <li>M.Sc. Wirtschaftsinformatik</li> <li>B.Sc. Psychologie in IT</li> <li>Joint B.A. Informatik</li> <li>B.Sc. Sportwissenschaft und Informatik</li> <li>M.Sc. Sportwissenschaft und Informatik</li> <li>May be used in other degree programs.</li> </ul>						
8	Grade bonu	s compliant to §25	(2)				

	In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.					
9	<b>References</b> Literature recommendations will be updated regularly, an example might be: A Primary Literature:					
	Handbook of R Dr. Max Mühlhät	esearch: Ubiquitous Computing Technology for Real Tim user, Dr. Iryna Gurevych, 2008, Information Science Reference	e Enterprises edited l , ISBN-10: 1599048329	by Prof.		
	B Secondary Literature:					
	<ol> <li>F. Adelstein, S</li> <li>Stefan Poslad:</li> <li>Kapitel Mobill</li> <li>LTE, GSM, GPRS</li> <li>J. Krumm (Ed. D. Cook, S. Das (</li> </ol>	. Gupta et al.: Fundamentals of Mobile & Pervasive Computing Ubiquitous Computing, Wiley 2009, ISBN 978-0-470-03560-3 communikation: M. Sauter: Grundkurs Mobile Kommunikatio und Wireless LAN; Vieweg-Teubner Studium 2010 ): Ubiquitous Computing Fundamentals, CRC Press 2010 Ed.): Smart Environments, Wiley 2005	g McGraw Hill 2004, 3 nssysteme: UMTS, HSD	PA und		
Cot	urses	Г <u> </u>				
	Course nr.Course name20-00-0120-ivTK3: Ubiquitous / Mobile Computing					
	Instructor		<b>Type</b> Integrated course	SWS 4		

Mo	Module name						
Op	Optical Communications - Components						
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
Lar		0 CP	180 11	Module owner	1 101111	Summer term	
Eng	glish			Prof. Dr. rer. nat.	Sascha Preu		
1	Image: Prof. Dr. Fer. nat. Sascha Fred         Image: Prof. Dr. Fer. nat. Sascha Fred						
2	Students un tions) of the	derstand concepts, ba	asics of physics, de sive and active con	esign criteria and sy nponents of optical	ystem requirements ( l communications.	component specifica-	
3	<b>Recommen</b> etit $1 + 2$ , P	<b>ded prerequisites fo</b> Physics	or participation				
4	Form of exa Module exa • Modul	<b>amination</b> m: e exam (Technical ex	xamination, Exam	ination, Duration:	90 Min., Default RS)		
5	<b>Prerequisit</b> Passing the	e for the award of cr final module examina	redit points				
6	<ul> <li>Grading Module exam:</li> <li>Module exam (Technical examination, Examination, Weighting: 100 %)</li> </ul>						
7	<b>Usability of</b> BSc ETiT, M	<b>the module</b> Sc ETiT, MSc iCE					
8	Grade bonus compliant to §25 (2)						

9	References					
	Lecture slides		1 1 (1)			
	IEXTDOOK (M. CV	ijetic, I. B. Djordjevic: "Advanced Optical Communication Syste	ems and Networks")			
Co	urses					
	Course nr. Course name					
	18-pr-1050-vl Optical Communications - Components					
	Instructor		Туре	SWS		
	Prof. Dr. rer. nat.	Sascha Preu	Lecture	3		
	Course nr.	Course name				
	18-pr-1050-ue	Optical Communications - Components				
	Instructor Type SWS					
	Prof. Dr. rer. nat.	Sascha Preu	Practice	1		

Mo Dat	<b>dule name</b> a Science I					
<b>Mo</b> 18-	<b>dule nr.</b> zo-2110	Credit points 5 CP	Workload 150 h	<b>Self-study</b> 90 h	Module duration	Module cycle Summer term
Lan Eng	<b>iguage</b> dish	1	I	<b>Module owner</b> Prof. DrIng. Abdelhak Zoubir		
1       Teaching content         The course covers the following topics:       •         •       Python programming basics         •       Data science introduction         •       Data storage and formats         •       Data storage and formats         •       Data exploration and visualization         •       Statistical methods and inference         •       Descriptive statistics (uni & bivariate)         •       Inferential statistics         •       Feature extraction         •       Time Series Data         •       Image data         •       Audio data         •       Statistical learning         •       Cross-validation, overfitting, annotation         •       Regression         •       Classification						
2	<b>Learning ol</b> This module knowledge a to visualizat	bjectives offers an introduction about all parts of a Da ion.	n to the topic of D ata Science process	ata Science with a s sing: From storage/	strong practical orien /data acquisition over	tation. Students gain r inferential statistics
3	Recommen	ded prerequisites fo	or participation			
4	Form of exa Module exa • Modul The examina 16 students will be anno	amination m: le exam (Technical ex ation takes place in fo register, the examina punced in the beginni	amination, Oral/ rm of a written ex tion will be an ora ng of the lecture.	written examinatio am (duration: 90 n ll examination (dur	n, Duration: 90 Min. ninutes). If one can es ration: 45 min.). The	, Default RS) stimate that less than type of examination
5	Prerequisite Passing the	e for the award of c final module examina	<b>redit points</b> ation			
6	Grading Module exa • Modul	m: le exam (Technical ex	kamination, Oral/	written examinatio	n, Weighting: 100 %	)
7	Usability of	the module				
8	Grade bonu Yes	is compliant to §25	(2)			
9	References					

- Lecture notes and slides can be downloaded here:
  - http://www.spg.tu-darmstadt.demoodle
- Further reading:

  - Wes McKinney: Python for Data Analysis, O'Reilly, 2017
    Christopher M. Bishop: Pattern Recognition and Machine Learning, 2011
  - James, Witten, Hastie and Tibshirani, Introduction to Statistical Learning, Springer, 2017

00						
	<b>Course nr.</b> 18-zo-2110-vl	<b>Course name</b> Data Science I				
	<b>Instructor</b> DrIng. Christiar	1 Debes	<b>Type</b> Lecture	SWS 2		
	<b>Course nr.</b> 18-zo-2110-ue	<b>Course name</b> Data Science I				
	<b>Instructor</b> DrIng. Christian	1 Debes	<b>Type</b> Practice	<b>SWS</b> 2		

Мо	dule name						
Dat	a Science II	1	Γ			1	
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
18-	zo-2120	8 CP	240 h				
Lan Eng	glish			Prof. DrIng. Abc	lelhak Zoubir		
1	<ul> <li>Teaching content         The course covers the following topics:         <ul> <li>Data Science Advanced Methods</li> <li>Data Management + Big data frameworks</li> <li>Statistical Learning                 <ul></ul></li></ul></li></ul>						
2	Learning ol After succes strong pract novel metho	<b>ojectives</b> sful completion of the ical relevance. They b ods in machine learni	e module, the stud have become fami ng) and can apply	lents have an in-de liar with modern da 7 them in a project	pth understanding o ata science technolog with real world data	f data science with a ;ies (from big data to	
3	Recomment Data Science	<b>ded prerequisites fo</b> e I (Lecture)	or participation				
4	Form of exa Module exa • Modul Report and/ the lecture.	amination m: e exam (Study achie or Presentation and/o	vement, Oral/wri or Colloquium. Th	tten examination, I le type of examinat	Duration: 90 Min., Do ion will be announce	efault RS) d in the beginning of	
5	Prerequisite Passing the	e for the award of c	<b>redit points</b> ation				
6	Grading Module exa • Modul	m: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 100 %)		
7	Usability of	the module					
8	Grade bonu	is compliant to §25	(2)				
9	References						

Lecture notes and slides can be downloaded here:

- http://www.spg.tu-darmstadt.de
- Moodle platform

Further reading:

- Wes McKinney: Python for Data Analysis, O'Reilly, 2017
- Christopher M. Bishop: Pattern Recognition and Machine Learning, 2011
- James, Witten, Hastie and Tibshirani, Introduction to Statistical Learning, Springer, 2017

<b>Course nr.</b> 18-zo-2120-se	Course name Data Science II		
<b>Instructor</b> DrIng. Christian	1 Debes	<b>Type</b> Seminar	SWS 4

Mo Inte	dule name ernational Sur	nmer School 'Microv	vaves and Lightwa	ives'				
<b>Mo</b> 18-	<b>dule nr.</b> pr-2020	Credit points 4 CP	Workload 120 h	Self-study 90 h	Module d	luration	Module cyc Summer ter	c <b>le</b> rm
Lar Eng	<b>iguage</b> glish			<b>Module owner</b> Prof. Dr. rer. nat. Sascha Preu				
1	<b>Teaching co</b> This summe technology,	ontent er school covers the and optical commun	fundamentals ar ication systems wi	nd the latest devel th particular focus	lopments o on the phy	of microwa vsical conce	ive electronic epts involved	cs, THz
2	<ul> <li>Learning objectives         Students understand the presented research topics, e.g.         <ul> <li>topics of microwave engineering, THz engineering, and optical communications</li> <li>of related electronics</li> <li>the influence of the relevant properties of materials and of waveguides on signal processing.</li> </ul> </li> <li>They gain inside into the latest developments in these fields.</li> </ul>							
3	Recommended prerequisites for participation							
4	Form of exa Module exa • Modul	<b>mination</b> n: e exam (Study achie	vement, Oral exa	nination, Duration	: 30 Min., I	Default RS	))	
5	Prerequisite Passing the	e <b>for the award of c</b> final module examin	<b>redit points</b> ation					
6	Grading Module exan • Modul	n: e exam (Study achie	vement, Oral exa	nination, Weightin	ıg: 100 %)			
7	<b>Usability of</b> BSc ETiT, M	<b>the module</b> Sc ETiT						
8	Grade bonu	s compliant to §25	(2)					
9	References A script (Eng	glish) will be distribu	ited or slides can	be downloaded.				
Co	urses							
	<b>Course nr.</b> 18-pr-2020-	se International	Summer School "N	licrowaves and Lig	ghtwaves"			
	<b>Instructor</b> Prof. Dr. rer.	nat. Sascha Preu, P	rof. DrIng. Rolf J	akoby		<b>Type</b> Seminar	_	SWS 2

<b>Mo</b> Gra	<b>dule name</b> oph Signal Pro	ocessing. Learning an	d Optimization			
Мо	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
18-	pe-2080	6 CP	180 h	120 h	1 Term	Winter term
<b>Lar</b> Eng	<b>iguage</b> glish			Module owner Prof. DrIng. Marius Pesavento		
1	Teaching coThe course of• Motivation• Fundation- d- d- A- C• Graph- C- C <tr< th=""><th>ontent covers the following t ation, Applications mentals efinition of graphs, c djecency matrix, Gra covariance matrix, cor signal processing consensus, Diffusion graph spectral analysi otal variational norm andlimited graph sig graph filters, Graph sa ork topology inference ink prediction association network in comographic network in comographic network earson product-mom causality, Partial correct conditional independer caussian Markov Ran- graphical LASSO, Gra- pplications analysis ubgraph identification ization over graphs verage consensus, di cradient tracking, pus pplications neuronal (convolution</th><th>asses of graphs, p ph Laplacian, Gra nditional depende s, Graph Fourier T , Graph Frequenc nals, smoothness ampling theorem e nference topology inference ent correlation elation ence graph dom Fields phical LASSO with m ffusion, exact diff sh-sum algorithm, onal) network</th><th>oroperties of graphs uph shift operator ence, precision mat fransform ies ce n Laplacian constra usion etc.</th><th>s, signals defined ove rix int</th><th>er graphs</th></tr<>	ontent covers the following t ation, Applications mentals efinition of graphs, c djecency matrix, Gra covariance matrix, cor signal processing consensus, Diffusion graph spectral analysi otal variational norm andlimited graph sig graph filters, Graph sa ork topology inference ink prediction association network in comographic network in comographic network earson product-mom causality, Partial correct conditional independer caussian Markov Ran- graphical LASSO, Gra- pplications analysis ubgraph identification ization over graphs verage consensus, di cradient tracking, pus pplications neuronal (convolution	asses of graphs, p ph Laplacian, Gra nditional depende s, Graph Fourier T , Graph Frequenc nals, smoothness ampling theorem e nference topology inference ent correlation elation ence graph dom Fields phical LASSO with m ffusion, exact diff sh-sum algorithm, onal) network	oroperties of graphs uph shift operator ence, precision mat fransform ies ce n Laplacian constra usion etc.	s, signals defined ove rix int	er graphs
2	Learning ol Graph signa interdisciplin will have gai learning, op concepts, al	bjectives al processing (i.e., th nary research field wi ined systematic knowl timization in graph ne gorithms and applica	e processing of s th numerous and c ledge in graph sigr etworks, and learn tion areas of grap	ignals defined over liverse applications. nal processing theor ing using graph neu h signal processing	r graphs) and netwo Upon completion of y, graph network ana Iral networks. They h	ork analysis form an the module, student alysis, graph topolog aave learned essentia
3	<b>Recommen</b> Basic knowl	<b>ded prerequisites fo</b> edge in linear algebra	or participation	ysis.		

4 Form of examination

	Module exam: • Module exa In general, the ex register in semes 20 min.). The typ registration phas	<ul> <li>Module exam:</li> <li>Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS)</li> <li>In general, the examination takes place in form of a written exam (duration: 120 minutes). If up to 20 students register in semesters in which the lecture does not take place, there will will be an oral examination (duration: 20 min.). The type of examination will be announced within one working weeks after the end of the examination registration phase.</li> </ul>				
5	<b>Prerequisite for</b> Passing the final	<b>the award of credit points</b> module examination				
6	Grading Module exam: • Module exa	<ul> <li>Grading</li> <li>Module exam:</li> <li>Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>				
7	<b>Usability of the</b> MSc (WI-) etit, E	<b>module</b> Sc/MSc iST, MSc iCE				
8	Grade bonus co	mpliant to §25 (2)				
9	References  • Lecture not	res and slides can be downloaded here: nts.tu-darmstadt.de e ding: M. Djuric, Cédric Richard, Cooperative and Graph Signal Pro 9780128136775.	cessing, Academic Press	5, 2018,		
Co	urses					
	<b>Course nr.</b> 18-pe-2080-vl	<b>Course name</b> Graph signal processing, learning and optimization				
	<b>Instructor</b> Prof. DrIng. Ma	rius Pesavento	<b>Type</b> Lecture	<b>SWS</b> 3		
	<b>Course nr.</b> 18-pe-2080-ue	<b>Course name</b> Graph signal processing, learning and optimization				
	Instructor Prof. DrIng. Ma	rius Pesavento	<b>Type</b> Practice	<b>SWS</b> 1		

Mo Res	Module name Resilient Communication Networks						
Мо	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
18-	sm-2340	4 CP	120 h	75 h	1 Term	Summer term	
Lan	iguage			Module owner			
Eng				Prof. Dr. rer. nat.	Bjorn Scheuermann		
1	<ul> <li>Teaching content</li> <li>The course covers the following topics:         <ul> <li>Resilience in the different disciplines</li> <li>Resilience in communication networks</li> <li>Importance of resilience for communication networks</li> <li>Requirements for current communication networks</li> <li>Methods to increase resilience in communication networks</li> <li>Wireless networks (e.g., mobile communications)                 <ul> <li>Wired networks</li> <li>Resilient network management in software-defined networks</li> <li>Resilience through adaptivity in software-defined networks</li></ul></li></ul></li></ul>						
2	2 Learning objectives Students are familiar with the idea and necessity of resilience in various disciplines with a focus on adaptive communication networks. They are familiar with various methods for increasing resilience, such as redundancy and diversity, and can apply these methods to the design of communication networks.						
3	Recommen	ded prerequisites fo	or participation				
4	Form of exa Module exar • Modul The examina 10 students will be anno	mination n: e exam (Technical ex ation takes place in f register, the examina unced in the beginni	kamination, Oral/ form of a written e tion will be an ora ng of the lecture.	written examinatio exam (duration: 90 al examination (du	n, Duration: 90 Min. min.). If one can est ration: 30 min.) The	, Default RS) timate that less than type of examination	
5	<b>Prerequisite</b> Passing the f	e <b>for the award of c</b> final module examina	redit points ation				
6	Grading Module exan • Modul	n: e exam (Technical ex	kamination, Oral/	written examinatio	n, Weighting: 100 %	)	
7	Usability of MSc WI-etit	<b>the module</b> , BSc/Msc iST, MSc i	CE				
8	Grade bonu Grade impro bonus exerci	s compliant to §25 ovements up to 0.4 a ises.	(2) ccording to APB 2	5(2) through bonu	is for regularly comp	leted and submitted	
9	References						

A lecture notes or slides can be downloaded:

Moodle Platform

Advanced literature

- Smith, Paul, et al. "Network resilience: a systematic approach." IEEE Communications Magazine 49.7 (2011): 88-97
- Sterbenz, James PG, et al. "Resilience and survivability in communication networks: Strategies, principles, and survey of disciplines." Computer networks 54.8 (2010): 1245-1265
- Mauthe, Andreas, et. al. "Disaster-resilient communication networks: Principles and best practices." 2016 8th International Workshop on Resilient Networks Design and Modeling (RNDM). IEEE, 2016

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	Course nr.	Course name						
	18-sm-2340-vlResilient Communication Networks							
	Instructor		Туре	SWS				
	Prof. Dr. rer. nat.	Björn Scheuermann, DrIng. Tobias Meuser	Lecture	2				
	Course nr.	Course name						
	18-sm-2340-ue	Resilient Communication Networks						
	Instructor		Туре	SWS				
Prof. Dr. rer. nat. Björn Scheuermann, DrIng. Tobias Meuser Practice								

Mo Tra	<b>dule name</b> nsport Protoc	ols and their Design					
<b>Mo</b> 18-	<b>dule nr.</b> sm-2320	Credit points 6 CP	Workload 180 h	Self-study 105 h	Module duration 1 Term	Module cy Irregular	cle
Lar	nguage	1	I	Module owner	I	0	
Ger	rman			Prof. Dr. rer. nat.	Björn Scheuermann	1	
1	Teaching co This module ease of impl protocol beh focus will be	ontent covers in-depth know ementation, efficienc navior and the interpl on the Transmission	vlege about transp y, performance ar lay of transport p 1 Control Protocol	ort protocols and re nd reliability. Of pa cotocols with other l (TCP) and its vari	elated aspects. We wi rticular interest will layers of the Interne ants.	ll consider rob be how to mo et protocol sta	oustness, odel the ock. The
2	Learning objectives After taking this module, students understand the protocol mechanisms of the transport layer in detail, including their interplay within the layer and with other protocol layers. They can use this knowledge to predict and evaluate the effects of protocol modifications. To this end, they are able to analyze the behavior of transport protocols and to assess the impact of key parameters including latency, bandwidth and buffer size on the suitability of different design variants.						
3	<b>Recommended prerequisites for participation</b> Basic knowledge in the field of communication networks, as covered for instance in the module "Kommunika- tionsnetze 1".						
4	Form of exa Module exam • Modul The examin less than 30 examination	mination n: e exam (Technical ex ation takes place in students register, th will be announced i	kamination, Oral/ form of a written he examination w n the beginning o	written examination n exam (duration: ill be an oral exam f the lecture.	on, Duration: 120 Mi 120 minutes). If o ination (duration: 3	in., Default RS ne can estima 30 min.). The	5) ate that type of
5	Prerequisite Passing the	e <b>for the award of c</b> final module examina	<b>redit points</b> ation				
6	Grading Module exan • Modul	n: e exam (Technical ex	xamination, Oral/	written examinatio	on, Weighting: 100 %	6)	
7	<b>Usability of</b> MSc etit, BS	t <b>he module</b> c/MSc iST, MSc WI-e	etit				
8	<b>Grade bonu</b> Yes	s compliant to §25	(2)				
9	<b>References</b> Technical lit	erature will be ment	ioned in the lectu	re.			
Co	urses						
	<b>Course nr.</b> 18-sm-2320	-vl Transport Prot	cocols and their D	esign			
	Instructor Prof. Dr. rer.	nat. Björn Scheuern	nann		<b>Type</b> Lecture		<b>SWS</b> 3
	<b>Course nr.</b> 18-sm-2320	-ue Transport Prot	ocols and their D	esign			
	<b>Instructor</b> Prof. Dr. rer.	nat. Biörn Scheuern	nann		<b>Type</b> Practice		SWS 2

Mo	dule name	D. 1 1-						
App Mo	dule nr	r Protocols on the In	ternet Workload	Self-study	Module d	uration	Module cv	cle
18-	sm-2330	6 CP	180 h	105 h	1 Term	urution	Irregular	cie
Lar	iguage		·	Module owner				
Ger	man			Prof. Dr. rer. nat.	Björn Sche	uermann		
1	Teaching co The module Internet. Thi to-peer syste the skills to	ontent covers in-depth knov is includes widely us ms, blockchains, etc design and impleme	vledge on applicat ed client-server pr .). The focus is on nt efficient and eff	ion architectures a rotocols like HTTP tradeoffs between fective protocols or	nd application as well as d design alter the applica	on-layer p listributed rnatives a ation layer	rotocols used architecture nd the acquis r.	l on the s (peer- sition of
2	Learning objectives After taking this module, students understand the key questions that the design of an application-layer protocols poses. They understand the design space and are able to recognize and avoid common problems and mistakes. They can apply this knowledge to design and analyze protocol designs, and they are able to design suitable protocol mechanisms for practically relevant design problems.							
3	Recommended prerequisites for participation Basic knowledge in the field of communication networks, as covered for instance in the module "Communication Networks I".							
4	<ul> <li>Form of examination Module exam: <ul> <li>Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS)</li> <li>The examination takes place in form of an oral examination (duration: 30 minutes). If one can estimate that more than 30 students register, the examination will be a written exam (duration: 120 min.). The type of examination will be announced in the beginning of the lecture.</li> </ul></li></ul>							
5	<b>Prerequisite</b> Passing the f	e for the award of c	<b>redit points</b> ation					
6	Grading Module exar • Module	n: e exam (Technical ez	xamination, Oral/	written examinatic	on, Weightin	ng: 100 %	)	
7	<b>Usability of</b> MSc etit, MS	<b>the module</b> Sc WI-etit, BSc/MSc	iST					
8	Grade bonu Announceme to accompar	<b>s compliant to §25</b> ents will be made at t by the lecture that w	(2) he beginning of the ill improve grades	e semester as to wh	ether there	will be ho	mework assig	nments
9	<b>References</b> Technical lite	erature will be ment	ioned in the cours	e.				
Coι	ırses							
	<b>Course nr.</b> 18-sm-2330-	vl Application-La	yer Protocols on t	he Internet				
	Instructor Prof. Dr. rer.	nat. Björn Scheuern	nann			<b>Type</b> Lecture		<b>SWS</b> 3
	<b>Course nr.</b> 18-sm-2330-	Course name Application-La	yer Protocols on t	he Internet				
	Instructor Prof. Dr. rer.	nat. Björn Scheuern	nann			<b>Type</b> Practice		SWS 2
Мо	dule name							
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One	e World Signa	l Processing Seminar	r Series			1		
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle		
18-	pe-2090	4 CP	120 h	90 h	1 Ierm	Every Semester		
Eng	i <b>guage</b> slish			Prof. DrIng. Mai	rius Pesavento			
1	<b>Teaching co</b> This semina machine lea	ontent r series covers addre rning and optimizati	sses latest trends on.	in Signal processir	ng with focus on mot	vile communications,		
2	<ul> <li>2 Learning objectives</li> <li>Students understand the presented research topics, e.g., the latest trends in <ul> <li>Signal processing</li> <li>Communications</li> <li>Graph signal processing</li> <li>Machine learning for communications and data analysis</li> <li>Coexistence of radar and communications</li> <li>Compressed sensing and sampling theory</li> <li>Convex Optimization</li> </ul> </li> <li>Students learn to prepare themselves for the participation in a scientific seminar based on reference to the scientific literature.</li> <li>Students learn to participate in scientific seminars, to contribute with thoughtful comment and appropriate questions and to initiate a fruitful scientific discussion.</li> <li>Students learn to summarize the main scientific findings and statements of the talk in a short written report. Students learn to summarize the main scientific findings of the talk in a scientific discussion and to defend the main statements.</li> </ul>							
3	Recommend	ded prerequisites fo	or participation					
4	Form of exa Module exa • Modul Report and/ the lecture.	mination m: e exam (Study achie or Presentation and/o	vement, Oral/wri or Colloquium. Th	tten examination, I le type of examinat	Default RS) ion will be announce	d in the beginning of		
5	<b>Prerequisite</b> Passing the f	e <b>for the award of c</b> r final module examina	redit points ation					
6	Grading Module exan • Modul	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 100 %)			
7	<b>Usability of</b> MSc etit, BS	the module c/MSc iST, MSc WI-e	etit					
8	Grade bonu	is compliant to §25	(2)					
9 Сот	References Slides can b URL for One 1178es	e downloaded. e World Signal Proces	ssing Seminar Ser	ies: https://www1	.se.cuhk.edu.hk/ htw	vai/oneworld		

<b>Course nr.</b> 18-pe-2090-se	<b>Course name</b> One World Signal Processing Seminar Series		
<b>Instructor</b> Prof. DrIng. Ma	rius Pesavento	<b>Type</b> Seminar	SWS 2

Mo	dule name	outed Cyber-Physical	Systems			
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
18-	fi-2020	6 CP	180 h	120 h	1 Term	Summer term
Laı Gei	<b>nguage</b> man/English			Module owner Prof. DrIng. Rolt	Findeisen	
1	Teaching co Cyber-physic and cyber-p detectability networked information centralized a time scale se	ontent cal systems and multi physical systems, con y, reachability, resilie control systems (cont loss, security, safety, & distributed control, eparation, hierarchica	i-variable systems: atrol & systems th ence, control & es trol & estimation and privacy), con consensus, synchi al control concepts	Aspects and fundate eory concepts (statimation of multivation over communication ttrol of interconnectronization), hierarcl s, optimization base	mentals of multivari bilizability, controlla ariable systems), on networks, control ted/multi-agent systen nical control (fundam ed control & real-tim	able, interconnected, ability, observability, systems and graphs, subject to delays/to ems (centralized, de- nentals, optimization, e optimization)
2	2 Learning objectives The students are familiar with the basic analysis and control methods for multivariable systems, networked control systems, and interconnected systems and their applications. They are able to model and analyse multivariable, interconnected systems, and networked control systems subject to delays, communication loss. Furthermore, they are able to design basic centralized, decentralized, distributed, hierarchical controllers and estimators, as well as controllers to achieve consensus and synchronization control. They are familiar with the concept of time-scale seperation for control and estimation.					
3	<b>Recommended prerequisites for participation</b> Basic concepts of control theory. Fundamentals of linear algebra, differential and difference equations.					
4	<ul> <li>Form of examination</li> <li>Module exam: <ul> <li>Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)</li> <li>The examination takes place in form of a written exam (duration: 90 minutes). If less than 25 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be announced in the beginning of the lecture</li> </ul></li></ul>					
5	<b>Prerequisit</b> Passing the	e for the award of c	<b>redit points</b> ation			
6	Grading Module exa • Modul	m: le exam (Technical ex	kamination, Oral/	written examinatio	n, Weighting: 100 %	)
7	Usability of	the module				
8	Grade bonu	is compliant to §25	(2)			
9	References					
	<ul> <li>References</li> <li>S. Skogestad, I. Postlethwaite, Multivariable Feedback Control, Wiley, 2005.</li> <li>J. Lunze (Ed.), Control Theory of Digitally Networked Dynamic Systems, Springer, 2014.</li> <li>J. Lunze. Networked Control of Multi-Agent Systems, Bookmundo Direct, 2019.</li> <li>M. Mesbahi, M. Egerstedt. Graph Theoretic Methods in Multiagent Networks, Princeton University Press.</li> </ul>					

<b>Course nr.</b> 18-fi-2020-vl	<b>Course name</b> Control of Distributed Cyber-Physical Systems		
Instructor Prof. DrIng. Rolf Findeisen		<b>Type</b> Lecture	<b>SWS</b> 3
<b>Course nr.</b> 18-fi-2020-ue	<b>Course name</b> Control of Distributed Cyber-Physical Systems		
<b>Instructor</b> Prof. DrIng. Rol	f Findeisen	<b>Type</b> Practice	<b>SWS</b> 1

<b>Module nr.</b> 18-ad-2130	Credit points 4 CP	Workload 120 h	<b>Self-study</b> 75 h	Module duration 1 Term	Module cycle Summer term
L <b>anguage</b> English			Module owner Prof. DrIng. Jürgen Adamy		
<ul> <li>Teaching co Part I: Class</li> <li>useful</li> <li>necess</li> <li>uncome convex</li> <li>Karush</li> <li>optimi proper</li> <li>optimi iterativ</li> <li>Part II: Opt</li> <li>conser</li> <li>distribi</li> <li>gradie</li> <li>constr weight</li> <li>state of challer</li> <li>Part III: Op</li> <li>generation</li> <li>Nash ei</li> <li>discreti</li> <li>continiii</li> <li>variatiii</li> <li>exister</li> <li>gradie</li> <li>continiii</li> <li>variatiii</li> <li>exister</li> <li>gradie</li> <li>continiii</li> <li>variatiii</li> <li>exister</li> <li>gradie</li> <li>non-co conver</li> </ul>	sical theory of uncor facts from analysis ( ary and sufficient con- strained optimization a optimization, its con- textuhn-Tucker condite ization subjected to in- ve procedure <b>imization in multi-a</b> assus in multi-agent sy- unication protocols: assus algorithm and it uted optimization pr nt-based procedure v ained distributed op t-balanced communic of the art (convergence ages) <b>timization in multi-</b> agence) of the art (convergence on methods in conver- onvergence in the cas gence) of the art (convergence on tertods in conver- onvergence in the cas gence) of the art (convergence on tertods in conver- onvergence in the cas gence) of the art (convergence on tertods in conver- tods in convergence on the tert (convergence)	nstrained and co differentiable fund nditions of extrem a problem: existen nvergence and con- tion convex simple co- equality constrain gent systems: Di- ystems, motivating gossip, weight-bal s convergence (wi oblems in multi-a- with weight-baland timization (motiv- cation and its conv- terate discussion, agent systems: G examples tence of a mixed-s- continuous action and of Nash equilibrium a games (converge- e of games with p cce rate discussion lern applications a	nstrained optimiz ctions, gradients, H um ce, uniqueness, and overgence rate instraints, gradient ts, primal-dual app istributed (cooper g examples anced communication gent systems, moti- ced communication vating examples, p regence, discussion unbalanced comm came-theoretic (not trategy Nash equili- games with convex their connection to in in convex games ence in the case of g urely monotone ma- n, information setti- and their challenge	ation: lessian matrices, conv d stability of solution, projection method a roach, Lagrangian, Ar ative) optimization cion eight-balanced comme vating examples n and its convergence projected gradient-ba n on the primal-dual punication, modern ap on-cooperative) opti ibrium cost functions, exam Nash equilibria proble games with strongly r appings, regularized a ings in the system: c s)	vex functions) , gradient descent : and its convergence row-Hurwicz-Uzaw unication) esed procedure with approach) oplications and the imization uples) ems in convex game monotone mapping algorithms and the communication- ar

	Firsty, students refresh the knowledge on the classical results in convex optimization. Next, students deal with two main types of optimization problems in multi-agent systems: cooperative and non-cooperative optimization. Some practical examples are demonstrated. Students learn how to solve cooperative optimization problems by mean of consensus-type communication-based algorithms in the networked multi-agent systems. Moreover, they get insights in the modern applications and current challenges of cooperative optimization. In the case when each agent in a multi-agent system follows the goal to optimize its own objective a so-called non- cooperative game-theoretic optimization problem is formulated in the system. Students are able to formulate this problem, namely to define a game with its main component and solution concepts (action sets, individual cost funtions, Nash equilibria). Further the focus is on continuous action convex games. To find a solution (a Nash equilibrium in a given game), students use the connection between Nash equilibria in games and solutions of the corresponding variational inequalities. Furthemore, students are able to investigate the properties of the game (strongly/strictly monotone, merely monotone game) to apply an appropriate optimization procedure (gradient-based or regularized one) to achieve a solution. Finally, students get insights in different settings of information in the game-theoretic optimization (where only partial information is available to each agent) and know approaches that can be applied in each case.					
3	<b>Recommended</b> J Mathematics I, II	prerequisites for participation , III				
4	Form of examination Module exam: • Module exam:	ation m (Technical examination, Oral examination, Duration: 30 M	in., Default RS)			
5	Prerequisite for the award of credit points Passing the final module examination					
6	Grading         Module exam:         • Module exam (Technical examination, Oral examination, Weighting: 100 %)					
7	<b>Usability of the</b> MSc etit, MSc iC	module E, BSc/Msc iST, MSc WI-etit				
8	Grade bonus co	npliant to §25 (2)				
9	References         1. Nedic and A. Ozdaglar "Cooperative Distributed Multi-Agent Optimization" in the book "Convex Optimization in Signal Processing and Communications" by Y. Eldar and D. Palomar         2. F. Facchinei JS. Pang "Finite-Dimensional Variational Inequalities and Complementarity Problems"					
Cot	urses					
	<b>Course nr.</b> 18-ad-2130-vl	Optimization in Multi-Agent Systems				
	<b>Instructor</b> Dr. rer. nat. Tatia	na Tatarenko	<b>Type</b> Lecture	<b>SWS</b> 2		
	<b>Course nr.</b> 18-ad-2130-ue	Course name Optimization in Multi-Agent Systems				
	<b>Instructor</b> Dr. rer. nat. Tatia	na Tatarenko	<b>Type</b> Practice	<b>SWS</b> 1		

Mo	dule name	1 *** * *						
Scie	entific Working	and Writing	Monthlood	Colf study	Madula du	ration	Modulo av	-1
18-	jk-1001	3 CP	90 h	60 h	1 Term	ration	Every Seme	ester
Lar Ger	<b>iguage</b> man/English			<b>Module owner</b> Prof. DrIng. Rol	f Jakoby			
1	<ul> <li>Content and goals         <ul> <li>Elaboration of a technical topic in cooperation with a research associate as supervisor</li> <li>Detailed study of technical articles</li> <li>Deeper understanding of the technical topic treated therein</li> <li>Practical experience with technical documentation</li> <li>Learning modern presentation techniques and their application</li> <li>Presentation and discussion of the technical topic in front of a group of people</li> </ul> </li> </ul>							
2	Learning objectives The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.							
3	<b>Recommended prerequisites for participation</b> Fundamental knowledge in microwave engineering, e.g. lecture "Hochfrequenztechnik 1".							
4	Form of exam Module exam • Module Report and/o announced at	nination : exam (Study achie r term paper and/o the beginning of tl	vement, Oral/wri r presentation (in 1e course.	tten examination, I preparation for the	Default RS) e thesis). The	e type of	examination	will be
5	<b>Prerequisite</b> Passing the fi	<b>for the award of c</b> nal module examination	<b>redit points</b> ation					
6	<b>Grading</b> Module exam • Module	: exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 10	00 %)		
7	<b>Usability of t</b> BSc etit, BSc	<b>he module</b> MEC, BSc iST						
8	Grade bonus	compliant to §25	(2)					
9	<b>References</b> According to	the advices and rec	ommendations of	the project superv	isor			
Coi	ırses							
	<b>Course nr.</b> 18-jk-1001-p:	<b>Course name</b> Scientific work	king and writing					
	I8-Jk-1001-ps       Scientific working and writing         Instructor       Type       SWS         DrIng. Martin Schüßler, Prof. DrIng. Rolf Jakoby       Introductory seminar       2							

Mo	dule name						
Scie	entific Workin	g and Writing		I			
Mo	dule nr.	Credit points	Workload	Self-study	Module durat	ion Module cy	cle
18-	KI-1001	3 CP	90 h	60 h	1 Ierm	Every Seme	ester
Ger	man/English			Prof. DrIng. Ani	a Klein		
1	<ul> <li>Teaching content</li> <li>Content and goals</li> <li>Elaboration of a technical topic in cooperation with a research associate as supervisor</li> <li>Detailed study of technical articles</li> <li>Deeper understanding of the technical topic treated therein</li> <li>Practical experience with technical documentation</li> <li>Learning modern presentation techniques and their application</li> <li>Presentation and discussion of the technical topic in front of a group of people</li> </ul>						
2	<b>Learning ob</b> The students and present it in writing	<b>jectives</b> are able to compred them in a structured and refer to its conto	hend and analyze manner. Using the ents.	scientific texts, pre e example of an ori	sent technical fa ginal work, they	ects in an orderly can correctly sun	manner nmarize
3	Recommended prerequisites for participation						
4	Form of exa Module exar • Module Report and/o announced a	mination n: e exam (Study achie or term paper and/o t the beginning of tl	vement, Oral/wri r presentation (in ne course.	tten examination, I preparation for the	Default RS) e thesis). The ty	pe of examination	ı will be
5	<b>Prerequisite</b> Passing the f	for the award of c	<b>redit points</b> ation				
6	Grading Module exam • Module	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 100 (	%)	
7	<b>Usability of</b> BSc etit, BSc	<b>the module</b> MEC, BSc iST					
8	Grade bonu	s compliant to §25	(2)				
9	<b>References</b> Literature w	ill be announced du	ring the course.				
Coι	ırses						
	<b>Course nr.</b> 18-kl-1001-r	Scientific work	king and writing				
	<b>Instructor</b> Prof. DrIng.	Anja Klein	<u> </u>		Typ Intro	e oductory seminar se	<b>SWS</b> 2

Mo	dule name							
Sci	entific Workin	g and Writing						
	dule nr.	Credit points	Workload	Self-study	Module	duration	Module cyc	cle
18-	pe-1001	3 CP	90 h		1 Ierm		Every Seme	ester
Ger	<b>iguage</b> man/English			Prof. DrIng. Ma	rius Pesave	ento		
1	<ul> <li>I reaching content</li> <li>Content and goals <ul> <li>Elaboration of a technical topic in cooperation with a research associate as supervisor</li> <li>Detailed study of technical articles</li> <li>Deeper understanding of the technical topic treated therein</li> <li>Practical experience with technical documentation</li> <li>Learning modern presentation techniques and their application</li> <li>Presentation and discussion of the technical topic in front of a group of people</li> </ul> </li> </ul>							
2	2 Learning objectives The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents							
3	Recommended prerequisites for participation							
4	Form of exa Module exar • Module Report and/o announced a	<b>mination</b> n: e exam (Study achie or term paper and/o t the beginning of tl	wement, Oral/writh or presentation (in the course.	tten examination, I preparation for the	Default RS e thesis). T	) The type of	examination	will be
5	<b>Prerequisite</b> Passing the f	e <b>for the award of c</b> inal module examinat	<b>redit points</b> ation					
6	Grading Module exar • Module	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting:	100 %)		
7	<b>Usability of</b> BSc etit, BSc	<b>the module</b> MEC, BSc iST						
8	Grade bonu	s compliant to §25	(2)					
9	References							
Co	urses							
	<b>Course nr.</b> 18-pe-1001-	<b>Course name</b> Scientific work	king and writing					
	<b>Instructor</b> Prof. DrIng	Marius Pesavento				<b>Type</b> Introduct course	ory seminar	SWS 2

Мо	dule name							
Scie	entific Working	and Writing		1			1	
	dule nr.	Credit points	Workload	Self-study	Module o	luration	Module cyc	cle
Io-		3 CP	90 11	Module owner	1 Ieriii		Every Sellie	ester
Eng	lish			Prof. DrIng. Abdelhak Zoubir				
1	<ul> <li>Content and goals</li> <li>Elaboration of a technical topic in cooperation with a research associate as supervisor</li> <li>Detailed study of technical articles</li> <li>Deeper understanding of the technical topic treated therein</li> <li>Practical experience with technical documentation</li> <li>Learning modern presentation techniques and their application</li> <li>Presentation and discussion of the technical topic in front of a group of people</li> </ul>							
2	2 Learning objectives The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.							
3	Recommended prerequisites for participation							
4	Form of exam Module exam • Module Report and/c announced at	nination :: exam (Study achie r term paper and/o : the beginning of tl	vement, Oral/wri r presentation (in ne course.	tten examination, I preparation for the	Default RS) e thesis). T	he type of	examination	will be
5	<b>Prerequisite</b> Passing the fi	for the award of c nal module examin	<b>redit points</b> ation					
6	Grading Module exam • Module	exam (Study achie	vement, Oral/wri	tten examination, V	Weighting:	100 %)		
7	Usability of	he module						
8	Grade bonus	compliant to §25	(2)					
9	<b>References</b> Literature wi	ll be announced ind	ividually dependi	ng on the chosen to	opic.			
Cot	ırses							
	<b>Course nr.</b> 18-zo-1001-p	s Scientific worl	king and writing					
	<b>Instructor</b> Prof. DrIng.	Abdelhak Zoubir				<b>Type</b> Introduct course	ory seminar	<b>SWS</b> 2

## **1.2 Optional Subjects SES: System on Chip and Embedded Systems**

Mo Ele	<b>dule name</b> ctronic and Ir	tegrated Circuits				
<b>Mo</b>	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
Lar Ger	nguage man	0 Gr	100 11	Module owner Prof. DrIng. Klar	us Hofmann	Summer term
1	<b>Teaching co</b> Basic analog Circuits; Mu Feedback Te	ontent g Building Blocks: C ulti Stage Amplifier, s chniques, Frequency	urrent- and Volta internal Structure Response, Clock	ge sources, Stabiliz and Properties of Generation and Ose	zing circuits, Curren Differential and Op cillators	t Mirrors, Reference erational Amplifiers,
2	2 Learning objectives A student is, after successful completion of this module, able to					
	<ol> <li>derive the fundamental properties of the MOS-Transistors from knowledge of the layout or fabrication process,</li> <li>derive fundamental MOSFET-circuits (current source, voltage source, current mirror, switch, active resistors, inverting amplifiers, differential amplifiers, output amplifiers, operational amplifiers, comparators) and knows their fundamental properties (y-Parameters, DC- and AC-properties),</li> <li>understands simulation methods for analog circuits on transistor level using SPICE,</li> <li>analyze feedback amplifiers regarding frequency gain, stability, bandwidth, root locus, amplitude and phase-margin,</li> <li>Analyze electronic circuits for voltage and current provision,</li> <li>Analyze basic circuits for clock/waveform generation</li> </ol>					
3	<b>Recommen</b> Lecture "Ele	<b>ded prerequisites fo</b> ctronics"	or participation			
4	Form of exa Module exa • Modul	<b>amination</b> m: e exam (Technical ex	amination, Exam	ination, Duration:	90 Min., Default RS)	
5	Prerequisite Passing the	e for the award of c	redit points ation			
6	Grading Module exa • Modul	m: e exam (Technical ex	xamination, Exam	ination, Weighting	: 100 %)	
7	<b>Usability of</b> BSc ETiT, B	<sup>e</sup> <b>the module</b> Sc Wi-ETiT, MSc iCE,	BSc/MSc iST, BS	c/MSc MEC, MSc I	EPE	
8	<b>Grade bonu</b> A grade imp	s compliant to §25 provement of up to 1,	(2) 0 due to a bonus	is possible, which c	an be earned with te	sts.
9	References Lecture Slid	e Copies; Richard Jae	eger: Microelectro	onic Circuit Design		
Coi	ırses					

	<b>Course nr.</b> 18-ho-1020-vl	<b>Course name</b> Analog Integrated Circuit Design		
Instructor Prof. DrIng. Klaus Hofmann		us Hofmann	<b>Type</b> Lecture	SWS 3
	<b>Course nr.</b> 18-ho-1020-ue	<b>Course name</b> Analog Integrated Circuit Design		
	<b>Instructor</b> Prof. DrIng. Kla	us Hofmann	<b>Type</b> Practice	<b>SWS</b> 1

Mo Dig	<b>dule name</b> ital Design Lal	)						
Мо	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle	
18-	hb-1030	- 3 CP	90 h	60 h	1 Term	Summer ter	rm	
Lar Ger	<b>iguage</b> man			<b>Module owner</b> Prof. DrIng. Christian Hochberger				
1	Teaching co	ntent						
	<ul> <li>Introduction to the MP3 encoding standard for audio signals</li> <li>Analysis of the individual steps of the decoding process wrt. the used algo-rithms</li> <li>Analysis of the individual steps of the decoding process wrt. the storage of in-termediate results</li> <li>Design and configuration of the datapath to realize the individual process steps</li> <li>Simulation on functional level and with timing annotation</li> <li>Check, whether the design meets all restrictions</li> <li>Test of the final HW design with all relevant MP3 variants (short and long frames)</li> </ul>							
2	<b>Learning objectives</b> After successfully completing the module, students will be able to map complex processes onto a digital target architecture by hand. They master the tools for implementing their solution on an FPGA. They know strategies to systematically search for errors. They can explore a design through simulation.							
3	Recommend Basic knowle	<b>ed prerequisites fo</b> lge of digital design	o <b>r participation</b>					
4	Form of exam Module exam • Module	nination :: exam (Study achie	evement, Oral exar	nination, Duration	: 30 Min., Default RS	5)		
5	<b>Prerequisite</b> Passing the fi	for the award of c nal module examin	r <b>edit points</b> ation					
6	Grading Module exam • Module	exam (Study achie	evement, Oral exam	nination, Weightin	g: 100 %)			
7	Usability of BSc ETiT, BS	<b>he module</b> c iST						
8	Grade bonus	compliant to §25	(2)					
9	9 References							
Co	irses							
	Course nr.	Course name	1					
	18-hb-1030-j	or Digital Design	Lab		1		<del></del>	
	InstructorTypeSWSProf. DrIng. Christian HochbergerInternship2							

Mo	Module name Embedded Systems Hands On 1: Design and Implementation of Hardware Software Systems								
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle			
Lar	nguage	0 Cr	100 11	Module owner		Every 2. Semester			
Ger	rman/English			Prof. Dr. rer. nat.	Oskar von Stryk				
1	<b>Teaching co</b> These labs a implementa	ontent are intended for stude tion of embedded sys	ents interested in o stems.	obtaining hands-on	practical experience	with the design and			
	The labs wil	l begin by introducin	g fundamentals s	uch as					
	<ul> <li>basic electrical engineering</li> <li>using lab test and measurement instruments</li> <li>design and fabrication of electronic circuits</li> <li>acquiring and processing data from sensors</li> <li>bus protocols in embedded systems</li> <li>programming and debugging heterogeneous embedded systems</li> <li>the use of the Linux kernel as an operating system in an embedded context</li> </ul>								
	The lab core then has the participants implement a concrete embedded system. A number of possible projects will be offered, each with a different focus (e.g., hardware or software) to match student interest.								
2	<ul> <li>2 Learning objectives         After successful completion, students are familiar with the practical techniques and tools required for designing, implementing and bringing-up embedded hardware/software systems.         This includes basic knowledge of electrical engineering, the use of lab test and measurement instruments, the use of languages and EDA/CAD tools for hardware design. They are able to program and debug     </li> </ul>								
3	Recommend Recommend Computer Sy obtained in	ded prerequisites for ed: Successful compl ystems", "Operating S other study program	or participation etion of "Digital Do Systems" and "Syst mes	esign", "Computer ( em-level and Parall	Organisation", "Archin lel Programming" or s	tecture and Design of similar competencies			
4	Form of exa Course relat • [20-00	amination ed exam: )-0959-pr] (Study ac	hievement, Oral/v	vritten examination	n, Default RS)				
5	Prerequisite Pass exam (2	e for the award of c 100%)	redit points						
6	<ul> <li>Grading Course related exam:</li> <li>• [20-00-0959-pr] (Study achievement, Oral/written examination, Weighting: 100 %)</li> </ul>								
7	Usability of	the module							
8	Grade bonu	is compliant to §25	(2)						
9	References								

Co	Courses								
	<b>Course nr.</b> 20-00-0959-pr	<b>Course name</b> Embedded Systems Hands-On 1: Design and Implementat Systems	ion of Hardware-Softw	are					
	Instructor Prof. Dr. rer. nat. Oskar von Stryk		<b>Type</b> Internship	SWS 4					

Мо	Module name								
HD	L Lab	- 11 I		a 10 1					
MO	<b>dule nr.</b> ho-1090	Credit points	Workload	Self-study	Module duration	Summer te	cle rm		
Lan Eng	<b>iguage</b> glish		100 11	Module owner Prof. DrIng. Kla	us Hofmann				
1	<b>Teaching co</b> Realisation o	<b>ntent</b> f a VHDL- or Verilog	g-based VLSI Syste	em Design Project i	n a Team with indus	trial constrair	nts		
2	<b>Learning ob</b> A student is,	<b>jectives</b> after successful con	pletion of this mo	odule, able to					
	<ol> <li>design, optimize and verify a complex digital system (e.g. a pipelined CPU or signal processor) using Verilog or VHDL,</li> <li>synthesize the HDL description using commercial CAD software to a gate level description After successful completion of this module the students are able to work constructively on a feasible solution. Aside, they are able to mutually support each other and present intermediate results to peers, and achieve an</li> </ol>								
3	Recommended prerequisites for participation           Lecture Computer Aided Design for System on Chips,           At least one high-level Programming Language, Basic Know-How Linux/Unix, Computer Architectures								
4	<ul> <li>Form of examination         Module exam:         <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)             Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in             the heating in a of the leature         </li> </ul></li></ul>								
5	<b>Prerequisite</b> Passing the f	for the award of c	<b>redit points</b> ation						
6	Grading Module exan • Module	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 100 %)				
7	<b>Usability of</b> BSc/MSc ET	<b>the module</b> iT, BSc/MSc Wi-ETi <sup>*</sup>	Г, MSc iCE, BSc/M	ISc iST, BSc/MSc N	MEC, MSc EPE				
8	Grade bonu	s compliant to §25	(2)						
9	9 References Lecture slides "CAD4SoC"								
Cot	ırses								
	Course nr.Course name18-ho-1090-prHDL Lab								
	InstructorTypeSWSProf. DrIng. Klaus Hofmann3								

Mo Pro	Module name Project Seminar Integrated Electronic Systems							
<b>Mo</b> 18-	<b>dule nr.</b> ho-1060	Credit points 8 CP	Workload 240 h	Self-study 180 h	<b>Module duration</b> 1 Term	Module cy Every Seme	<b>cle</b> ester	
Lar Ger	n <b>guage</b> rman			<b>Module owner</b> Prof. DrIng. Kla	us Hofmann			
1	<b>Teaching co</b> Research-ori Final Report	<b>ntent</b> ented project in the and Presentation of	e domain of Integr Results in a Team	rated Electronic Sy	stems or Microelec	tronic System	Design,	
2	2 Learning objectives After completion of this module, a student is able to fulfill/implement a given task or project in the domain of Integrated Electronic System design (optionally in a group of students), write a final report and present the results to an audience.							
3	Recommend Lecture Elect	ed prerequisites for ronic and Integrate	or participation d Circuits					
4	<ul> <li>Form of examination Module exam:</li> <li>Module exam (Study achievement, Oral examination, Duration: 30 Min., Default RS)</li> </ul>							
5	<b>Prerequisite</b> Passing the f	<b>for the award of c</b> nal module examin	<b>redit points</b> ation					
6	Grading Module exam • Module	n: e exam (Study achie	vement, Oral exar	nination, Weightin	g: 100 %)			
7	Usability of BSc ETiT, Wi	<b>the module</b> ETiT						
8	Grade bonu	s compliant to §25	(2)					
9	9 References Material on the subject will be handed out							
Coi	Courses							
	Course nr.Course name18-ho-1060-pjProject Seminar Integrated Electronic Systems							
	InstructorTypeSWSProf. DrIng. Klaus HofmannProject seminar4							

Mo Pro	Module name Project Seminar Computer Systems							
<b>Mo</b> 18-	<b>dule nr.</b> hb-1040	Credit points 8 CP	Workload 240 h	Self-study 180 h	Module duration 1 Term	Module cy Every Seme	<b>cle</b> ester	
Lar Ger	<b>nguage</b> rman			<b>Module owner</b> Prof. DrIng. Chi	ristian Hochberger	-		
1	<b>Teaching co</b> Students ela documentati solutions to a	ntent porate on a researc on and a presentat given problem.	h-oriented subjec ion of the acquire	t in the area of co ed advanced know	mputer-systems. The ledge. They provide	ey present a e a set of alte	written ernative	
2	Learning ob Students are necessary fur	ectives able to systematica damental knowled	lly develop desigr ge in terms of refe	n alternatives to a grences and termine	given problem. They ology.	learn to acqu	uire the	
3	<b>Recommend</b> Basic knowle	<b>ed prerequisites fo</b> dge of digital design	<b>or participation</b>					
4	<ul> <li>Form of examination Module exam: <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> <li>Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.</li> </ul> </li> </ul>							
5	<b>Prerequisite</b> Passing the fi	for the award of c nal module examin	<b>redit points</b> ation					
6	Grading Module exan • Module	: exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 100 %)			
7	Usability of BSc ETiT, BS	<b>he module</b> c/MSc iST						
8	Grade bonus	compliant to §25	(2)					
9	References							
Co	Courses							
	<b>Course nr.</b> 18-hb-1040-j	j Course name Project Semin	ar Computer Syste	ems				
	InstructorTypeSWSProf. DrIng. Christian Hochberger4							

Mo Hig	Module name High Level Synthesis							
<b>Mo</b>	<b>dule nr.</b> hb-2020	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module duration	Module cy Winter terr	cle	
Lar Eng	i <b>guage</b> lish			Module owner Prof. DrIng. Chi	ristian Hochberger			
1	<ul> <li>Teaching content</li> <li>Mapping of behavioral descriptions (e.g. in the form of program fragments) on FPGA and CGRA structures</li> <li>Sub-tasks allocation, scheduling, binding</li> <li>Exact or heuristic solutions</li> <li>Design principles of heuristic solutions</li> </ul>							
2	2 Learning objectives Students that have completed this module know alternative approaches for all of the tasks of the high level synthesis and can select appropriate ones for specific applications. They can evaluate the memory and time complexity of the given algorithms. They are enabled to adapt the algorithms for new constraints and new target technologies.							
3	<b>Recommended prerequisites for participation</b> Knowledge of hardware synthesis on the basis of at least one hardware description language is required (e.g. Reese/Thornton: Introduction to Logic Synthesis Using Verilog Hdl oder Brown/Vranesic: Fundamentals of Digital Logic with VHDL Design). The student should have basic knowledge of at least one object oriented programming language, preferably Java							
4	Form of exa Module exar • Module	mination n: e exam (Technical e:	xamination, Oral e	examination, Durat	ion: 30 Min., Defaul	t RS)		
5	<b>Prerequisite</b> Passing the f	e for the award of c final module examin	<b>redit points</b> ation					
6	Grading Module exar • Module	n: e exam (Technical e:	xamination, Oral e	examination, Weigl	nting: 100 %)			
7	<b>Usability of</b> MSc ETiT, B	<b>the module</b> Sc/MSc iST, MSc iCl	E					
8	Grade bonu	s compliant to §25	(2)					
9	<b>References</b> English slide	es can be obtained th	rough Moodle.					
Coi	ırses							
	Course nr.Course name18-hb-2020-vlHigh-Level Synthesis							
	Instructor Prof. DrIng	. Christian Hochberg	ger		<b>Type</b> Lecture		<b>SWS</b> 2	
	<b>Course nr.</b> 18-hb-2020-	pr High-Level Sy	nthesis					
	<b>Instructor</b> Prof. DrIng	. Christian Hochberg	ger		<b>Type</b> Internshi	р	SWS 2	

Mo Lov	<b>dule name</b> v-Level Synthe	esis							
<b>Mo</b>	<b>dule nr.</b> hb-2010	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module	duration	Module cyc Summer ter	c <b>le</b> rm	
Lan Eng	<b>iguage</b> glish			Module owner Prof. DrIng. Chi	Module owner Prof. DrIng. Christian Hochberger				
1	<b>Teaching co</b> The module approaches s two level mi level is achi add geomet (Simulated A	ontent deals with synthesi suitable for FPGAs. At nimizations, exact a eved by different d ric information to th Annealing, Genetic P	s steps on all abst t the logic level diff nd heuristic multi ecomposition and ne technology maj lacers) and routin	raction layers belo erent types of minin level logic minimi structural mappin pped circuit. Analy g is illustrated thro	ow the reg mization ar zations). T ng techniq ytical and ough the Pa	ister trans re explaine he transiti ues (Flow heuristic p athFinder a	fer level focus d (exact and h on to the tech Map). Places lacers are dis algorithm.	sing on leuristic 1nology &Route scussed	
2	2 Learning objectives After completion of the module, students are enabled to investigate synthesis approaches for low level synthesis tasks. They can evaluate these approaches regarding their time and space complexity, as well as regarding their applicability to specific implementation technologies. Students can apply these approaches to new architectures and technologies.								
3	<ul> <li>Recommended prerequisites for participation</li> <li>Knowledge of hardware synthesis on the basis of at least one hardware description language is required (e.g. Reese/Thornton: Introduction to Logic Synthesis Using Verilog Hdl oder Brown/Vranesic: Fundamentals of Digital Logic with VHDL Design). The student should have basic knowledge of at least one object oriented programming language, preferably Java.</li> </ul>								
4	Form of exa Module exa • Modul	<b>mination</b> n: e exam (Technical e:	xamination, Oral e	examination, Durat	ion: 30 Mi	in., Defaul	t RS)		
5	<b>Prerequisite</b> Passing the f	e <b>for the award of c</b> final module examin	<b>redit points</b> ation						
6	Grading Module exan • Modul	n: e exam (Technical e:	xamination, Oral 6	examination, Weigl	nting: 100	%)			
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> ISc iCE, MSc iST							
8	Grade bonu	s compliant to §25	(2)						
9	<b>9 References</b> The slides of the lecture will be distributed through moodle.								
Coι	Courses								
	Course nr.Course name18-hb-2010-vlLow-Level Synthesis								
	Instructor Prof. DrIng	. Christian Hochberg	ger			<b>Type</b> Lecture		<b>SWS</b> 2	

<b>Course nr.</b> 18-hb-2010-pr	Course name Low-Level Synthesis		
<b>Instructor</b> Prof. DrIng. Chr	istian Hochberger	<b>Type</b> Internship	<b>SWS</b> 2

Mo Pro	<b>dule name</b> ject Seminar I	Reconfigurable Syste	ms					
<b>Mo</b>	<b>dule nr.</b> hb-2040	Credit points	Workload	Self-study	Module of	luration	Module cyc	cle ester
Lan Ger	nguage man	0.01	100 11	Module owner Prof. DrIng. Chr	istian Hocl	hberger		.5001
1	Teaching co Students wi be defined i particularly architecture Usually, the followed by	ontent Il work on their own ndividually for each means the extensio s as well as the prote course starts with a the practical part an	n or in two-person group. In this co- n, improvement, otypical implemen literature search d finally the result	n teams in this cou urse reconfigurable or adaptation of c ntation of application to get acquainted ts are presented in	urse. Topic e architectu omponenta ons on such with the un a written r	s and app ures will b s and tool h reconfig nderlying eport and	lication conto e investigate s for reconfigurable archite architecture. a presentatio	ext will ed. This gurable ectures. This is on.
2	2 Learning objectives Successful students will know how to use reconfigurable systems within a given application context. They can use tools to program these systems and know how to map an application onto a given reconfigurable architecture. They are capable to evaluate the performance critical parts of an application. They understand the implications of different coding styles for a particular task.							
3	<ul> <li>Recommended prerequisites for participation</li> <li>Knowledge of reconfigurable devices (cf. course computer systems II)</li> <li>Knowledge of computer architecture (cf. course computer systems I)</li> <li>Solid programming skills (either in C or Java depending on the application scenario).</li> </ul>							
4	Form of exa Module exa • Modul Report and/	<b>mination</b> n: e exam (Study achie or Presentation. The	vement, Oral/writ type of examinat	tten examination, I ion will be announ	Default RS) ced in the l	) beginning	of the lecture	2.
5	Prerequisite Passing the	e for the award of c	redit points ation					
6	Grading Module exan • Modul	n: e exam (Study achie	vement, Oral/writ	tten examination, V	Veighting:	100 %)		
7	<b>Usability of</b> MSc ETiT, M	t <b>he module</b> ISc iST, MSc Informa	ıtik, MSc iCE					
8	Grade bonu	s compliant to §25	(2)					
9	9 References Will be given to the students during the individual seminar kick-off meeting.							
<b>Cot</b>	rses Course nr.	Course name						
	18-hb-2040-	pj Project Semina	ar Reconfigurable	Systems				1
	InstructorTypeSWSProf. DrIng. Christian HochbergerProject seminar3							

Mo Ind	Module name Industrial Colloquium								
<b>Mo</b>	<b>dule nr.</b> dt-2010	Credit points 2 CP	Workload 60 h	Self-study 30 h	Module duration 1 Term	Module cy Summer te	<b>cle</b> rm		
Lan Ger	i <b>guage</b> man			<b>Module owner</b> Prof. DrIng. Ral	f Steinmetz				
1	<b>Teaching co</b> Primary goa be linked to students wil	ontent Il of this module is to industry representa I get an impression c	o get an overview tives to improve c of different ways to	of current trends chances for an inte o give a technical p	in the ICT industry. rnship or job opport resentation.	Also, studer unities. Addi	nts shall tionally,		
2	<b>Learning ol</b> Students tha They can fo written repo	<b>ojectives</b> It have successfully find Ilow a technical present.	nished this module sentation and the	e know various job y can summarize t	types in the area of c he presentation in t	omputer engi heir own wo	neering. rds as a		
3	Recomment Mandatory: capeable to	<b>ded prerequisites fo</b> Basic knowledge in understand the techr	or participation Information Syst nical aspects and t	ems and Commub o summerize them	nication Systems. T in a written report a	he sutdent ha as a short pap	as to be er.		
4	<ul> <li>Form of examination</li> <li>Module exam:         <ul> <li>Module exam (Study achievement, Report, Default RS)</li> <li>Report (including submission of programming code)</li> </ul> </li> </ul>								
5	Prerequisite Passing the	e <b>for the award of c</b> final module examina	<b>redit points</b> ation						
6	Grading Module exa • Modul	n: e exam (Study achie	vement, Report, V	Veighting: 100 %)					
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> ISc iST, MSc iCE							
8	Grade bonu	is compliant to §25	(2)						
9	References								
Coι	ırses								
	<b>Course nr.</b> 18-dt-2010-	ko Industrial Coll	oquium						
	InstructorTypeSWSProf. DrIng. Klaus Hofmann, Prof. DrIng. Ralf Steinmetz, Prof. Dr. rer. nat.Colloquium2Florian Steinke, Prof. DrIng. Christian Hochberger, Prof. Dr. rer. nat. AndreasColloquium2								

Mo Adv	Module name Advanced Topics in Embedded Systems and Applications								
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle			
Lai	nguage	9 CP	270 11	Module owner					
Gei	rman/English			Prof. DrIng. And	lreas Koch				
1	Teaching co The course of including for determined technical as - Computing	ontent covers current topics ocused ones in the a by current research o well as introductory systems architecture	in research and d preas of embedde efforts in the ESA scientific skills, fo e at the processor	levelopment of con d and application- group and are inter r example, includir and systems-level	nputing systems and specific architecture nded to guide studen 1g one or more of the	programming tools, s. The subjects are ts towards acquiring following domains:			
	<ul> <li>Computing systems architecture at the processor and systems-level</li> <li>Design of digital electronic circuits and hardware systems</li> <li>Use of Field-Programmable Gate Arrays</li> <li>Hardware/Software design and programming tools</li> <li>Operating systems and low-level programming</li> <li>Hardware/Software Co-Design</li> <li>Application-specific architectures and techniques</li> <li>Design and/or programming of compute accelerators</li> <li>Debugging and analysis techniques for hardware/software-systems</li> </ul>								
2	<ul> <li>2 Learning objectives         Participants are intended to acquire the skills necessary to quickly become familiar with a new domain and then solve a complex practical problem within that domain. These skills can include studies of scientific literature, surveying existing code-bases from the hardware/software domains, and the practical implementation of hardware and/or software systems. The final talk should show proficiency with basic presentation techniques.     </li> </ul>								
3	Recommend An interest t pre-requisite programmin	<b>ded prerequisites fo</b> to develop high-qualities will be required. The tag. Such skills can be	or participation ity solutions in the nese can include d acquired by succe	e assigned problem igital design, compi essfully completing	domain. For differer iler construction, syste the appropriate lect	nt domains, different em-level and parallel ures.			
4	Form of exa Course relat • [20-00	mination ed exam: )-1001-pp] (Study ac	chievement, Oral/v	written examinatio	n, Default RS)				
5	Prerequisite Pass exam (1	e for the award of c 100%)	redit points						
6	Grading Course relat • [20-00	ed exam: )-1001-pp] (Study ac	hievement, Oral/v	written examinatio	n, Weighting: 100 %	)			
7	Usability of B.Sc. Inform M.Sc Inform May be used	<b>the module</b> hatjk hatik l in other degree pro	grams.						
8	Grade bonu	s compliant to §25	(2)						
9	References								
Co	urses								

<b>Course nr.</b> 20-00-1001-pp	<b>Course name</b> Advanced Topics in Embedded Systems and Applications		
Instructor Prof. DrIng. And	lreas Koch	<b>Type</b> Project	<b>SWS</b> 6

Mo Mic	<b>dule name</b> croprocessor S	ystems						
<b>Mo</b> 18-	<b>dule nr.</b> ho-2040	Credit points 4 CP	Workload 120 h	Self-study 75 h	Module 1 Term	duration	Module cyc Summer ter	c <b>le</b> rm
Lar Eng	<b>iguage</b> glish			<b>Module owner</b> Prof. DrIng. Kla	us Hofman	ın		
1	Teaching co Microprocess	ntent sor Architectures, DS	SP Architectures a	nd Hardware relat	ed Progran	nming		
2	Learning ob Upon success	<b>jectives</b> sful completion of th	ne module, studen	ts will be able to:				
	<ol> <li>gain the overview on the fundamentals of computer architecture and the different processor classes (RISC, CISC, Mikrocontroller, CPU, DSP),</li> <li>understand the central building blocks of a CPU</li> <li>understand the major properties of the required semiconductor memories, I/O blocks and data busses (USB, PCI, RS232),</li> <li>understand the most commonly used Interrupt- and Trap-handling algorithms,</li> </ol>							
	<ol> <li>know the common software development methodologies for microcontrollers (assembler, pseudooperations, makros, subprograms and subroutines),</li> <li>understand the most important fundamentals of hardware oriented programming using C.</li> </ol>							
3	Recommended prerequisites for participation Basics of Computer Architectures							
4	Form of exa Module exan • Module	<b>mination</b> n: e exam (Technical e:	xamination, Exam	ination, Duration:	90 Min., D	efault RS)		
5	<b>Prerequisite</b> Passing the f	for the award of c	<b>redit points</b> ation					
6	Grading Module exan • Module	n: e exam (Technical e:	xamination, Exam	ination, Weighting	: 100 %)			
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> Sc Wi-ETiT, MSc iCl	E, MSc iST, MSc N	IEC, MSc EPE				
8	Grade bonu	s compliant to §25	(2)					
9	References Slide Copies							
Coi	urses							
	<b>Course nr.</b> 18-ho-2040-	vl Microprocesso	or Systems					
	<b>Instructor</b> DrIng. Matt	-no-2040-vi Microprocessor Systems <b>Type SWS</b> -Ing. Matthias Rychetsky, M.Sc. Dominik Großkurth Lecture 2						

<b>Course nr.</b> 18-ho-2040-ue	Course name Microprocessor Systems		
<b>Instructor</b> DrIng. Matthias	Rychetsky, M.Sc. Dominik Großkurth	<b>Type</b> Practice	<b>SWS</b> 1

Mo Adv	Module name Advanced Integrated Circuit Design Lab						
<b>Mo</b> 18-	<b>dule nr.</b> ho-2120	Credit points 6 CP	Workload 180 h	Self-study 135 h	Module duration	Module cy Summer te	<b>cle</b> rm
Lar Eng	<b>iguage</b> glish	I	1	Module owner Prof. DrIng. Kla	us Hofmann		
1	<b>Teaching co</b> Practical Des Tools	ontent sign Tasks in Full Cus	stom Design of Dig	ital or Analog Cirui	ts using State-of-th	le-Art Commerc	cial CAD
2	<ul> <li>A student is, after successful completion of this module, able to</li> <li>1. develop and verify transistor circuitry using Cadence</li> <li>2. simulate logic and analog circuits (Pre- and Postlayout)</li> <li>3. draw, verify and extract layout</li> <li>After successful completion of this module the students are able to work constructively on a feasible solution.</li> <li>Aside, they are able to mutually support each other and present intermediate results to peers, and achieve an overall feasible solution.</li> <li>B Recommended prerequisites for participation</li> </ul>						
3	Recomment Lecture "Adv	<b>ded prerequisites fo</b> vanced Digital Integr	or participation ated Circuit Desig	n" or "Electronic a	nd Integrated Circ	ıits"	
4	Form of examination         Module exam:         • Module exam (Study achievement, Oral/written examination, Default RS)         Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes)         and/or Colloquium (testate). The type of examination will be appounced in the beginning of the lecture						
5	<b>Prerequisite</b> Passing the	e for the award of c final module examin	<b>redit points</b> ation				
6	Grading Module exame • Modul	n: e exam (Study achie	evement, Oral/wri	tten examination, V	Weighting: 100 %)		
7	Usability of MSc ETiT, M	<b>the module</b> ISc Wi-ETiT, MSc iCl	E, MSc iST, MSc M	IEC, MSc EPE			
8	Grade bonu	s compliant to §25	(2)				
9	<ul> <li>References</li> <li>ADIC Lecture Slide Copies</li> <li>John P. Uyemura: Fundamentals of MOS Digital Integrated Circuits</li> <li>Neil Weste et al.: Principles of CMOS VLSI Design</li> </ul>						
Cot	ırses						
	<b>Course nr.</b> 18-ho-2120-	pr Advanced Inte	egrated Circuit Des	sign Lab			
	Instructor Prof. DrIng	. Klaus Hofmann			<b>Type</b> Interns	hip	<b>SWS</b> 3

Mo Ser	<b>dule name</b> ninar Integrat	ed Electronic System	ns Design A					
<b>Mo</b> 18-	<b>dule nr.</b> ho-2160	Credit points 4 CP	Workload 120 h	Self-study 90 h	Module of 1 Term	duration	Module cyc Every Seme	c <b>le</b> ester
Lar Eng	<b>iguage</b> glish			<b>Module owner</b> Prof. DrIng. Kla	us Hofman	ın		
1	<b>Teaching co</b> Research or written Docu	ontent iented Formulation umentation and Pres	of a Topic within entation; Team W	the area of Microo ork	electronics	System D	esign; Creati	on of a
2	<b>Learning of</b> A student is,	<b>jectives</b> after successful con	pletion of this mo	odule, able to				
	1. gain a 2. write a	deep understanding in essay on the chose	of the chosen resense of the chosen reserved at the chosen reserved at the content of the chosen reserved at the content of the chosen reserved at the chosen re	earch subject in the nprehesive form an	e field of in id present	ntegrated e the outcom	lectronic syst ne to an audio	ems, ence
3	Recomment Advanced D	ded prerequisites for igital Integrated Circ	or participation ruit Design, CAD M	Aethods, Computer	Architectu	ures, Progr	amming Kno	w-How
4	<ul> <li>Form of examination</li> <li>Module exam:</li> <li>Module exam (Study achievement, Oral examination, Duration: 45 Min., Default RS)</li> </ul>							
5	Prerequisite Passing the f	e for the award of c	<b>redit points</b> ation					
6	Grading Module exar • Modul	n: e exam (Study achie	vement, Oral exar	nination, Weightin	g: 100 %)			
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> ISc Wi-ETiT, MSc iCl	E, MSc iST, MSc N	IEC				
8	Grade bonu	s compliant to §25	(2)					
9	<ul> <li>References</li> <li>Topic-oriented Materials will be provided</li> </ul>							
Co	urses							
	<b>Course nr.</b> 18-ho-2160-	se Seminar Integ	rated Electronic S	ystems Design A				
	InstructorTypeSWSProf. DrIng. Klaus HofmannSeminar2							

Mo Cor	Module name Computer Aided Design for SoCs							
<b>Mo</b>	dule nr.	Credit points	Workload 150 h	Self-study 90 h	Module duration	Module cy	<b>cle</b> rm	
Lar Eng	i <b>guage</b> Jish		100 11	Module owner Prof. DrIng. Kla	us Hofmann			
1	Teaching co CAD-Concep	ntent ts for the design and	l simulation of int	egrated system-on-	chips			
2	<ul> <li>Learning objectives</li> <li>A student is, after successful completion of this module, able to understand <ul> <li>the most important design and verification abstractions as well as the design flow for the design of integrated electronic systems,</li> <li>selected algorithms for optimization, simulation and solving of design tasks,</li> <li>advanced methods for the design and simulation of analog integrated circuits in modern CMOS technologies,</li> <li>advanced concepts of hardware description languages and their concepts (Verilog, VHDL, Verilog-A, Verilog-AMS, System-Verilog)</li> </ul> </li> </ul>							
3	<b>Recommended prerequisites for participation</b> Lecture "Advanced Digital Integrated Circuit Design" (can be attended in parallel) and "Electronic and Integrated Circuits" and "Logic Design"							
4	<ul> <li>Form of examination</li> <li>Module exam:</li> <li>Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)</li> </ul>							
5	<b>Prerequisite</b> Passing the f	e for the award of c	<b>redit points</b> ation					
6	Grading Module exar • Module	n: e exam (Technical e:	xamination, Exam	ination, Weighting	: 100 %)			
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> Sc iST, MSc MEC, M	ISc Wi-ETiT, MSc	iCE				
8	Grade bonu A grade imp the embedde	<b>s compliant to §25</b> rovement of up to 1,0 ed labs.	<b>(2)</b> O due to a bonus is	s possible, which ca	n be earned by succ	essful particip	ation in	
9	<b>References</b> Slide Copies							
Coi	ırses							
	<b>Course nr.</b> 18-ho-2200-	vl Course name Computer Aid	ed Design for SoC	S				
	Instructor Prof. DrIng	. Klaus Hofmann			<b>Type</b> Lecture		SWS 2	
	<b>Course nr.</b> 18-ho-2200-	ue Computer Aid	ed Design for SoC	s				
	<b>Instructor</b> Prof. DrIng	. Klaus Hofmann			<b>Type</b> Practice		<b>SWS</b> 1	

	<b>Course nr.</b> 18-ho-2200-pr	<b>Course name</b> Computer Aided Design for SoCs		
	<b>Instructor</b> Prof. DrIng. Kla	us Hofmann	<b>Type</b> Internship	<b>SWS</b> 1

Mo	dule name						
Lab	os on Compute	er Engineering		a 10 - 1			
Mo   20-	<b>dule nr.</b> 00-0647	Credit points	Workload	Self-study	1 Term	Every 2 Se	<b>:le</b> mester
Lar		0.01	100 11	Module owner	1 ICIIII	Livery 2. De	
Ger	man/English			Prof. DrIng. And	lreas Koch		
1	<b>Teaching co</b> Participants Computer Ei research per	ntent independently solv ngineering. The prob formed at the Embe	e alone or in a sn lems are usually p dded Systems and	nall group an indiv programming or has Applications Grou	vidually posed probler rdware development p.	em from the tasks inspired	area of l by the
2	<b>Learning of</b> After success the field of C with other e	<b>ojectives</b> Ifully completing the Computer Engineerin xisting solutions.	labs, the participa Ig. They can evalu	nt/s is/are able to a ate the quality of t	independently solve a heir solution and cor	a complex pro npare and con	blem in ntrast it
3	Recommend Depending of	<b>led prerequisites f</b> oon topic.	or participation				
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>• [20-00-0647-pr] (Study achievement, Oral/written examination, Default RS)</li> </ul>						
5	Prerequisite for the award of credit points Pass exam (100%)						
6	<ul> <li>Grading Course related exam:</li> <li>• [20-00-0647-pr] (Study achievement, Oral/written examination, Weighting: 100 %)</li> </ul>						
7	Usability of B.Sc. Inform M.Sc. Inform B.Sc. Compu M.Sc. Compu M.Sc. Wirtso B.Sc. Psycho Joint B.A. In B.Sc. Sportv M.Sc. Sportv Can be used	the module latik natik utational Engineering utational Engineering chaftsinformatik ologie in IT formatik vissenschaft und Info wissenschaft und Info	g ormatik formatik grams.				
8	Grade bonu	s compliant to §25	(2)				
9	9 References Depending on topic.						
Cot	urses						
	<b>Course nr.</b> 20-00-0647-	pr Practical Lab i	n Technical Found	lations of Compute	r Science		
	<b>Instructor</b> Prof. DrIng	. Andreas Koch			<b>Type</b> Internshi	р	SWS 4

Mo Prir	Module name Printed Electronics							
Mo	dule nr.	Credit points	Workload	Self-study	Module d	duration	Module cyc	cle
16-	17-5110	4 CP	120 h	90 h	1 Term		Summer ter	rm
Lan Eng	<b>iguage</b> glish			Module owner Prof. Dr. Edgar D	örsam			
1	<b>Teaching con</b> Printing tech electronics (a photovoltaic,	ntent nologies for function erial, OFET, RFID); batteries, lab on a	nal printing (print Activities for qua chip).	ing methods and s lity assurance; Exa	vstems); De mples of a	esign and pplication	materials for (aerial, RFID	printed ), OFET,
2	<ul> <li>On successful completion of this module, students should be able to:</li> <li>1. Describe the printing technologies that are applicable for "Printed Electronics".</li> <li>2. Name materials that are appropriate to printing processes and to describe the impact of the materials on the design e.g. of antennas and OFETs.</li> <li>3. Classify and rate different activites for quality assurance.</li> <li>4. Explain basic functions, configurations, materials, and specific properties of printed antennas, RFIDs, photovoltaics and batteries.</li> <li>5. Describe "Printed Electronics" as a multidisciplinary task that consists of electrical engineering, material science, and mechanical engineering.</li> </ul>							
3	Recommended prerequisites for participation Mechanical components and Mechatronics I and II recommended							
4	<ul> <li>Form of examination</li> <li>Module exam:</li> <li>Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)</li> <li>Oral exam 30 min</li> </ul>							
5	<b>Prerequisite</b> Passing the e	for the award of c xamination	redit points					
6	Grading Module exam • Module	ı: exam (Technical ex	xamination, Oral e	examination, Weigh	nting: 100	%)		
7	Usability of WPB Master WPB Master Master ETiT	t <b>he module</b> MB III (Wahlfächer PST III (Fächer aus IMNT; Master Mech	aus Natur- und In Natur- und Ingen atronik	genieurwissenscha Ieurwissenschaft fü	ft) r Papiertec	chnik)		
8	Grade bonus	s compliant to §25	(2)					
9	<ul> <li>9 References</li> <li>The current lecture notes can be downloaded from the web pages of the institute while the semester is in session.</li> </ul>							
Cot	urses							
	<b>Course nr.</b> 16-17-5110-v	l Course name Printed Electro	onics					
	Instructor					<b>Type</b> Lecture		<b>SWS</b> 2

Mo	dule name	ma Handa On 2. Des	igning Hardware	Aggalarators for S-	stoms on C	Thin		
Mo	dule nr.	Credit points	Workload	Self-study	Module of	duration	Module cy	cle
20-	00-0968	6 CP	180 h	120 h	1 Term		Every 2. Se	mester
Lan Ger	<b>iguage</b> man			Module owner Prof. DrIng. And	lreas Koch			
1	<b>Teaching co</b> These practi systems-on-o	ontent ical labs are intende chips.	d for students inte	erested in learning	how to dea	sign hardv	vare accelera	tors for
	It covers a wide range of topics, including							
	- OS drivers	for accelerators						
	- design and	interfacing of accele	erators in Bluespec	e SystemVerilog				
	- Design flows and tool chains for hardware/software co-development							
	The actual accelerators covered are inspired by typical applications, e.g., image processing or stereovi- sion computations.							
2	<b>Learning objectives</b> Acquire skills in using the knowledge and techniques taught in prior classes to actually perform a complete hardware/software co-design of an application in an embedded systems context.							
3	<b>Recommended prerequisites for participation</b> Basic knowledge using Linux on embedded Systems (e.g., acquired in ESHO1). Knowledge of the Bluespec SystemVerilog hardware description language (e.g., as taught in Architecture and Design of Computing Systems).							
4	Form of exa Course relat • [20-00	mination ed exam: )-0968-pr] (Study ac	hievement, Oral/v	vritten examinatio	n, Default I	RS)		
5	<b>Prerequisite</b> Pass exam (	e for the award of c 100%)	redit points					
6	Grading Course relat • [20-00	ed exam: )-0968-pr] (Study ac	hievement, Oral/v	vritten examinatio	n, Weightir	ng: 100 %)	)	
7	Usability of	the module						
8	Grade bonu	s compliant to §25	(2)					
9	References							
Coi	ırses							
	Course nr.	Course name						
	20-00-0968-	pr Embedded Sys	stems Hands-On 2	: Designing Hardw	are Accele	rators for	Systems-on-C	Chip
	Instructor Prof. DrIng	. Andreas Koch				<b>Type</b> Internshi	p	SWS 4

Se	odule name nsor Techniqu	e					
<b>M</b> o 18	odule nr. -kn-2120	Credit points 4 CP	Workload 120 h	Self-study 75 h	Module duration 1 Term	Module cycle Winter term	
La Ge	<b>nguage</b> rman	1		<b>Module owner</b> Prof. Dr. Mario K	upnik	1	
1	<ul> <li>The module teaches basic principles of different sensors and the required knowledge for correct application of sensors. With regard to the measurement chain, the focus of the course is on the conversion of any, generally non-electrical quantities into electrically evaluable signals.</li> <li>Resistive, capacitive, inductive, piezoelectric, optical, and magnetic measurement principles are covered in the module to provide knowledge of the measurement of important quantities such as force, torque pressure, acceleration, velocity, displacement, and flow. In addition to a phenomenological description of the principles and a derived technical description, the main elements of primary and secondary electronics for each measurement principle will also be presented and understood.</li> <li>In addition to the measurement principles, the description of errors will be dealt with. In addition to static and dynamic errors, errors in signal processing and error consideration of the entire measurement chain will be discussed. In the exercises the method of peer instruction is utilized.</li> <li><b>2</b> Learning objectives</li> <li>The Students acquire knowledge of the different measuring methods and their advantages and disadvantages.</li> </ul>						
2	<b>Learning objectives</b> The Students acquire knowledge of the different measuring methods and their advantages and disadvantages. They can understand error in data sheets and descriptions interpret in relation to the application and are thus able to select a suitable sensor for applications in electronics and information, as well process technology and to apply them correctly.						
3	Recomment Measuring T	<b>ded prerequisites fo</b> Technique	r participation				
4	Form of exa Module exa • Modul	amination m: le exam (Technical ex	amination, Exam	ination, Duration:	90 Min., Default RS)		
5	Prerequisite Passing the	e for the award of c final module examina	r <b>edit points</b> ation				
6	Grading Module exa • Modul	m: le exam (Technical ex	amination, Exam	ination, Weighting	: 100 %)		
7	Usability of MSc ETiT, N	<b>the module</b> ISc WI-ETiT, MSc ME	EC, MSc Medizinte	echnik			
8	Grade bonu	is compliant to §25	(2)				
9 Co	References         • Slide set of lecture         • Script of lecture         • Textbook Tränkler "Sensortechnik", Springer         • Exercise script						

<b>Course nr.</b> 18-kn-2120-vl	Course name Sensor Technique							
<b>Instructor</b> Prof. Dr. Mario K	Jupnik	<b>Type</b> Lecture	<b>SWS</b> 2					
<b>Course nr.</b> 18-kn-2120-ue	<b>Course name</b> Sensor Technique							
Instructor Prof. Dr. Mario K	Tupnik	<b>Type</b> Practice	<b>SWS</b> 1					
Mo	dule name							
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Scie	entific Workin	g and Writing		1				
Mo	dule nr.	Credit points	Workload	Self-study	Module	duration	Module cyc	cle
18-	ho-1001	3 CP	90 h	60 h	1 Term		Every Seme	ester
Lar Ger	<b>nguage</b> man/English			Module owner Prof. DrIng. Kla	us Hofman	in		
1	<ul> <li>Content and goals         <ul> <li>Elaboration of a technical topic in cooperation with a research associate as supervisor</li> <li>Detailed study of technical articles</li> <li>Deeper understanding of the technical topic treated therein</li> <li>Practical experience with technical documentation</li> <li>Learning modern presentation techniques and their application</li> <li>Presentation and discussion of the technical topic in front of a group of people</li> </ul> </li> </ul>							
2	<b>Learning objectives</b> The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.							
3	Recommended prerequisites for participation Lecture "Elektronische und Integrierte Schaltungen"							
4	<ul> <li>Form of examination Module exam:</li> <li>Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course</li> </ul>							
5	<b>Prerequisite</b> Passing the f	e for the award of c	<b>redit points</b> ation					
6	Grading Module exar • Module	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting:	100 %)		
7	<b>Usability of</b> BSc etit, BSc	<b>the module</b> MEC, BSc iST						
8	Grade bonu	s compliant to §25	(2)					
9	9 References							
Coi	urses							
	<b>Course nr.</b> 18-ho-1001-	<b>Course name</b> ps Scientific work	king and writing					
	I8-ho-1001-ps     Scientific working and writing       Instructor     Type     SWS       Prof. DrIng. Klaus Hofmann     Introductory seminar     2							

Mo	dule name							
Sci	entific Workin	g and Writing	T	Ι			1	
Mo	dule nr.	Credit points	Workload	Self-study	Module o	duration	Module cyc	cle
18-	hD-1001	3 CP	90 h	60 h	1 Term		Every Seme	ester
Lar Ger	<b>rguage</b> rman			Prof. DrIng. Chi	ristian Hoc	hberger		
1	<ul> <li>Content and goals</li> <li>Elaboration of a technical topic in cooperation with a research associate as supervisor</li> <li>Detailed study of technical articles</li> <li>Deeper understanding of the technical topic treated therein</li> <li>Practical experience with technical documentation</li> <li>Learning modern presentation techniques and their application</li> <li>Presentation and discussion of the technical topic in front of a group of people</li> </ul>							
2	2 <b>Learning objectives</b> The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.							
3	Recommended prerequisites for participation							
4	<ul> <li>Form of examination         Module exam:         <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> <li>Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course</li> </ul> </li> </ul>							
5	<b>Prerequisite</b> Passing the f	for the award of c	<b>redit points</b> ation					
6	Grading Module exam • Module	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting:	100 %)		
7	<b>Usability of</b> BSc etit, BSc	<b>the module</b> MEC, BSc iST						
8	Grade bonu	s compliant to §25	(2)					
9	9 References							
Co	urses							
	<b>Course nr.</b> 18-hb-1001-	<b>Course name</b> Scientific worl	king and writing					
	I8-hb-1001-ps       Scientific working and writing         Instructor       Type       SWS         Prof. DrIng. Christian Hochberger       Introductory seminar course       2							

Mo Ma	Module name Mastering Modern Embedded System Processors						
<b>Mo</b> 20-	<b>dule nr.</b> 00-1004	Credit points	Workload 150 h	Self-study 105 h	<b>Module duration</b>	Module cycle Every 2. Semester	
Lar Ger	nguage man/English			Module owner Prof. DrIng. And	lreas Koch		
1	<ul> <li>* Processor architectures in embedded systems</li> <li>* ARM instruction set and microarchitecture</li> <li>* ARM compiler and simulator</li> <li>* ARM bootloading and (realtime) operating systems</li> <li>* ARM debugging, profiling and tracing</li> <li>* ARM peripheral control</li> <li>* ARM power management</li> <li>* ARM application scenarios (Cortex-M/-A/-R)</li> <li>* Future development of embedded processors</li> <li>* Recent research results</li> </ul>						
2	Learning objectives After successful participation, students are able to * outline the essential components and functionality of embedded processors, * differentiate the advantages and disadvantages of different processor architectures, * use relevant development tools for embedded processors, * examine the functionality and efficiency of existing source code, * develop efficient source code for specific applications, * assess recent embedded systems research results.						
3	<b>Recommend</b> Successful p	ded prerequisites for articipation in "Rech	or participation nerorganisation" c	or similar			
4	Form of exa Course relat • [20-00	<b>mination</b> ed exam: )-1004-iv] (Technica	examination, Ora	ıl/written examina	tion, Default RS)		
5	Prerequisite Pass exam (1	e for the award of c 100%)	redit points				
6	Grading Course relat • [20-00	ed exam: )-1004-iv] (Technica	examination, Ora	al/written examina	tion, Weighting: 100	)%)	
7	Usability of B.Sc. Inform M.Sc. Inform May be used	<b>the module</b> natik natik l in other degree pro	grams.				
8	Grade bonu	is compliant to §25	(2)				
9	References						
Co	ırses						

<b>Course nr.</b> 20-00-1004-iv	<b>Course name</b> Mastering Modern Embedded System Processors		
<b>Instructor</b> Prof. DrIng. And	dreas Koch	<b>Type</b> Integrated course	SWS 3

Mo Pra	Module name Practical Programming of FPGAs using High-Level Languages						
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle	
La	nguage	5.01	70 H	Module owner		Livery 2. Semester	
Gei	rman			Prof. DrIng. And	lreas Koch		
1	Teaching co FPGAs have heterogeneo Verilog or V	ontent e been used very su bus systems. Howeve HDL is still the norm	ccessfully in rece er, programming	nt years to impler with conventional	nent application-spe hardware description	cific accelerators in n languages such as	
	As an alternative, high-level synthesis tools that can also generate hardware from high-level languages such as $C/C++$ play an increasingly important role in the implementation of such accelerators. During this course you will gain useful background knowledge on the basic algorithms of high-level synthesis as well as knowledge in practical design and optimization of FPGA designs using high-level synthesis tools.						
	In addition, you will learn relevant techniques for the integration of FPGA-based accelerators into het- erogeneous systems. During the practical phase of this course, you will create an FPGA-based accelerator for a given problem and implement it on a typical heterogeneous system in real hardware.						
2	Learning objectives         - Understanding the basics of HLS systems						
	- Understanding of important internals of HLS systems (e.g. optimization, scheduling)						
	- Ability to cutable FPG	design high-level A designs	language hardwa	are accelerators a	nd use HLS system	ns to generate exe-	
	- Experience	in troubleshooting a	nd optimization o	f HLS generated h	ardware designs		
	- Experience hardware/se	e in the integration oftware co-design to	of hardware ac	ccelerators into he	eterogeneous compu	iting systems using	
3	Recomment - Basics of D	<b>ded prerequisites fo</b> igital Logic (DT))	or participation				
	- Basics of Systems (AE	Computer Architec R)	cure (Computer )	Organization RO,	Architecture and D	esign of Computer	
	- Basic know	ledge of compilers is	dvantageous, but	not obligatory			
	- Using Linu	x systems and virtua	machines				
4	Form of exa Course relat • [20-00	<b>mination</b> ed exam: )-1081-iv] (Technica	examination, Ora	ıl/written examina	tion, Default RS)		
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points				
6	Grading						

	Course related ex • [20-00-108	Course related exam: • [20-00-1081-iv] (Technical examination, Oral/written examination, Weighting: 100 %)					
7	Usability of the	module					
	B.Sc. Informatik	B.Sc. Informatik					
	M.Sc. Informatik						
	May be used in other degree programs.						
8	Grade bonus compliant to §25 (2)						
9	References						
Cot	urses						
	Course nr.	Course name					
	20-00-1081-iv	Practical Programming of FPGAs using High-Level Languages	S				
	Instructor		Туре	SWS			
	Prof. DrIng. And	lreas Koch	Integrated course	2			

Mo Hai	<b>dule name</b> rdware for Net	ural Networks					
<b>Mo</b>	dule nr. zh-2010	<b>Credit points</b>	Workload	Self-study	Module duration	Module cy	cle
Lar Eng	<b>iguage</b> glish	0.01	100 11	Module owner Prof. DrIng. Li Z	Zhang	- Summer te	1111
1	Teaching co • Trainir • Challer • Compu • Neural • Neural	ntent ng and inference of n nges in accelerating itation cost reduction networks accelerati networks accelerati	neural networks neural networks n in neural networ on with logic desi on with in-memor	ks gn and FPGAs y-computing platfo	orms		
2	<b>Learning of</b> Students tha accelerating and select th performance	<b>Learning objectives</b> Students that have completed this module know the development of neural networks and the challenges in accelerating neural networks with CPUs and GPUs. They can evaluate the computation cost of neural networks and select the corresponding methods to reduce the computation cost. They are also enabled to evaluate the performance of the different hardware acceleration platforms for neural networks.					
3	<b>Recommended prerequisites for participation</b> Basic programming skills in Python.						
4	<ul> <li>Form of examination</li> <li>Module exam:</li> <li>Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)</li> </ul>						
5	<b>Prerequisite</b> Passing the f	e for the award of c	<b>redit points</b> ation				
6	<b>Grading</b> Module exar • Module	n: e exam (Technical ez	xamination, Exam	ination, Weighting	: 100 %)		
7	<b>Usability of</b> MSc etit, MS	<b>the module</b> Sc WI-etit, BSc/MSc	iST, MSc iCE				
8	Grade bonu	s compliant to §25	(2)				
9	<b>References</b> Slides can be	e downloaded throug	gh Moodle platfor	m			
Coi	ırses						
	<b>Course nr.</b> 18-zh-2010-	Course namevlHardware for	Neural Networks				1
	Instructor Prof. DrIng	. Li Zhang			<b>Type</b> Lecture		<b>SWS</b> 2
	<b>Course nr.</b> 18-zh-2010-	pr Hardware for	Neural Networks				
	Instructor Prof. DrIng	. Li Zhang			<b>Type</b> Internshi	p	<b>SWS</b> 2

Mo Ser	Module name Seminar: Integrated Electronic Systems Design B							
<b>Mo</b> 18-	<b>dule nr.</b> ho-2161	Credit points 6 CP	Workload 180 h	Self-study 135 h	Module of 1 Term	duration	Module cyc Every Seme	c <b>le</b> ester
Lar Eng	<b>iguage</b> glish			<b>Module owner</b> Prof. DrIng. Kla	us Hofman	ın		
1	<b>Teaching co</b> Research or written Docu	ontent iented Formulation umentation and Pres	of a Topic within entation; Team W	the area of Microo ork	electronics	System D	esign; Creati	on of a
2	Learning of A student is	<b>jectives</b> after successful con	pletion of this mo	odule, able to				
	1. gain a 2. write a	deep understanding in essay on the chose	of the chosen res en subject in a cor	earch subject in the nprehesive form ar	e field of in id present i	ntegrated e the outcom	lectronic syst ne to an audio	ems, ence
3	Recommended prerequisites for participationAdvanced Digital Integrated Circuit Design, CAD Methods, Computer Architectures, Programming Know-How							
4	<ul> <li>Form of examination</li> <li>Module exam:</li> <li>Module exam (Study achievement, Oral examination, Duration: 45 Min., Default RS)</li> </ul>							
5	Prerequisite Passing the	e <b>for the award of c</b> final module examin	<b>redit points</b> ation					
6	Grading Module exan • Modul	n: e exam (Study achie	vement, Oral exar	nination, Weightin	g: 100 %)			
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> ISc Wi-ETiT, MSc iCl	E, MSc iST, MSc M	IEC				
8	Grade bonu	s compliant to §25	(2)					
9	References Topic-orient	ed Materials will be	provided					
Cot	urses							
	<b>Course nr.</b> 18-ho-2161-	se Seminar: Inte	grated Electronic	Systems Design B				
	Instructor     Type     SWS       Prof. DrIng. Klaus Hofmann     3							

Mo Mo	Module name Modelling and Simulation of Circuits						
<b>Mo</b>	<b>dule nr.</b> sc-2010	<b>Credit points</b>	Workload 120 h	Self-study 75 h	Module duration	Module cycle	
Lar Ger	nguage man/English		120 11	Module owner Prof. Dr. rer. nat. Sebastian Schöps			
1	Teaching co The content • Circuit • Modifi • Flux a • Differe • Linear • Nume • Time-o • Freque • Impler	ontent of this course is the t interpretation as dir ied nodal and loop ar nd charge oriented fe ential algebraic equat system solver rical solution of nonli- domain methods ency-domain solutior mentation of the nun	following: rected graphs nalysis ormulations tions inear systems				
2	Learning objectives Students understand the theoretical and numerical fundamentals of circuit simulation and how the equations can be derived from Maxwell's equations. Circuit properties can be expressed in tems of graph theory. The sparse systems of equations such as the flux/charge oreinted modified nodal analysis can be assembled. In order to solve the obtained systems, different numerical methods for the simulation of circuits are relevant. This includes methods for the solution of linear systems (direct and iterative solvers), root-finding algorithms for nonlinear systems and implicit time integration methods. Mathematical concepts such as stability, convergence order or complexity are known and can be employed to judge the advantages and disadvantages of the various methods. Eventually, the students are able to programm their own circuit simulator, that can return both frequency as well as time domain solutions of electric networks.						
3	<b>Recommen</b> 18-hs-1070 20-00-0304	<b>ded prerequisites fo</b> Elektrotechnik und 1 Allgemeine Informati	<b>or participation</b> Informationstechr k I, 04-10-0602 St	nik I, 18-gt-1020 El atistics/Probability	lektrotechnik und Int 7 Theory, 04-10-0603	formationstechnik II, Scientific Computing	
4	Form of exa Module exa • Modul	amination m: le exam (Technical ex	xamination, Oral e	examination, Durat	ion: 20 Min., Defaul	t RS)	
5	Prerequisite Passing the	e for the award of c final module examina	<b>redit points</b> ation				
6	Grading Module exame • Module	m: le exam (Technical ez	kamination, Oral e	examination, Weigl	nting: 100 %)		
7	<b>Usability of</b> BSc/MSc et	the module it, BSc/MSc iST, BSc	MEC, MSc iCE, M	Sc WI-etit			
8	Grade bonu Grade bonu	<b>is compliant to §25</b> s of 0,4 if correctly in	(2) nplemented progr	ams are submitted			
9	References	· ·					

- L. W. Nagel, "SPICE2: A computer program to simulate semiconductor circuits", University of Berkeley, Tech. Rep., 1975.
- C.-W. Ho, A. E. Ruehli, and P. A. Brennan, "The modified nodal approach to network analysis", IEEE Trans. Circ. Syst., vol. 22, no. 6, pp. 504-509, Jun. 1975.
- J. Vlach, K. Singhal, Computer methods for circuit analysis and design. New York : Van Nostrand Reinold, 1983.

## Courses

uu	uises							
	<b>Course nr.</b> 18-sc-2010-vl	<b>Course name</b> Modelling and simulation of circuits						
	Instructor		<b>Type</b> Lecture	SWS 2				
	<b>Course nr.</b> 18-sc-2010-ue	<b>Course name</b> Modelling and simulation of circuits						
	Instructor		<b>Type</b> Practice	<b>SWS</b> 1				

Mo	Module name						
Ind	ustrial Electro	onics					
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
18- Lot	ho-2210	4 CP	120 h	75 h	1 Term	Winter term	
Gei	man/English			Prof. DrIng. Kla	us Hofmann		
1	<b>Teaching co</b> Typical Stru Sensor Fron Knowledge	ontent ture of Industrial Ele tend, Actuator Front of Relevant Standard	ctronics Compone end, Supply and F s and Technical R	ents. Characteristics Reference Level), Fr egulations.	s of Typical Building unctioning of Relevan	Blocks (Digital Core, nt Field Bus Systems,	
2	Learning objectives         After successfull completion of the module, students are able to:         1. understand the use of electronic components in typical industrial environments,         2. understand the function of the building blocks of typical IE comonents,         3. deeply understand the functioning of analog bulding blocks,         4. understand relevant field bus systemes,         5. understand the regulatory and technical standards of industrial electronics components.         Recommended prerequisites for participation						
3	Recomment Lecture "Ele	<b>ded prerequisites fo</b> ktronik" and "Electro	or participation nic and Integrated	d Circuits"			
4	<ul> <li>Form of examination</li> <li>Module exam: <ul> <li>Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)</li> <li>The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 5 students register, the examination will be an oral examination (duration: 30 min.). The type of examination will be announced in the beginning of the lecture.</li> </ul></li></ul>						
5	Prerequisite Passing the	e for the award of c	<b>redit points</b> ation				
6	Grading Module exan • Modul	m: e exam (Technical ex	kamination, Oral/	written examinatio	n, Weighting: 100 %	))	
7	<b>Usability of</b> MSc ETiT, N	the module I.Sc. iCE, M.Sc. MEC	:				
8	Grade bonu	is compliant to §25	(2)				
9	References <ul> <li>Dietma Jörg C nik"; V</li> <li>Gunter th Ed.</li> <li>Ulrich Ed. 20</li> </ul>	ar Schmid, Gregor Há lestreich, Oliver Gom /erlag Europa-Lehrm r Wellenreuther, Diet 2015. Tietze, Christoph Scl 116.	iberle, Bernd Schi ber, Albrecht Schi ittel, 11 th Ed. 20 er Zastrow; "Auto henk, Eberhard Ga	emann, Werner Phi lling: "Fachkunde I 13. matisieren mit SPS amm: "Halbleiter-S	lipp, Bernhard Grimm ndustrieelektronik u - Theorie und Praxis chaltungstechnik"; S	n, Günther Buchholz, nd Informationstech- "; Springer Verlag, 6 pringer Verlag, 15 th	

<b>Course nr.</b> 18-ho-2210-vl	<b>Course name</b> Industrieelektronik		
<b>Instructor</b> DrIng. Roland S	Steck	<b>Type</b> Lecture	SWS 2
<b>Course nr.</b> 18-ho-2210-ue	<b>Course name</b> Industrieelektronik		
Instructor DrIng. Roland S	Steck	<b>Type</b> Practice	<b>SWS</b> 1

## 1.3 Optional Subjects SWE: Software-Engineering

Mo C/C	<b>Module name</b> C/C++ Programming Lab					
<b>Mo</b>	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
Lar	nguage	5 Cr	90 II	Module owner	1 leilli	Summer term
Gei	man			Prof. Dr. rer. nat.	Andreas Schürr	
1	<ul> <li>Teaching content         The programming lab is divided into two parts.         In the first part of the lab, the basic concepts of the programming languages C and C++ are taught during the semester through practical exercises and presentations. All aspects will be deepened by extended practical exercises in self-study on the computer. For this purpose, all necessary materials such as presentation slides, presentation recordings, exercises, sample solutions of the exercises and recordings of the exercise discussions are provided in purely digital form.         The second part of the lab is about programming a microcontroller using the C programming language. For this purpose, the students are provided with a microcontroller for two days, with which they can work on practical programming tasks under supervision.         The following topics will be covered in the course:         <ul> <li>Basic concepts of the programming languages C and C++</li> <li>Memory management and data structures</li> <li>Object oriented programming in C++</li> <li>(Multiple) Inheritance, polymorphism, parametric polymorphism</li> <li>(Low-level) Programming of embedded systems with C</li> </ul> </li> </ul>					
2	Learning objectives During the module, students acquire basic knowledge of C and C++ language constructs. Additionally, they learn how to handle both the procedural and the object-oriented programming style. Through practical programming exercises, students acquire a feeling for common mistakes and dangers in dealing with the language, especially in the development of embedded system software, and learn suitable solutions to avoid them. Furthermore, through hands on experience with embedded systems, students acquire additional expertise in low level programming.				lditionally, they learn actical programming nguage, especially in 'urthermore, through '-level programming.	
3	<b>Recommen</b> Java skills	ded prerequisites fo	or participation			
4	Form of examination         Module exam:         • Module exam (Study achievement, Oral/written examination, Default RS)         The examination has the form of a Report (including submission of programming code) and/or a Presentation and/or an Oral examination (25 minutes) and/or a Colloquium (testate), but never more than two out of it.         From a number of 10 students registered for the course, the examination may take place in form of a written examination will be approximately in the beginning of the locature					
5	Prerequisite Passing the f	e for the award of c	<b>redit points</b> ation			
6	Grading Module exan • Modul	n: e exam (Study achie	vement, Oral/writ	ten examination, V	Weighting: 100 %)	
7	Usability of BSc ETiT, BS	<b>the module</b> Sc MEC, BSc iST, BSc	e Wi-ETiT			
8	Grade bonu	s compliant to §25	(2)			

	Grade improvem submitted bonus The content of th Oriented Program each, which mus Bonus credit is g Total bonus = 1.	ents up to 1.0 according to APB 25(2) can be achieved throug assignments. e course is divided into 5 topics. For each topic (Fundamentals nming, Advanced Concepts, and C) there is one assignment sh to be solved and handed in by the students. The assignment i iven in proportion to the ratio of passed bonus tasks and the to $0 \times$ Number of passed tasks / Total number of bonus tasks	gh a bonus system for r s, Memory Management leet with one bonus ass s considered either pas otal number of bonus ta	egularly t, Object ignment s or fail. sks.	
9	<ul> <li>References         <ul> <li>A recording of the presentations as well as presentation slides are available in the corresponding Moodle course.</li> <li>Additional literature:                 <ul> <li>Schellong, Helmut: Moderne C Programmierung, 3. Auflage. Springer, 2014</li> <li>Schneeweiß, Ralf: Moderne C++ Programmierung, 2. Auflage. Springer, 2012</li> <li>Stroustrup, Bjarne: Programming - Principles and Practice Using C++, 2nd edition. Addison-Wesley, 2014</li> <li>Stroustrup, Bjarne: A Tour of C++, 2nd edition. Pearson Education, 2018</li> </ul> </li> </ul> </li> </ul>				
Co	urses				
	<b>Course nr.</b> 18-su-1030-pr	<b>Course name</b> C/C++ Programming Lab			
	Instructor Prof. Dr. rer. nat.	Andreas Schürr	<b>Type</b> Internship	SWS 2	

<b>Mo</b> Rea	<b>dule name</b> l-Time Syster	ns				
<b>Mo</b>	<b>dule nr.</b> \$11-2020	Credit points	Workload	Self-study	Module duration	Module cycle
Lar Ger	nguage man		100 H	Module owner Prof. Dr. rer. nat.	Andreas Schürr	
1	<ul> <li>Teaching content         The lecture basically covers a model-driven software engineering process which is specially customized for real-time systems. This process is more deeply explored in the exercise using an automotive example. A focus is laid on object-oriented techniques. In this context, a real-time specific state-of-the-art CASE tool is introduced and used. Furthermore, fundamental characteristics of real-time systems and system architectures are introduced. Scheduling algorithms are discussed to get insights into real-time operating systems. Finally, a comparison between the Java programming language and its expansion for real-time operating systems (RT Java) will conclude the lecture.     </li> <li>Learning objectives</li> </ul>					
2	<ul> <li>2 Learning objectives         After successful completion of the module, students are able to use and evaluate model-based (object-oriented) techniques for the development of embedded real-time systems. This includes a deeper understanding of the following topics:</li></ul>					
3	<b>Recommen</b> Basic knowl programmir	<b>ded prerequisites fo</b> edge of software eng 1g language (preferal	or participation gineering techniqu bly Java)	les and excellent k	nowledge of at least	one object-oriented
4	Form of exa Module exam • Modul The examina 15 students will be anno	amination m: e exam (Technical ex ation takes place in fo register, the examina ounced in the beginni	kamination, Oral/ orm of a written ex tion will be an ora ing of the lecture.	written examinatio am (duration: 90 m al examination (dur	n, Duration: 90 Min. iinutes). If one can es ation: 30 min.). The	, Default RS) stimate that less than type of examination
5	Prerequisite Passing the	e for the award of cr final module examina	<b>redit points</b> ation			
6	Grading Module exa • Modul	m: e exam (Technical ex	xamination, Oral/	written examinatio	n, Weighting: 100 %	)
7	<b>Usability of</b> MSc ETiT, B	the module Sc iST, MSc Wi-ETiT,	, BSc Informatik			
8	Grade bonu Grade impro	<b>is compliant to §25</b> ovements up to 0.4 pe	<b>(2)</b> er APB 25 (2) du	e to bonus for regu	larly submitted home	ework tasks
9	References https://www	w.es.tu-darmstadt.de,	/lehre/aktuelle-ve	eranstaltungen/es-v	v and Moodle	
Cou	ırses					

<b>Course nr.</b> 18-su-2020-vl	Course nr.Course name18-su-2020-vlReal-Time Systems				
Instructor		<b>Type</b>	<b>SWS</b>		
Prof. Dr. rer. nat. Andreas Schürr		Lecture	3		
<b>Course nr.</b> 18-su-2020-ue	Course name Real-Time Systems				
<b>Instructor</b>	<b>Type</b>	<b>SWS</b>			
M.Sc. Hendrik G	Practice	1			

Mo Pro	<b>dule name</b> jektseminar S	Software Systems				
<b>Mo</b>	<b>dule nr.</b> su-1060	Credit points 8 CP	Workload 240 h	Self-study 180 h	Module duration	Module cycle Every Semester
Lar Ger	nguage man			Module owner Prof. Dr. rer. nat.	Andreas Schürr	
1	1       Teaching content         The course deals with various development and research topics in the area of model-driven engineering and object-oriented software engineering. Besides a general overview, it provides a deep insight into a special scientific topic. The topics are selected according to the specific working areas of the participating researchers and convey technical and scientific competences in one or more of the following topics:         • Model-Driven Enginnering and Model Synchronization         • Model Transformation         • Object-Oriented Refactorings         • Program Variability (Software Product Lines)         • Feature Model Analysis					
2	<ul> <li>Learning objectives         The student gains practical experience in development (reengineering and maintenance) of complex software systems. He/She learns to work and function in a team, and to analyze and solve a non- trivial task. Moreover, students exercise using theoretical knowledge in the group (e.g. from lectures like software engineering - introduction / Design / Maintenance &amp; Quality Assurance) to solve a concrete and practical problem. Students that have successfully completed this seminar are able to independently organize and set-up a non-trivial software project and function to analyze and solve a certain task. Attendees gain the following skills in detail:</li></ul>					
3	Recommen Basic softwa	ded prerequisites for are technology knowl	or participation edge and advance	d knowledge of ob	ject-oriented program	nming languages
4	Form of exa Module exa • Modul Report and/	amination m: le exam (Study achie ⁄or Presentation. The	vement, Oral/writ	tten examination, I ion will be announ	Default RS) ced in the beginning	of the lecture.
5	<b>Prerequisit</b> Passing the	e for the award of c	<b>redit points</b> ation			
6	Grading Module exa • Modul	m: le exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 100 %)	
7	<b>Usability of</b> BSc ETiT, M	f <b>the module</b> ISc ETiT, BSc iST				
8	Grade bonu	is compliant to §25	(2)			
9	References www.es.tu-c	larmstadt.de/lehre/a	ıktuelle-veranstalt	ungen/ps-software	esysteme/	
Coι	urses					

<b>Course nr.</b> 18-su-1060-pj	<b>Course name</b> Projektseminar Software Systems		
Instructor M.Sc. Lars Luthn	nann, Prof. Dr. rer. nat. Andreas Schürr	<b>Type</b> Project seminar	SWS 4

Mo Inti	dule name	Compiler Construction	n			
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
20-	00-0904	5 CP	150 h	105 h	1 Term	Winter term
Ger Ger	iguage man			Prof. Dr. phil. nat	t. Marc Fischlin	
1	1       Jeaching content         - Structure of compilers       -         - Context-free grammars for the description of language syntax         - Lexing and parsing techniques         - Intermediate representations         - Semantic analysis         - Run-time organisation         - Code generation         - Software tools for compiler constructions         - Implementation techniques for compilers					
2	<ul> <li>2 Learning objectives         After successfully attending the course, students are familiar with the structure of compilers. They understand formal concepts for the description of syntax and semantics of programming languages. They can combine these concepts with algorithmic techniques to independently construct a compiler that maps a specified programming language to a given target machine. They know software tools supporting the construction of compilers and can apply these together with manual techniques to implement the compilers.     </li> </ul>					
3	<b>Recommended prerequisites for participation</b> Recommended: Participation of lecture "Algorithmen und Datenstrukturen", "Funktionale und objektorientierte Programmierung" and "Rechnerorganisation", respectively according knowledge.					
4	Form of exa Course relat • [20-00	<b>amination</b> ted exam: 0-0904-iv] (Study acl	nievement, Oral/v	vritten examinatior	ı, Default RS)	
5	<b>Prerequisit</b> Pass exam ( Course achi discussion o	e for the award of c (100%) ievement may be ac on colloquiums. Each	<b>redit points</b> quired through e area must be pass	xercises, hands-on sed.	training, programn	ning and successfull
6	Grading Course relat • [20-00	ted exam: 0-0904-iv] (Study acl	nievement, Oral/v	vritten examinatior	n, Weighting: 100 %)	
7	Usability of B.Sc. Inform B.Sc. Inform May be used	<b>f the module</b> natik nationssystemtechnik d in other degree pro	grams.			
8	Grade bonu	us compliant to §25	(2)			
9	<b>References</b> Literature re Watt/Brown	ecommendations will n: Programming Lang	be updated regul uage Processors i	arly, an example m n Java	light be:	
Coi	irses					

<b>Course nr.</b> 20-00-0904-iv	<b>Course name</b> Introduction to Compiler Construction		
Instructor Prof. DrIng. And	dreas Koch	<b>Type</b> Integrated course	<b>SWS</b> 3

Mo	dule name	a and Writing						
Mo	dule nr.	Credit points	Workload	Self-study	Module	duration	Module cyc	cle
18-	su-1001	3 CP	90 h	60 h	1 Term		Summer ter	rm
Lar Ger	<b>iguage</b> man			<b>Module owner</b> Prof. Dr. rer. nat.	Andreas S	Schürr		
1	<ul> <li>Teaching content Content and goals         <ul> <li>Elaboration of a technical topic in cooperation with a research associate as supervisor</li> <li>Detailed study of technical articles</li> <li>Deeper understanding of the technical topic treated therein</li> <li>Practical experience with technical documentation</li> <li>Learning modern presentation techniques and their application</li> <li>Presentation and discussion of the technical topic in front of a group of people</li> </ul> </li> </ul>							
2	2 Learning objectives The students are able to assess the reliability of information sources, comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.							
3	Recommend	led prerequisites fo	or participation					
4	Form of exa Module exar • Modul Report and/ announced a	mination n: e exam (Study achie or term paper and/o at the beginning of tl	vement, Oral/wri r presentation (in ne course.	tten examination, I preparation for the	Default RS) e thesis). T	) The type of	examination	will be
5	Prerequisite Passing the f	e for the award of c	<b>redit points</b> ation					
6	Grading Module exar • Modul	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting:	100 %)		
7	Usability of	the module						
8	Grade bonu	s compliant to §25	(2)					
9	9 References https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/sst-s							
Cot	ırses							
	<b>Course nr.</b> 18-su-1001-	ps Course name Scientific work	king and writing					
	<b>Instructor</b> Prof. Dr. rer.	nat. Andreas Schür	r			<b>Type</b> Introduct course	ory seminar	SWS 2

Mo Mu	<b>dule name</b> ltithreading in	n C++						
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study         Module duration         Module cycle           210 h         1 Term         Every 2 Semester				
Lar	nguage rman/English	10 Cr	500 11	Module owner Prof. Dr. rer. nat.	Oskar von Stryk		IIICSICI	
1	<ul> <li>Teaching content <ul> <li>C++ offers one of the most advanced threading interfaces available today. Using this interface as an example, the course teaches how to develop parallel software for shared memory with threads.</li> <li>Shared memory architectures</li> <li>Managing threads</li> <li>Sharing data between threads</li> <li>Synchronizing concurrent operations</li> <li>Designing lock-based concurrent data structures</li> <li>Designing programs for concurrency</li> <li>Testing and debugging</li> </ul> </li> </ul>					xample,		
2	<ul> <li>2 Learning objectives Skill of developing parallel programs</li> <li>• Systematically develop correct and efficient multithreaded programs</li> <li>• Design and implement parallel data structures</li> </ul>							
3	<b>Recommended prerequisites for participation</b> • Knowledge of C/C++							
4	Form of exa Course relat • [20-00	<b>mination</b> ed exam: ŀ-0953-iv] (Technica	l examination, Ora	al/written examina	tion, Default RS)			
5	Prerequisite Pass exam (1 Students wh	e for the award of c 100%) ich passed 20-00-08	redit points	in this lecturen.				
6	Grading Course relat • [20-00	ed exam: -0953-iv] (Technica	l examination, Ora	al/written examina	tion, Weighting: 100	) %)		
7	Usability of	the module						
8	Grade bonu	s compliant to §25	(2)					
9	References							
Co	urses							
	<b>Course nr.</b> 20-00-0953-	iv Multithreadin	g in C++					
	Instructor Prof. Dr. rer.	nat. Oskar von Stry	k		<b>Type</b> Integrate	ed course	<b>SWS</b> 6	

Mo Adv	dule name vanced Compi	iler Construction				
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle
Lar	nguage	0.01	100 11	Module owner Prof. DrIng. And	lreas Koch	Every 2. Semester
1	<ul> <li>Teaching content         <ul> <li>Compilation and run-time environment for object-oriented programming languages</li> <li>Control flow graphs as intermediate representations</li> <li>Static dataflow analysis</li> <li>Static single-assignment form</li> <li>Eliminating total and partial redundancy</li> <li>Scalar optimization</li> <li>Register allocation</li> <li>Scheduling</li> <li>Loop optimization</li> <li>Structure and organization of real compilers (e.g., phases, intermediate representations, compfile flow)</li> </ul> </li> </ul>					
2	2 Learning objectives After successfully attending the course, students understand techniques for the compilation and execution of object-oriented programs at the machine-level. The can apply static dataflow analysis to control flow graphs and are practiced using their SSA form. They are familiar with optimizing techniques for a number of problems as well as fundamental algorithms for register allocation. They know the internal structure of real production-grade compilers.					
3	Recomment Successfull	ded prerequisites for participation of "Einf	or participation ührung in den Co	mpilerbau"		
4	Form of exa Course relat • [20-00	mination red exam: )-0701-vl] (Technica	l examination, Ora	al/written examina	tion, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0701-vl] (Technica	l examination, Ora	al/written examina	tion, Weighting: 100	9%)
7	Usability of B.Sc. Inform M.Sc. Inform B.Sc. Comp M.Sc. Comp M.Sc. Wirtse B.Sc. Psycho Joint B.A. In B.Sc. Sportv M.Sc. Sportv Can be used	the module natik natik utational Engineering outational Engineerin chaftsinformatik ologie in IT formatik vissenschaft und Info wissenschaft und Info	g Ig ormatik ormatik grams.			
8	Grade bonu	is compliant to §25	(2)			

9	References Literature recom Cooper/Torczon: Muchnick: Advar Aho/Lam/Sethi/	mendations will be updated regularly, an example might be: Engineering a Compiler need Compiler Design and Implementation Ullman: Compilers - Principles, Techniques, and Tools		
Co	urses			
	<b>Course nr.</b> 20-00-0701-vl	<b>Course name</b> Advanced Compiler Construction		
	Instructor Prof. DrIng. And	dreas Koch	<b>Type</b> Lecture	<b>SWS</b> 3

Mo	dule name					
Aut	onomous Driv	ving Lab I	1	1		1
<b>Mo</b>	<b>dule nr.</b> su-2070	Credit points	Workload	Self-study 135 h	Module duration	Module cycle Winter term
Lar	iguage	0.01	100 11	Module owner	1 101111	Winter term
Ger	man			Prof. Dr. rer. nat.	Andreas Schürr	
1	<ul> <li>Teaching content During this module students gain practical experience in software development for embedded systems in the field of autonomous driving using a model car. In teamwork, they learn to cope with an extensive task. In order to solve this task they practice to use the theoretical knowledge available in the group (from other courses such as real-time systems, software engineering - introduction, C++ lab, digital control systems). <ul> <li>Hands-on programming experience with C++ in the development of embedded software systems for autonomous driving based on a model car <ul> <li>Application of control methods from the area of autonomous driving</li> <li>Application of software engineering techniques (design, documentation, test,) of a non-trivial embedded software system with hard real-time requirements and limited resources (memory,)</li> <li>Use of a given software framework and further libraries including a modular (real-time) operating system</li> <li>Hands-on experience using source code management systems, time management and other project management tools</li> <li>Presentations of the project results</li> </ul></li></ul></li></ul>					
2	<ul> <li>2 Learning objectives</li> <li>Students that have successfully participated in this module are able to organize and set-up a non-trivial software project in an interdisciplinary team according to a given problem independently. The participants acquire the following skills in detail: <ul> <li>Independent familiarization with a given software framework and ready-made libraries</li> <li>Transfer of theoretic knowledge into a software system</li> <li>Extensive use of tools for version, configuration, and change management</li> <li>Realistic time and resource management (project management)</li> <li>Development of hardware/software systems with C++ considering important limitations of embedded systems</li> <li>Planning and implementation of extensive quality assurance measures</li> <li>Collaboration and communication in and between teams</li> </ul> </li> </ul>					
3	Recommen	ded prerequisites fo	or participation			
	<ul> <li>ETIT/DT, iST, Informatik, WI-ET/DT: Basic software technology knowledge and advanced knowledge of object-oriented programming languages (especially C++)</li> <li>Additionally desired:         <ul> <li>Basic knowledge of the development of real-time systems or image processing</li> <li>ETIT/AUT, MEC: Basic knowledge in control engineering including state space control design, soma additional basic knowledge in digital control design may be helpful</li> </ul> </li> </ul>					vanced knowledge of ontrol design, some
4	Form of exa Module exa • Modul	amination m: e exam (Study achie	vement, Oral exar	nination, Duration	: 30 Min., Default RS	5)
5	Prerequisite Passing the	e for the award of c	<b>redit points</b> ation			
6	Grading					

	Module exam: • Module exa	<ul><li>Module exam:</li><li>Module exam (Study achievement, Oral examination, Weighting: 100 %)</li></ul>					
7	<b>Usability of the module</b> MSc ETiT, BSc iST						
8	Grade bonus compliant to §25 (2)						
9	References https://www.es.	tu-darmstadt.de/lehre/aktuelle-veranstaltungen/ps-af-i and Me	oodle				
Co	urses						
	<b>Course nr.</b> 18-su-2070-pj	<b>Course name</b> Autonomous Driving Lab I					
	<b>Instructor</b> Dr. Ing. Eric Len	z, Dr. Ing. Stefan Tomaszek, Prof. Dr. rer. nat. Andreas Schürr	<b>Type</b> Project seminar	<b>SWS</b> 3			

Mo Aut	<b>dule name</b> conomous Driv	ving Lab II				
<b>Mo</b> 18-	<b>dule nr.</b> su-2100	Credit points 6 CP	Workload 180 h	Self-study 135 h	Module duration 1 Term	Module cycle Summer term
Lar	nguage	1		Module owner		1
Ger	man/English			Prof. Dr. rer. nat.	Andreas Schürr	
1	Teaching co	ontent				
	<ul> <li>Further development and optimization of a robust C++ framework for solving non-trivial problems in the field of autonomous driving based on realistic challenges from the Carolo Cup, an international student competition for autonomous model cars</li> <li>Development and implementation of different algorithms (e.g., for motion planning, image processing, control, and obstacle avoidance) in an embedded system with hard real-time requirements and limited resources (memory,)</li> <li>Application and further development of control methods in the field of autonomous driving</li> <li>Application of software engineering techniques (design, documentation, testing,) for solving the problem</li> <li>Using source code management systems, time management and other project management tools</li> <li>Presentations of the project results</li> </ul>					
2	Learning ol Students lea autonomous practically a Students w and solve a o skills in deta • Furthe dently • Solvin • Extens • Realist • Furthe tal cor • Planni • Collab	pjectives arn to independently s driving. Realistic p nd the implementation ho have successfully complex and realistic ail: er development and of sive use of tools for ve- tic time planning and er development and of aditions ng and implementation oration, communicat	develop, impleme roblems from the on is ensured by o y participated in task in the field o optimization of an on of non-trivial, re ersion, configurati l resource allocati ptimization of con ion of extensive que ion and organizat	ent and present ne Carolo Cup are so juality assurance m this project semi f autonomous drivi existing software ealistic control eng ion, change, and qu on (project manage plex hardware/sof uality assurance me ion within the tear	w concepts and algo olved with existing k heasures. nar are able to ind ng. The participants a system and the used ineering challenges hality assurance man ement) tware systems under easures n	rithms in the field of mowledge and skills dependently analyze acquire the following algorithms indepen- agement realistic environmen-
3	Recomment	<b>ded prerequisites fo</b>	or participation	nomous Driving I"	or course with simil	ar content.
4	Form of exa Module exa • Modul	mination m: e exam (Study achie	vement, Oral exar	nination, Duration	: 30 Min., Default RS	3)
5	Prerequisite Passing the	e for the award of c final module examina	redit points ation			
6	Grading Module exa • Modul	m: e exam (Study achie	vement, Oral exar	nination, Weightin	g: 100 %)	
7	Usability of	the module				

8	Grade bonus compliant to §25 (2)					
9	References					
	https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/ps-af-ii und Moodle					
Coi	urses					
	Course nr.	Course name				
	18-su-2100-pj Autonomous Driving Lab II					
	Instructor Type					
	Dr. Ing. Eric Len	Ζ	Project seminar	3		

Mo Adv	<b>dule name</b> vanced Multit	nreading in C++						
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module dura	ation Mo	dule cyc	: <b>le</b> mester
Lar	nguage	0.01	100 11	Module owner Prof. Dr. rer. pat	Oskar von Str	wk	.19 2. 001	
1	Teaching co C++ offers of course teach Based on th ics: • C++ mem	ontent one of the most mode es advanced techniq ne contents of the nory model and atom	ern threading inter jues to develop pa course Multithrea ic operations	faces available tod rallel software for s ading in C++, th	ay. Using this i shared memor	nterface as a y with threa l cover the	an examj ads. followii	ple, the ng top-
	<ul> <li>Designing lock-free concurrent data structures</li> <li>Advanced thread management (e.g., thread pools)</li> </ul>							
2	Learning objectives         After successfully completing the course, the students have advanced skills of developing parallel programs.         They are able to         - Systematically develop correct and efficient multithreaded programs         - Design and implement parallel data structures							
3	<ul> <li>Recommended prerequisites for participation</li> <li>Knowledge of C/C++</li> <li>Foundations of programming threads in C++ (lock-based synchronization and lock-based concurrent data structures)</li> </ul>							
4	Form of exa Course relat • [20-00	<b>mination</b> ed exam: -0977-iv] (Technica	l examination, Ora	al/written examina	tion, Default F	RS)		
5	Prerequisite Pass exam ( Students w aren't allowe	e for the award of c 100%) ho passed Modul ed to pass this Modu	<b>redit points</b> "Fortgeschrittene I.	parallele Program	nmierung 2"	(FPPROG2	2), 20-00	0-0938
6	Grading Course relat • [20-00	ed exam: -0977-iv] (Technica	l examination, Ora	al/written examina	tion, Weightin	g: 100 %)		
7	Usability of	the module						
8	Grade bonu	s compliant to §25	(2)					
9	References							
Со	ırses							
	<b>Course nr.</b> 20-00-0977-	Course nameivAdvanced Mu	tithreading in C+	+				
	<b>Instructor</b> Prof. Dr. rer.	nat. Oskar von Strv	k		Ty	pe regrated cou	ırse	SWS 4

Mo Ser	Module name Seminar Software System Technology							
<b>Mo</b> 18-	<b>dule nr.</b> su-2080	Credit points 4 CP	Workload 120 h	Self-study 90 h	Module of 1 Term	duration	Module cyc Summer ter	c <b>le</b> rm
Lar Ger	<b>iguage</b> man			Module owner Prof. Dr. rer. nat. Andreas Schürr				
1	<b>Teaching co</b> In this course subject relate	ntent e, the students produ ed to IT system devel	ice scientific repor lopment and produ	ts from changing su ice a written report	ıbject areas as well as	s. Each stue a final talk	dent has to ex with a presen	xplore a ntation.
2	2 Learning objectives Upon successful completion of the module, the students will be able to assess the reliability of information sources and explore an unknown topic under scientific aspects. The students learn to support the exploration by a literature research and to analyze the subject critically. They achieve the skills to present a definite subject in a written report as well as in an oral presentation.							
3	Recommended prerequisites for participation Basic knowledge in software engineering and programming languages							
4	<ul> <li>Form of examination         Module exam:         <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> <li>Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of             the lecture         </li> </ul> </li></ul>							
5	<b>Prerequisite</b> Passing the f	e for the award of c	r <b>edit points</b> ation					
6	Grading Module exar • Module	n: e exam (Study achie	evement, Oral/wri	tten examination, V	Weighting:	100 %)		
7	Usability of BSc iST, BSc	<b>the module</b> Informatik, MSc ET	ïΤ					
8	Grade bonu	s compliant to §25	(2)					
9	References https://www	v.es.tu-darmstadt.de	/lehre/aktuelle-ve	eranstaltungen/sst-	·S			
Coi	ırses							
	<b>Course nr.</b> 18-su-2080-s	<b>Course name</b> Se Seminar Softw	vare System Techr	nology				
	Instructor Prof. Dr. rer.	nat. Andreas Schür	r			<b>Type</b> Seminar		<b>SWS</b> 2

Mo	dula nomo						
Intr	coduction to S	cientific Computing	in C++				
<b>Mo</b>	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
Lar	iguage	5 CF	130 11	Module owner			
Eng	glish			Prof. Dr. rer. nat.	Sebastian Schöps		
1	<ul> <li>Teaching content</li> <li>Students with basic programming experience will get an introduction to computational programming of numerical algorithms in C++. The first half of this course will focus on basics of the programming language C++, and highlight aspects in which the language differs from scripting languages such as Python or Matlab. Subsequently, the focus of the course will be on efficient memory management: We discuss modern best practices such as the usage of reference types and idioms like RAII ("Resource Acquisition is Initialization") rather than classical pointers ("Raw-Pointers"). During the exercises, we illustrate the effect of memory handling for numerical linear algebra applications, and introduce STL (Standard Template Library) data structures in this context. In the second half of the lecture, the students implement more complex algorithms from different application areas using the "Eigen" library (for linear algebra) and openMP (for parallel computing). Here, the focus lies on understanding both libraries, improving the students' programming level from the first lecture half, and solving programming tasks from different areas such as stochastics, numerical solution of differential equations, and approximations.</li> <li>Learning objectives</li> </ul>						
2	<ul> <li>Learning objectives</li> <li>Students will obtain a basic understanding for the implementation of numerical algorithms in C++ including: <ul> <li>Basics of C++ (Syntax, development environments, compilation,)</li> <li>Differences to Python / Matlab (types, classes, pointers, references,)</li> <li>Data types for numerical application (e.g. float, double, Unum/Posit, HDF,)</li> <li>Modern C++ (Templates, RAII, Lambdas,) according to standard &gt;= 11</li> <li>Working with CMake and Git</li> <li>Data types of STL and "Eigen", and the development of numerical software on their basis</li> <li>Memory management, performance benchmarks, parallelization with openMP</li> </ul> </li> </ul>						
3	Recommen	ded prerequisites fo	or participation				
	<ul><li>Essent</li><li>Mathe lation</li></ul>	ials of programming matik I - IV, in partic problems, numerics	in Python / Matla ular: Linear algeb of ordinary differe	ab ra, numerical soluti ential equations	on of systems of linea	ar equations, interpo-	
4	Form of exa	amination					
	Module example in Module example in Module example in Module example in the students regression to the announce of the students regression in the stude	le exam (Technical ex m (Technical examir es place in form of a ister, the examination ed in the beginning o	kamination, Oral/ nation, Oral/writt written exam (du n will be an oral ex of the lecture.	written examinatio en examination, D tration: 90 minute camination (duratio	n, Duration: 90 Min. uration: 90 Min., De s). If one can estima n: 25 min.). The type	., Default RS) fault RS) The exam- ate that less than 30 e of examination will	
5	Prerequisite Passing the	e for the award of c	<b>redit points</b> ation				
6	Grading Module exa • Modul	m: le exam (Technical ex	xamination, Oral/	written examinatio	n, Weighting: 100 %	))	
7	<b>Usability of</b> MSc etit, MS	t <b>he module</b> Sc CE; BSc/MSc WI-e	etit, BSc/MSc iST				

8	<b>Grade bonus compliant to §25 (2)</b> Yes. An earned bonus is creditable until the exercises are offered again.						
9	References Will be handed out during the lecture and is provided via Moodle.						
Co	Courses						
	Course nr. 18-sc-2050-vlCourse nameIntroduction to Scientific Computing in C++						
	<b>Instructor</b> Dr. Manuel Baun	ann, Dr. Felix Wolf	<b>Type</b> Lecture	<b>SWS</b> 2			
	<b>Course nr.</b> 18-sc-2050-ue	<b>Course name</b> Introduction to Scientific Computing in C++					
	Instructor		<b>Type</b> Practice	SWS 2			

Mo Opt	Module name Optimizing Compiler Project							
<b>Mo</b> 20-	<b>dule nr.</b> 00-0498	Credit points 3 CP	Workload 90 h	Self-study 60 h	Module du 1 Term	ration	Module cy Every 2. Se	cle mester
Lar Ger	n <b>guage</b> man			Module owner Prof. DrIng. Andreas Koch				
1	<b>Teaching co</b> - Compiler in representation	ontent mplementation in Ja on - scalar optimizat	ava - Modification ions on new IR	of an existing con	npiler - Exter	nsion by	a new interr	nediate
2	Learning of	ojectives						
3	Recommend The lectures	<b>led prerequisites fo</b> Optimizing Compile	or participation ers in the same ter	m.				
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>[20-00-0498-pr] (Study achievement, Oral/written examination, Default RS)</li> </ul>							
5	Prerequisite Pass exam (2	e for the award of c 100%)	redit points					
6	Grading Course relate • [20-00	ed exam: )-0498-pr] (Study ac	hievement, Oral/v	vritten examinatio	n, Weighting	: 100 %)	)	
7	Usability of	the module						
8	Grade bonu	s compliant to §25	(2)					
9	References							
Cot	urses							
	<b>Course nr.</b> 20-00-0498-	pr Praktikum Op	timierende Compi	ler				
	Instructor Prof. DrIng	. Andreas Koch			T It	T <b>ype</b> nternshij	р	<b>SWS</b> 2

Mo For	Module name Formal Principles of Computer Science III							
<b>Mo</b> 20-	<b>dule nr.</b> 00-0003	Credit points 6 CP	Workload 180 h	Self-study 135 h	Module of 1 Term	luration	Module cyc Every 2. Se	c <b>le</b> mester
Lar Ger	<b>iguage</b> man		1	Module owner Prof. Dr. phil. nat. Marc Fischlin				
1	<b>Teaching co</b> The course i	ontent s given in German						
2	Learning of The course i	<b>jectives</b> s given in German						
3	Recommended prerequisites for participation The course is given in German							
4	Form of examination         Course related exam:         • [20-00-0901-iv] (Technical examination, Oral/written examination, Default RS)         • [20-00-0901-iv] (Study achievement, Oral/written examination, p/np RS)							
5	Prerequisite Pass exam (2	e for the award of c 100%)	redit points					
6	<b>Grading</b> Course relat • [20-00 • [20-00	ed exam: )-0901-iv] (Technica )-0901-iv] (Study acl	l examination, Ora nievement, Oral/v	al/written examina vritten examinatior	ition, Weigl 1, Weightin	nting: 100 g: 0 %)	%)	
7	Usability of	the module						
8	Grade bonu	s compliant to §25	(2)					
9	References							
Coi	urses							
	<b>Course nr.</b> 20-00-0901-	iv Formale Meth	ods in Software D	esign				
	Instructor Prof. DrIng	. Andreas Koch				<b>Type</b> Integrate	d course	SWS 3

Mo Cor	dule name	ramming Languages				
<b>Mo</b> 20-	dule nr.	Credit points	Workload 180 h	Self-study 120 h	Module duration	Module cycle Winter term
Lar Eng	<b>iguage</b> glish		100 H	Module owner Prof. DrIng. Erm	nira Mezini	
1	Fundamental concepts of programming languages. In particular, we identify various basic concepts of programming languages and discuss them in detail, for example:         • role of syntax         • functions         • meta-interpreters         • recursion         • lazy evaluation         • state and side effects         • continuations         • domain-specific languages and macros         • object-oriented programming					
2	<ul> <li>Learning objectives</li> <li>After the successful completion of the lecture, students will be able to perform the following tasks: <ul> <li>they will be able to identify the defining features of programming languages;</li> <li>they will be familiar with fundamental theoretical concepts of programming languages;</li> <li>they will be able to implement simple programming languages using different implementation techniques;</li> <li>students will understand the influence of different programming languages on the solution space of various software development problems;</li> <li>students will be able to overcome stereotypical categorizations of programming languages.</li> </ul> </li> </ul>					
3	Recomment Recomment	<b>ded prerequisites fo</b> led: Funktionale und	or participation Objektorientierte	Programmierkonz	epte	
4	Recommended: Funktionale und Objektorientierte Programmierkonzepte         Form of examination         Course related exam:         • [20-00-0072-iv] (Technical examination, Oral/written examination, Default RS)         The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.         Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework					
5	Prerequisit Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0072-iv] (Technical	examination, Ora	al/written examina	tion, Weighting: 100	9%)
7	Usability of	the module				

	B. Sc. Informatik M. Sc. Informatil M. Sc. Computer M. Sc. Autonome M.Sc. IT Sicherh M.Sc. IT Security May be used in o	Science Systeme und Robotik eit , ther degree programs.					
8	<b>Grade bonus compliant to §25 (2)</b> In dieser Veranstaltung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25(2) der 6. Novelle der Allgemeinen Prüfungsbestimmungen der TU Darmstadt und den vom Fachbereich Informatik am 14.07.2022 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.						
9	<ul><li>References</li><li>S. Krishnan</li><li>M. Scott: P</li><li>D. Friedma</li></ul>	nurthi: Programming Languages - Application and Interpretati rogramming Language Pragmatics, Morgan Kaufmann n et al.: Programming Language Essentials, MIT Press	on				
Cot	urses						
	<b>Course nr.</b> 20-00-0072-iv	<b>Course name</b> Concepts of Programming Languages					
	Instructor		<b>Type</b> Integrated course	<b>SWS</b> 4			
Mo Cor	<b>dule name</b> npiler Constr	uction Lab					
--------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------	----------------------------------	------------------------	---------------------	--
Module nr.Credit pointsWorkload20-00-09116 CP180				Self-study 120 h	<b>Module duration</b>	Module cycle	
Lar Ger	nguage man/English		100 H	Module owner Prof. DrIng. Ern	nira Mezini		
1	Teaching co Independen or back-end	ontent tly implement a com s).	piler or extend an	existing compile fl	ow (e.g., realize new	optimization passes	
2	2 Learning objectives After successfully completing the labs, students are able to independently implement core parts of a modern com- piler, either from scratch or integrating them into an existing compiler framework. In this process, they can apply and improve their knowledge both of compiler technology (e.g., use of different intermediate representations), as well as of general implementation techniques (e.g., applying design patterns).						
3	Recommended prerequisites for participation Recommended: Participation of lecture "Rechnerorganisation", "Einführung in den Compilerbau" and "Fortgeschrittener Com- pilerbau", respectively according knowledge.						
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>[20-00-0911-pr] (Study achievement, Oral/written examination, Default RS)</li> </ul>						
5	<b>Prerequisit</b> Pass exam (	e for the award of c 100%)	redit points				
6	Grading Course relat • [20-00	ted exam: D-0911-pr] (Study ac	hievement, Oral/v	vritten examinatio	n, Weighting: 100 %)	)	
8	Usability of B.Sc. Inform M.Sc. Inform B.Sc. Comp M.Sc. Comp M.Sc. Wirts B.Sc. Psycho Joint B.A. Ir B.Sc. Sporty M.Sc. Sporty M.Sc. Inform May be used Grade bond	f <b>the module</b> natik natik utational Engineering outational Engineerin chaftsinformatik ologie in IT nformatik wissenschaft und Info wissenschaft und Info nationssystemtechnil d in other degree pro <b>15 compliant to §25</b>	g g ormatik ormatik k grams. (2)				
0	Deferences	is compliant to 925	(4)				
9	Will be give	n to actual topic.					
Co	urses	Courses					

	<b>Course nr.</b> 20-00-0911-pr	<b>Course name</b> Compiler Construction Lab		
	<b>Instructor</b> Prof. DrIng. Err	nira Mezini	<b>Type</b> Internship	SWS 4

Mo	dule name	isation and Somantic						
Modeling, Specification and Semantics           Module nr.         Credit points         Workload				Self-study	Module duration	Module cycle		
20-	20-00-0013 5 CP 150 h			105 h	1 Term	Winter term		
<b>Language</b> German				Prof. Dr. phil. nat	t. Marc Fischlin			
1	Teaching co	ontent						
	<ul> <li>Models and their significance for Computer Science</li> <li>Introduction to discrete modeling using mathematical logic and algebraic concepts</li> <li>Interpretation and faithfulness of formal models</li> <li>Abstraction, refinement, composition, and decomposition of models</li> <li>Systematic construction of models and deliberate design decisions</li> <li>Syntax and operational semantics of programming languages</li> <li>Introduction to specification languages</li> <li>Syntax and denotational semantics of formal specification languages</li> <li>Elementary proof techniques and their use</li> <li>Modeling of systems and of requirements</li> <li>Modeling of coordination and communication in concurrent systems</li> </ul>							
2	Learning objectives After successfully completing this module, students know basic concepts and methods of modeling, specification, and semantics. They are able to use predicate logic and algebraic concepts to formalize informally described scenarios and to assess the faithfulness of formal system models. They are able to develop discrete models in a systematic fashion, to make necessary design decisions, and to employ informal notation and graphics to facilitate the construction of formal models. They know selected formal specification languages and are able to use at least one such language. They understand the distinction between the syntax and semantics of formal languages, and they are able to prove propositions about concrete programs and specifications as well as simple meta-properties about programming and specification languages. They are able to formalize basic system							
3	Recommend Recommend Participation logik", respe	<b>ded prerequisites fo</b> led: n of lecture "Automat ective according knov	or participation en, formale Sprace vledge.	chen und Entscheic	lbarkeit" and "Aussaş	gen- und Prädikaten-		
4	Form of exa Course relat • [20-00 Written Exa	amination red exam: D-0013-iv] (Technical m (90 min.)	examination, Ora	al/written examina	tion, Default RS)			
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points					
6	Grading Course related exam: • [20-00-0013-iv] (Technical examination, Oral/written examination, Weighting: 100 %)							
7	Usability of the module B. Sc. Informatik Lehramt an Gymnasien - Fach Informatik May be used in other degree programs.							
8	Grade bonu	is compliant to §25	(2)					

	In dieser Veranstaltung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25(2) der 6. Novelle der Allgemeinen Prüfungsbestimmungen der TU Darmstadt und den vom Fachbereich Informatik am 14.07.2022 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.					
9	ReferencesU. Kastens, H. Kleine Büning: Modellierung - Grundlagen und formale Methoden, HanserG. Winskel: The Formal Semantics of Programming Languages, MIT PressC. A. R. Hoare: Communicating Sequential Processes, Prentice-HallLiterature recommendations will be updated regularly.					
Co	urses					
	<b>Course nr.</b> 20-00-0013-iv	<b>Course name</b> Modellierung, Spezifikation und Semantik				
	Instructor		<b>Type</b> Integrated course	<b>SWS</b> 3		

Mo Sof	Module name Software Engineering for Artificial Intelligence						
<b>Mo</b>	Module nr.Credit pointsWorkload20.00-10074 CP120 h		Self-study	Module duration	Module cycle		
Lar	nguage		120 11	Module owner Prof Dr-Ing Erm	nira Mezini	Every 2. Semester	
1	<ul> <li>Teaching content</li> <li>Data-driven artificial intelligence (AI) solutions are being adopted in many areas, including finance, medicine, cognitive sciences, and biology. Such machine learning (ML) approaches require an accurate domain and requirement analysis, proper software design and development, dedicated testing and debugging, as well as specific techniques that ensure scalability and maintainability. While AI-enabled systems continue to have a tremendous impact on many fields, developers and data scientists still follow methods (scripting, informal/non-written specifications, trial-and-error testing) that do not conform to the state of the art of engineering disciplines. In this context, it is of paramount importance to take advantage of the decades-long developments of software engineering (SE) to systematize the development process of ML solutions.</li> <li>In this course, each student will be assigned a topic regarding SE for AI. Based on provided resources and personal extending research, each student prepares a presentation with following discussion. These will be conducted in regular appointments. The students not presenting at a particular date, prepare via introductory reading for the respective discussion. Grading will be based on the preparation of the assigned topic and its</li> </ul>						
	For more https://allpi	e information a rojects.github.io/SE4	articipation in all t and announcer	ments, please	consult the	course webpage:	
2	Integr.//anprojects.ginitab.io/SE4Ai/         Learning objectives         After successful completion of the module students will have developed a deeper understanding of software engineering for artificial intelligence. This includes the key topics requirements engineering, quality assurance, development processes, and software architecture and design accounting for modularity, reusability, efficiency, scalability, fairness and privacy.						
	heterogeneo in scientific	ous background know discussions as well as	ledge. Moreover, s s their moderation	tudents train efficie	ent preparation of and	d active participation	
3	Recomment Recomment	<b>ded prerequisites fo</b> led: Basic knowledge	or participation e of software engir	neering. Interest in	artificial intelligence		
4	<ul> <li>Form of examination</li> <li>Course related exam:         <ul> <li>[20-00-1097-se] (Study achievement, Oral/written examination, Default RS)</li> <li>The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible:</li> <li>Colloquium (optional: including presentation).</li> </ul> </li> </ul>						
5	Prerequisite Pass exam (	e for the award of c	redit points				
6	Grading Course related exam: • [20-00-1097-se] (Study achievement, Oral/written examination, Weighting: 100 %)						
7	Usability of	the module					

	B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.					
8	Grade bonus compliant to §25 (2)					
9	References	References				
Co	urses					
	<b>Course nr.</b> 20-00-1097-se	<b>Course name</b> Software Engineering for Artificial Intelligence				
	Instructor Prof. DrIng. Err	nira Mezini	<b>Type</b> Seminar	SWS 3		

Mo Sta	Module name Static and Dynamic Program Analysis							
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle		
Lar Eng	nguage	0 CP	180 11	Module owner Prof. DrIng. Hei	ko Mantel	Every 2. Semester		
1	Teaching content         - operational semantics for sequential and parallel programs         - overview of techniques for static and dynamic program analysis         - abstract interpretation         - data flow analysis         - slicing techniques         - type-based program analysis         - concepts of runtime monitoring         - techniques for implementing runtime monitoring         - language-based security         - soundness and precision of program analysis							
2	<b>Learning objectives</b> After successfully participating in this course the students will know a range of different program analyses. The students will understand the functionality of each program analysis and the difference between each of the considered program analyses. Furthermore, the students will be able to judge which program analysis is suitable for a specific problem, and they will be able to apply the different program analyses. The students will also be able to judge the precision and soundness of program analyses. Finally, the students will be able to implement and define the considered program analyses and variants of them.							
3	<b>Recommended prerequisites for participation</b> Knowledge of Computer Science and Mathematics equivalent to the first four semesters in the Computer Science Bachelor program, in particular basic knowledge about logic and the ability to understand formal calculi.							
4	Form of exa Course relat • [20-00	amination red exam: D-0580-iv] (Technical	examination, Ora	ıl/written examina	tion, Default RS)			
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points					
6	Grading Course relat • [20-00	ed exam: )-0580-iv] (Technical	examination, Ora	l/written examina	tion, Weighting: 100	%)		
7	Usability of B.Sc. Inform M.Sc. Inform May be used	E <b>the module</b> natik natik l in other degree pro	grams.					
8	Grade bonu	is compliant to §25	(2)					
9	References							
Со	ırses							

<b>Course nr.</b> 20-00-0580-iv	<b>Course name</b> Static and Dynamic Program Analysis		
<b>Instructor</b> Prof. DrIng. Hei	ko Mantel	<b>Type</b> Integrated course	SWS 4

Mo Dat	<b>dule name</b> a Manageme	nt - Lab						
<b>Mo</b>	<b>dule nr.</b> 00-1041	Credit points	Workload	Self-study	Module duration	Module cycle		
Lar Ger	nguage rman/English		100 H	Module owner Prof. Dr. techn. J	ohannes Fürnkranz			
1	<ul> <li>Teaching content         Participants independently solve alone or in a small group an individually a given problem. The problems are usually programming projects inspired by the research performed at the Data Management Lab.     </li> <li>Possible areas are:         <ul> <li>Scalable Databases &amp; Modern Hardware</li> <li>Cloud Databases &amp; Blockchains</li> <li>Interactive Data and Text Exploration</li> <li>Natural Language Interfaces for Databases</li> <li>Scalable Systems for Machine Learning</li> </ul> </li> <li>In this lab the students will realise a project defined by their advisor. Compared to the "Data Manage-</li> </ul>							
2	ment - Lab", the "Data Management - Extended Lab" requires more effort.         2       Learning objectives         After completion of this course the students are able to         - Understand state-of-the-art techniques in modern data management systems         - Apply and implemenation of techniques in individual projects         Derayida curverimental originance for design designed with banchmarks and (or real workloads)							
3	Recomment Depending of	ded prerequisites for on selected topic.	or participation					
4	Form of exa Course relat • [20-00	amination ed exam: )-1041-pr] (Study ac	hievement, Oral/v	vritten examination	n, Default RS)			
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points					
6	Grading Course relat • [20-00	ed exam: )-1041-pr] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %	)		
7	Usability of B.Sc. Inform M.Sc. Inform May be used	<b>the module</b> natik natik l in other degree pro	grams.					
8	Grade bonu	is compliant to $\S{25}$	(2)					
9	References							
Co	Courses							

<b>Course nr.</b> 20-00-1041-pr	<b>Course name</b> Data Management - Lab		
<b>Instructor</b> Prof. Dr. techn. J	ohannes Fürnkranz	<b>Type</b> Internship	SWS 4

Mo Dat	Module name Data Management - Extended Lab							
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle		
Lar Ger	nguage rman/English		27011	Module owner Prof. Dr. techn. Je	ohannes Fürnkranz	Every 2. beniester		
1	<ul> <li>Teaching content         Participants independently solve alone or in a small group an individually a given problem. The problems are usually programming projects inspired by the research performed at the Data Management Lab.     </li> <li>Possible areas are:         <ul> <li>Scalable Databases &amp; Modern Hardware</li> <li>Cloud Databases &amp; Blockchains</li> <li>Interactive Data and Text Exploration</li> <li>Natural Language Interfaces for Databases</li> <li>Scalable Systems for Machine Learning</li> </ul> </li> <li>In this lab the students will realise a project defined by their advisor. Compared to the "Data Management - Lab" the "Data Management - Extended Lab" requires more effort</li> </ul>							
2	Learning objectives         After completion of this course the students are able to         - Understand state-of-the-art techniques in modern data management systems         - Apply and implemenation of techniques in individual projects         - Provide experimental evidence for design decisions with benchmarks and/or real workloads							
3	Recommen Depending	<b>ded prerequisites fo</b> on selected topic.	or participation					
4	Form of exa Course relat • [20-00	amination red exam: )-1042-pp] (Study ac	hievement, Oral/	written examinatio	n, Default RS)			
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points					
6	Grading Course relat • [20-00	ed exam: )-1042-pp] (Study ac	hievement, Oral/	written examinatio	n, Weighting: 100 %	)		
7	Usability of B.Sc. Inform M.Sc. Inform May be used	E <b>the module</b> natik natik l in other degree pro	grams.					
8	Grade bonu	is compliant to §25	(2)					
9	References							
Cot	Courses							

	<b>Course nr.</b> 20-00-1042-pp	<b>Course name</b> Data Management - Extended Lab		
	<b>Instructor</b> Prof. Dr. techn. J	ohannes Fürnkranz	<b>Type</b> Project	<b>SWS</b> 6

Mo Sca	Module name Scalable Data Management Systems							
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle		
Lar	nguage	0.04	100 11	Module owner				
Eng	glish			Prof. Dr. techn. J	ohannes Fürnkranz			
1	<ul> <li>This course introduces the fundamental concepts and computational paradigms of scalable data management systems. The focus of this course is on the systems-oriented aspects and internals of such systems for storing, updating, querying, and analyzing large datasets.</li> <li>Topics include:</li> <li>Database Architectures</li> <li>Parallel and Distributed Databases</li> </ul>							
	Data Warehousing MapReduce and Hadoop Spark and its Ecosystem Optional: NoSOL Databases, Stream Processing, Graph Databases, Scalable Machine Learning							
2	Learning objectives After the course the student will have a good overview of the different concepts, algorithms, and systems aspects of scalable data management. The main goal is that the students will know how to design and implement such systems including hands-on experience with state-of-the-art systems such as Spark.							
3	<ul> <li>3 Recommended prerequisites for participation</li> <li>Programming in C++ and Java Informationsmanagement (20-00-0015-iv)</li> <li>Optional:</li> <li>Foundations of Distributed Systems (20-00-0998-iv)</li> </ul>							
4	Form of exa Course relat • [20-00	<b>mination</b> ed exam: )-1017-iv] (Technica	l examination, Ora	ıl/written examina	tion, Default RS)			
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points					
6	Grading Course relat • [20-00	ed exam: )-1017-iv] (Technica	l examination, Ora	al/written examina	tion, Weighting: 100	%)		
7	Usability of B.Sc. Inform M.Sc. Inform May be used	<b>the module</b> natik natik l in other degree pro	grams.					
8	Grade bonu	is compliant to $\S{25}$	(2)					
9	References							
Cot	ırses							

<b>Course nr.</b> 20-00-1017-iv	<b>Course name</b> Scalable Data Management Systems		
<b>Instructor</b> Prof. Dr. techn. J	ohannes Fürnkranz	<b>Type</b> Integrated course	SWS 4

Mo Adv	dule name	Janagement System	3					
Mo	dule nr.	Credit points	Workload	Self-study	Module d	luration	Module cy	cle
20-	00-1039	6 CP	180 h	120 h	1 Term		Every 2. Se	mester
Eng	<b>iguage</b> glish			Prof. Dr. techn. J	ohannes Fi	irnkranz		
1	<ul> <li>The course expects the reading of research papers (SIGMOD, VLDB, etc.) for each class. Programming projects will implement concepts discussed in selected papers. The final grade will be based on the results of the programming projects. There will be no final exam.</li> </ul>							
2	<ul> <li>Learning objectives         Upon successful completion of this course, the student should be able to:         - Understand state-of-the-art techniques for modern data management systems         - Discuss design decision of modern data management systems with emphasis on constructive improvements         - Implement advanced data management techniques and provide experimental evidence for design decisions     </li> </ul>							
3	Recommended prerequisites for participationSolid Programming skills in C and C++Scalable Data Management (20-00-1017-iv)Information Management (20-00-0015-iv)							
4	Form of exa Course relate • [20-00	<b>mination</b> ed exam: -1039-iv] (Technica	l examination, Ora	al/written examina	tion, Defau	ılt RS)		
5	Prerequisite Pass exam (1	e for the award of c	redit points					
6	Grading Course relate • [20-00	ed exam: -1039-iv] (Technica	l examination, Ora	al/written examina	tion, Weigl	nting: 100	%)	
7	Usability of B.Sc. Inform M.Sc. Inform May be used	<b>the module</b> atik natik in other degree pro	grams.					
8	Grade bonu	s compliant to §25	(2)					
9	References							
Co	urses							
	Course nr.	Course name						
	20-00-1039-	iv Advanced Dat	a Management Sy	stems	г			
	Instructor Prof. Dr. tech	ın. Johannes Fürnkı	anz			<b>Type</b> Integrate	d course	SWS 4

## 2 Applications

## 2.1 Optional Subjects AIS-AS: Automotive Systems

Mo Svs	Module name System Dynamics and Automatic Control Systems I							
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle		
18-	fi-1010	6 CP	180 h	120 h	1 Term	Winter term		
Lar Ger	i <b>guage</b> man			<b>Module owner</b> Prof. DrIng. Rolf	f Findeisen			
1	1 Teaching content Description and classification of dynamic systems; Linearization around an equilibrium point; Stability of dynamic systems; Frequency response; Linear time-invariant closed-loop systems; Controller design; Control structure optimization							
2	2 Learning objectives Students will know how to describe and classify different dynamic systems. They will be able to analyse the dynamic behaviour in time and frequency domain. The students will be able to design controllers for linear time invariant systems.							
3	Recommended prerequisites for participation							
4	Form of exa	mination						
	• Module exar	n: e exam (Technical ex	amination, Exam	ination, Duration:	120 Min., Default RS			
5	<b>Prerequisite</b> Passing the f	e for the award of c	redit points ation					
6	Grading         Module exam:         • Module exam (Technical examination, Examination, Weighting: 100 %)							
7	Usability of	the module						
8	Grade bonus compliant to §25 (2)							
9	References							

- Skript Konigorski: "Systemdynamik und Regelungstechnik I", Aufgabensammlung zur Vorlesung, Lunze: • "Regelungstechnik 1: Systemtheoretische Grundlagen, Analyse und Entwurf einschleifiger Regelungen", • Föllinger: "Regelungstechnik: Einführung in die Methoden und ihre Anwendungen",
- Unbehauen: "Regelungstechnik I:Klassische Verfahren zur Analyse und Synthese linearer kontinuierlicher Regelsysteme, Fuzzy-Regelsysteme", Föllinger: "Laplace-, Fourier- und z-Transformation",
- Jörgl: "Repetitorium Regelungstechnik", •
- Merz, Jaschke: "Grundkurs der Regelungstechnik: Einführung in die praktischen und theoretischen • Methoden",
- Horn, Dourdoumas: "Rechnergestützter Entwurf zeitkontinuierlicher und zeitdiskreter Regelkreise", •
- Schneider: "Regelungstechnik für Maschinenbauer", Weinmann: "Regelungen. Analyse und technischer Entwurf: Band 1: Systemtechnik linearer und lin-• earisierter Regelungen auf anwendungsnaher Grundlage"

## Courses

00	Jourses							
	<b>Course nr.</b> 18-fi-1010-vl	urse nr.Course name-fi-1010-vlSystem Dynamics and Automatic Control Systems I						
	Instructor M.Sc. Florian Weigand, Prof. DrIng. Rolf Findeisen		<b>Type</b> Lecture	<b>SWS</b> 3				
	<b>Course nr.</b> 18-fi-1010-tt	<b>Course name</b> System Dynamics and Automatic Control Systems I- Auditori	um Exercise					
	<b>Instructor</b> Prof. DrIng. Rol	f Findeisen	<b>Type</b> Tutorial	<b>SWS</b> 1				

Мо	Module name								
Tec	hnical Therm	odynamics I				1			
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle			
Io-	14-3010	0 CP	180 11	Madula cumor					
Ger	man			Prof. DrIng. Pete	er Stephan				
1	Teaching co Fundamenta (internal ene first law of t entropy bala carnot cycle processes fo	ontent al terms of thermodyn ergy, heat, work, entha thermodynamics and ances for technical sy e for power generation r gas turbines, combu	amics; thermodyn alpy); properties a l energy balances ystems; exergy an on or refrigeration ustion engines, po	amic equilibrium a nd equations of stat for technical syste alysis; thermodyna n; energy efficienc wer plants, refriger	nd temperature; diffe e for gases and incom ms; second law of th mic behaviour durin y and coefficient of rators and heat pump	erent forms of energy pressible substances; hermodynamics and g phase change; the performance; cyclic os.			
2	<ul> <li>2 Learning objectives On successful completion of this module, students should be able to: <ol> <li>Explain the relationships between thermodynamic properties and the thermodynamic state of a system and apply them within calculations of thermal system behaviour.</li> <li>Distinguish between different types of energy (e.g. work, heat, internal energy, enthalpy) and define them.</li> <li>Analyse technical systems and processes using energy balances and equations of state.</li> <li>Assess energy conversion processes by means of an entropy balance or an exergy analysis. <li>Characterise the thermal behaviour of gases, liquids and solids and corresponding phase change processes.</li> <li>Apply this basic knowledge (15.) to examine machines (turbines, pumps etc.) and processes for energy conversion (combustion engine, power plants, refrigerators, heat pumps). </li> </li></ol></li></ul>								
3	Recommen	ded prerequisites fo	r participation						
4	Form of exa Module exa • Modul	<b>amination</b> m: e exam (Technical ex	amination, Exam	ination, Duration:	150 Min., Default RS	;)			
5	<b>Prerequisit</b> Passing the	e for the award of creater and the examination	redit points						
6	Grading Module exan • Modul	m: e exam (Technical ex	amination, Exam	ination, Weighting	: 100 %)				
7	<b>Usability of</b> Bachelor MI Bachelor WI Master ETiT	<b>the module</b> 3 Pflicht I-MB MFT, Bachelor Mech	atronik						
8	Grade bonu	is compliant to §25	(2)						
9	References         P. Stephan; K. Schaber; K. Stephan; F. Mayinger: Thermodynamik, Band 1: Einstoffsysteme, Springer Verlag.         Further material (slides, collection of exercises, table of fomulas etc.) is available through the Moodle system of TU Darmstadt.								
Οι Οι	ırses								

<b>Course nr.</b> 16-14-5010-vl	<b>Course name</b> Technical Thermodynamics I		
Instructor		<b>Type</b> Lecture	<b>SWS</b> 3
<b>Course nr.</b> 16-14-5010-gü	<b>Course name</b> Technical Thermodynamics I - Group Exercise		
Instructor		<b>Type</b> Group practice	<b>SWS</b> 1
<b>Course nr.</b> 16-14-5010-hü	<b>Course name</b> Technical Thermodynamics I		
Instructor		<b>Type</b> Lecture hall practice	<b>SWS</b> 1

Мо	dule name							
Mo	tor Vehicles		X47	0.10.11	D.C. J. J. 4		Nr. 1.1.	.1.
16-1	dule nr. 27-5010	6 CP	180 h	Self-study 105 h	1 Term	uration	Summer ter	cie rm
Lar Ger	<b>iguage</b> man		I	Module owner Prof. DrIng. Ste	ven Peters			
1	<b>Teaching co</b> Layout and f resistance &	<b>ntent</b> unction of vehicle co performance; safety	omponents (e.g. e. r; aerodynamics ar	ngine, transmissior nd automotive com	ı, chassis, ti puting.	ires, breał	xs, steering);	driving
2	<ul> <li>2 Learning objectives <ul> <li>On successful completion of this module, students should be able to:</li> <li>1. Calculate the factors that influence fuel consumption and discuss the strategies to reduce fuel consumption.</li> <li>2. Derive upper bounds for combustion engine efficiencies and discuss the future opportunities &amp; challenges of electromobility.</li> <li>3. Explain the basic requirements, working principles, and basic structure of the drivetrain, powertrain, and chassis assemblies (including tires, wheels, brakes, steering, springs, dampers and axles).</li> <li>4. Name and explain the methods to increase safety in individual traffic.</li> <li>5. Explain the effects of aerodynamic measures on driving dynamics and fuel consumption.</li> </ul> </li> </ul>							
3	<b>Recommended prerequisites for participation</b> Basic knowledge of technical mechanics (force diagram, equations of motion) and basic knowledge of thermody- namics recommended.							
4	<ul> <li>Form of examination</li> <li>Module exam:</li> <li>Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)</li> </ul>							
5	<b>Prerequisite</b> Passing the e	e for the award of c	redit points					
6	Grading Module exar • Module	n: e exam (Technical e:	xamination, Exam	ination, Weighting	: 100 %)			
7	<b>Usability of</b> WP Bachelor Bachelor Me MSc. Inform	<b>the module</b> <sup>•</sup> MB chatronik atik (Anwendungsfa	ch Fahrzeugtechn	ik, Spezialisierung)	)			
8	Grade bonu	s compliant to §25	(2)					
9	<b>References</b> Manuscript,	CD-ROM (can be pu	rchased at the dep	partment's office), i	nternet dov	wnload		
Coι	ırses							
	<b>Course nr.</b> 16-27-5010-	vl Motor Vehicles	S					
	Instructor	I				<b>Type</b> Lecture		SWS 3

<b>Course nr.</b> 16-27-5010-ue	Course name Motor Vehicles		
Instructor		<b>Type</b> Practice	<b>SWS</b> 2

Module name Laboratory Control Engineering I								
<b>Mo</b> 18-	<b>dule nr.</b> fi-1020	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module of 1 Term	duration	Module cyc Summer ter	c <b>le</b> rm
Lar Ger	nguage man			Module owner Prof. DrIng. Rolf Findeisen				
1	<ol> <li>Teaching content         Using appropriate test benches the students apply controller design methods taught in the basic lecture of control systems. The priority hereby lies in the application of the design methods and the evaluation of the parameters they provide. Additionally, some further topics of the domain of control systems (e.g. automation engineering, data-driven modelling) are presented by practical Experiments.     </li> </ol>							
2	Learning of After comple for different experiments	<b>pjectives</b> tion of this module the dynamic systems p and to bring them i	he students will be resented in the m nto operation at tl	able to practically a odule "System dyr ne lap setup.	apply the m namics and	nodelling and l control sy	nd design tecl ystems I" to 1	hniques real lab
3	Recommended prerequisites for participation System Dynamics and Control Systems I							
4	<ul> <li>Form of examination Module exam: <ul> <li>Module exam (Study achievement, Oral/written examination, p/np RS)</li> <li>Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the basic prime of the lastware </li> </ul></li></ul>							
5	Prerequisite Passing the f	e <b>for the award of c</b> final module examin	<b>redit points</b> ation					
6	Grading Module exar • Modul	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting:	100 %)		
7	<b>Usability of</b> BSc ETiT	the module						
8	Grade bonu	s compliant to §25	(2)					
9	<b>References</b> Lab handout	s will be given to stu	ıdents.					
Co	urses							
	<b>Course nr.</b> 18-ko-1020-	pr Laboratory Co	ntrol Engineering	I				
	Instructor Prof. DrIng	. Ulrich Konigorski				<b>Type</b> Internshi	р	SWS 4

Mo Lab	Module name Laboratory Matlab/Simulink I							
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle	
18-	fi-1030	3 CP	90 h	45 h	1 Term	Every Seme	ester	
Lar Ger	i <b>guage</b> man			Module owner Prof. DrIng. Rol	f Findeisen			
1	In this lab tutorial, an introduction to the software tool MatLab/Simulink will be given. The lab is split into two parts. First the fundamentals of programming in Matlab are introduced and their application to different problems is trained. In addition, an introduction to the Control System Toolbox will be given. In the second part, the knowledge gained in the first part is applied to solve a control engineering specific problem with the software tools.							
2	<b>Learning objectives</b> Fundamentals in the handling of Matlab/Simulink and the application to control engineering tasks.							
3	Recommen The lab show	<b>ded prerequisites fo</b> ald be attended in pa	or participation arallel or after the	lecture "System Dy	namics and Control	Systems I"		
4	<ul> <li>Form of examination</li> <li>Module exam:</li> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> </ul>							
5	<b>Prerequisit</b> Passing the	e <b>for the award of c</b> final module examination	<b>redit points</b> ation					
6	Grading Module exa • Modul	m: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 100 %)			
7	Usability of BSc ETiT; B	t <b>he module</b> Sc MEC						
8	Grade bonu In case of E-	<b>is compliant to §25</b> Learning: Possibility	(2) to improve the gr	ade up to 1,0				
9	References							
	<ul> <li>Lecture notes for the lab tutorial can be obtained at the secretariat</li> <li>Lunze; Regelungstechnik I</li> <li>Dorp; Bishop: Moderne Regelungssysteme</li> <li>Moler: Numerical Computing with MATLAB</li> </ul>							
Coι	ırses							
	<b>Course nr.</b> 18-fi-1030-p	or Laboratory Ma	atlab/Simulink I					
	Instructor M.Sc. Alexa	nder Steinke, Prof. D	rIng. Rolf Findei	sen	<b>Type</b> Internshi	ip	SWS 3	

<b>Mo</b> Rid	Module name Ride and Handling								
<b>Mo</b> 16-	<b>dule nr.</b> 27-5020	Credit points 6 CP	Workload 180 h	Self-study 105 h	Module duration	Module cycle Winter term			
Lan Ger	n <b>guage</b> man			Module owner Prof. DrIng. Ste	ven Peters				
1	<b>Teaching co</b> Longitudina testing & ca	ontent l and lateral dynami libration	cs; vehicle dynam	ics control; handlir	ng & comfort; suspen	sion & body control;			
2	<ul> <li>2 Learning objectives <ul> <li>On successful completion of this module, students should be able to:</li> <li>1. Derive vehicle longitudinal dynamics from driving and frictional conditions as well as from the design.</li> <li>2. Employ the basic equations of lateral dynamics with the fundamental motion and force dimensions of the single-track model and describe and assess vehicle behaviour at steady state skidpad testing as well as at load changes during curve-driving.</li> <li>3. Discuss measures which influence a vehicle's self-steering properties. Discuss measures to influence self-steering behavior</li> <li>4. Explain the transmission of lateral forces between the road and tyre and discuss the interaction between longitudinal and lateral forces.</li> <li>5. Explain the principal ESP estimation and control processes incl. their meaning regarding to vehicle dynamics control.</li> <li>6. Discuss challenges as well as opportunities for driving dynamics of battery electric vehicles.</li> <li>7. List steady and unsteady state road trials for handling and assessment and refer to results of road trials for making conclusions about handling characteristics.</li> </ul> </li> </ul>								
3	Recommended prerequisites for participation Fundamentals of automotive engineering, basic knowledge of technical mechanics (force diagram, equations of motion), basic knowledge of thermodynamics, basic knowledge of vibrations recommended								
4	Form of exa Module exa • Modul Written Exa	<b>amination</b> m: e exam (Technical ex m 90 min or oral Exa	kamination, Oral/ 1m 45 min	written examinatio	n, Default RS)				
5	<b>Prerequisite</b> Passing the	e for the award of c	redit points						
6	Grading Module exan • Modul	m: e exam (Technical ex	kamination, Oral/	written examinatio	n, Weighting: 100 %	))			
7	<ul> <li>7 Usability of the module</li> <li>WPB Master MB II (Kernlehrveranstaltung aus dem Maschinenbau)</li> <li>Master MB II SP FAS</li> <li>WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)</li> <li>WI/MB, MSc Traffic&amp;Transport, (Vertiefungsmodul FB16, ggf. Auflage), Master Mechatronik, MSc.</li> <li>Informatik (Anwendungsfach Fahrzeustechnik, Spezialisierung)</li> </ul>								
8	Grade bonu	is compliant to §25	(2)						
9	References manuscript,	e-Learning Materials	s via Moodle						
Coι	ırses								

<b>Course nr.</b> 16-27-5020-vl	<b>Course name</b> Ride and Handling		
Instructor		<b>Type</b> Lecture	<b>SWS</b> 3
<b>Course nr.</b> 16-27-5020-ue	<b>Course name</b> Ride and Handling		·
Instructor		<b>Type</b> Practice	<b>SWS</b> 2

Mo Tre	<b>dule name</b> nds in Automo	tive Engineering (a	unite!-Lecture)				
Мо	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle
16-	27-5030	4 CP	120 h	90 h	1 Term	Summer ter	rm
Lan Eng	<b>iguage</b> dish			Module owner Prof. DrIng. Stev	ven Peters		
1	<b>Teaching con</b> This (usually and current advanced dri	ntent virtually offered) "E research topics of v ving assistance syste	uropean Lecture" rehicle technology ems or automated	covers developmen v institutes in unite driving systems, su	t trends in the global el: system and funct ustainable powertrain	automotive i tion developr 1 technology,	ndustry nent in etc.
2	<ul> <li>Learning objectives         <ul> <li>On successful completion of this module, students should be able to:                 <ol> <li>Report and discuss about present and forward-looking technologies in the fields of driver assistance systems and automated driving technology as well as sustainable powertrain solutions.</li> <li>Explain current developments.</li> <li>Evaluate possibilities and limitations of distinct approaches.</li> </ol> </li> </ul></li></ul>						
3	<b>Recommended prerequisites for participation</b> Fundamentals of automotive engineering recommended						
4	<ul> <li>Form of examination</li> <li>Module exam: <ul> <li>Module exam (Technical examination, Oral/written examination, Default RS)</li> </ul> </li> <li>Written exam 90 min or oral exam 30 min.</li> </ul>						
5	<b>Prerequisite</b> Passing the e	<b>for the award of c</b> xamination.	redit points				
6	Grading Module exam • Module	n: e exam (Technical ex	xamination, Oral/	written examinatio	n, Weighting: 100 %	)	
7	Usability of WPB Master WPB Master Master Mech Traffic&Trans	t <b>he module</b> MB III (Wahlfächer PST III (Fächer aus atronik, MSc. Inforr sport, (Vertiefungsn	aus Natur- und In Natur- und Ingeni natik (Anwendunş 10dul FB16, ggf. A	genieurwissenscha eurwissenschaft fü gsfach Fahrzeugtec uflage)	ft) r Papiertechnik) hnik, Spezialisierung	), MSc	
8	Grade bonus	compliant to §25	(2)				
9	<b>References</b> Manuscript, e	e-Learning Material	s via Moodle				
Coi	ırses						
	<b>Course nr.</b> 16-27-5030-v	d Course name Trends in Auto	omotive Engineeri	ng (a unite!-Lecture	e)		
	Instructor				<b>Type</b> Lecture		SWS 2

Mo AD	dule name P (6 CP) Auto	motive Engineering				
<b>Mo</b> 16-	<b>dule nr.</b> 27-a061	Credit points 6 CP	Workload 180 h	Self-study 180 h	Module duration 1 Term	Module cycle Every Semester
Laı Gei	<b>nguage</b> rman			Module owner Prof. DrIng. Ste	ven Peters	-
1	<b>1 Teaching content</b> Current research topic from the general area of the administering institute.					
2	2 Learning objectives The students become acquainted with teamwork and are able to take over responsibility for leading tasks within the team. They learn to assess divergent positions and the necessity of common agreements in interpersonal relationships as well as typical engineering challenges in a positive manner. They are able to recognize and specify complex problems and to distinguish between different solutions. They also study how to valuate the importance of an exact time and work schedule positively.					
3	<b>Recommended prerequisites for participation</b> Possible prerequisites will be prescribed by the individual institute supervising the project.					
4	<ul> <li>Form of examination Module exam:</li> <li>Module exam (Technical examination, Special form, Default RS)</li> </ul>					
5	<b>Prerequisite</b> Passing the	e for the award of c	redit points ation			
6	Grading Module exan • Modul	n: e exam (Technical ex	amination, Specia	al form, Weighting:	: 100 %)	
7	Usability of	the module				
8	8 Grade bonus compliant to §25 (2)					
9	References will depend	on topic; available u	pon announcemei	nt		

Mo Avi	dule name onics System S	Safety					
<b>Mo</b>	<b>dule nr.</b> 23-5110	Credit points	Workload	Self-study 90 h	Module duratio	n Module cy Every 2 Se	<b>cle</b>
Lar Eng	<b>iguage</b> glish		120 11	Module owner Prof. DrIng. Uw	e Klingauf		
1	<b>Teaching co</b> Operational design of saf	<b>ntent</b> requirements for fli e systems, pilot assis	ght guidance syste stance systems in t	ems, structure of fl the cockpit, human	ight guidance syst factors.	ems, architectu	ires and
2	<ul> <li>2 Learning objectives <ul> <li>On successful completion of this module, students should be able to:</li> <li>1. Describe the basics of automated flight operations and human-machine interfaces in modern aircraft flight decks.</li> <li>2. Explain the basic concepts and methods in the design of safety critical systems in flight control.</li> <li>3. Differentiate between the different system architecture concepts.</li> <li>4. Describe and discuss the complex interplay of technical systems, operational processes and humans using the example of avionics systems</li> </ul> </li> </ul>						
3	<ul> <li>Recommended prerequisites for participation</li> <li>Recommended: Flight Mechanics I: Performance, Fundamentals of Navigation I, Systemic Evaluation</li> <li>of Air Transportation</li> </ul>						
4	<ul> <li>Form of examination</li> <li>Module exam:</li> <li>Module exam (Technical examination, Oral/written examination, Default RS)</li> <li>Written exam 60 min or oral exam 20 min</li> </ul>						
5	<b>Prerequisite</b> Passing the e	<b>for the award of c</b> xamination	redit points				
6	Grading Module exam • Module	n: e exam (Technical e	xamination, Oral/	written examinatio	n, Weighting: 100	%)	
7	<b>Usability of</b> WPB Master Master AE II WPB Master	<b>the module</b> MB II (Kernlehrvera Kernlehrveranstaltı PST III (Fächer aus	anstaltung aus der ing Natur- und Ingeni	n Maschinenbau) ieurwissenschaft fü	r Papiertechnik)		
8	Grade bonu	s compliant to §25	(2)				
9	<ul> <li><b>References</b></li> <li>Bahr, N.J.: System Safety Engineering and Risk Assessment: A Practical Approach, 2ndEdition, CRC Press</li> <li>2015Dhillon, B.S.: Transportation Systems Reliability and Safety, CRC Press 2011C.C. Rodriges, S.K. Cusick:</li> <li>Commercial Aviation Safety, McGraw Hill 2011R. Isermann: Fault Diagnosis Systems, Springer 2006</li> </ul>						
Co	urses						
	<b>Course nr.</b> 16-23-5110-	Course namevlAvionics Syste	m Safety				
	Instructor				<b>Type</b> Lectur	e	SWS 2

Mo Cor	<b>dule name</b> nbustion Engi	ines I				
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle
Lan	iguage	0.01	100 11	Module owner	hristian Poidl	winter term
Ger	man			Prof. Dr. techn. C	nristian Beidi	
1	<ul> <li>Introduction: Historic review, economic and ecological aspects, classification of engines.</li> <li>Fundamentals of the thermodynamic process: Carnot cycle, constant-volume cycle, constant-pressure cycle, Seiliger cycle.</li> <li>Fundamentals of engine construction: Crank shaft, con-rod, bearing, piston, piston rings, piston pin, liner, cylinder head gasket, cylinder head, charge cycle.</li> <li>Parameters: Mean pressure, power, torque, fuel consumption, efficiency, cylinder charge, air fuel ratio, kinematics of the crank mechanism, compression ratio, characteristic diagrams, main dimensions.</li> <li>Fuel: Chemical configuration, characteristics, heat value, characteristics of ignition, production, alternative fuels. Basics of carburation: Spark-ignition engines: Carburator, electronic fuel injection, HCCI (Homogeneous Charge Compression Ignition).</li> <li>Ignition of spark-ignition engines: Requirements, spark plug, ignition systems, magnetic systems, knock control systems.Mixture formation of diesel engines: basics, classification of different methods, mixture distribution and mixture formation, injection systems.</li> <li>Learning objectives</li> </ul>					
2	<ul> <li>mixture formation, injection systems.</li> <li>2 Learning objectives <ul> <li>On successful completion of this module, students should be able to:</li> <li>1. Explain the principles and the construction of combustion engines (ranging from small two-stroke models to the marine diesel engine).</li> <li>2. Explain the physical principles of combustion engines.</li> <li>3. Develop the essential parameters and apply these to characterise engines.</li> <li>4. Explain the economic and ecological relevance of combustion engines.</li> <li>5. Apply the thermodynamic basics of combustion engines to develop new drive concepts.</li> <li>6. Describe the basics of the engine construction.</li> <li>7. Analyse and evaluate the interdependency of fuel, mixture formation, and combustion.</li> <li>8. Explain the difference by mixture formation and ignition process of spark ignited engines and diesel engines.</li> <li>9. Explain the ignition and ignition systems of the spark ignited engine.</li> </ul> </li> <li>3 Recommended prerequisites for participation</li> </ul>					
4	<ul> <li>Form of examination         Module exam:         <ul> <li>Module exam (Technical examination, Oral/written examination, Default RS)             Written or oral exam [written: 90 min; oral: 90 min (per group with 4 people 22,5 min per participiant).             Will be announced at the beginning of the term depending on the circumstances (number of students, pandemic         </li> </ul> </li></ul>					
5	<b>Prerequisite</b> Passing the	e for the award of c	redit points			
6	<ul> <li>Grading Module exam:</li> <li>Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>					
7	Usability of	the module				

	WP Bachelor MB Bachelor Mechatronik					
8	Grade bonus co	mpliant to §25 (2)				
9	References         VKM I - script, available at the secretariat					
0.0		1				
	Course nr.Course name16-03-5010-vlCombustion Engines I					
	Instructor		<b>Type</b> Lecture	<b>SWS</b> 3		

Automotive Mechatronics and Assistance Systems					
Module nr.Credit pointsWorkloadSel16-27-50406 CP180 h	lf-study 105 h	Module duration	Module cycle		
Language     Mo       German     Pro	odule owner of. DrIng. Stev	ven Peters			
1Teaching contentSensors for advanced driver assistance systems (ultra assistance; lateral control assistance; active collision pro safety)	asonic, radar, otection system	lidar, camera,); l s; navigation; autom	longitudinal control ated driving (AI and		
<ul> <li>2 Learning objectives <ul> <li>On successful completion of this module, students should be able to:</li> <li>1. Indicate special difficulties at recognising the vehicle's surrounding field and describe the consequences of these difficulties for the system utilisation.</li> <li>2. Explain the effect chain of the sensors from detection over perception up to surrounding field representation for ultrasonic, radar, lidar, and video.</li> <li>3. Describe the basic functions and the function limits of automatically acting driver assistance systems and collision mitigation systems.</li> <li>4. Evaluate the benefits and modes of action of vehicle safety systems and illustrate the course of an accident and describe a crash test.</li> <li>5. Illustrate the function of the modules necessary in the vehicle for navigation.</li> <li>6. Decipt challenges of automated driving in passenger cars and trucks and discuss risk minimal introduction paths.</li> </ul> </li> </ul>					
<b>3 Recommended prerequisites for participation</b> Fundamentals of automotive engineering recommended	d				
<ul> <li>Form of examination Module exam:</li> <li>Module exam (Technical examination, Oral/writt Written exam 90 min or oral exam 45 min</li> </ul>	ten examinatio	n, Default RS)			
5 Prerequisite for the award of credit points Passing the examination					
<ul> <li>6 Grading Module exam:</li> <li>• Module exam (Technical examination, Oral/writt</li> </ul>	ten examinatio	n, Weighting: 100 %	)		
<ul> <li>7 Usability of the module</li> <li>WPB Master MB II (Kernlehrveranstaltung aus dem Maschinenbau)</li> <li>Master MB II FAS Pflicht</li> <li>WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)</li> <li>WI/MB, MSc Traffic&amp;Transport, (Vertiefungsmodul FB16, ggf. Auflage), Master Mechatronik, MSc. Informatik</li> <li>(Anwendungsfach Fahrzeugtechnik, Spezialisierung</li> </ul>					
8 Grade bonus compliant to §25 (2)					
9 References Manuscript; e-Learning Materials via Moodle					

<b>Course nr.</b> 16-27-5040-vl	<b>Course name</b> Automotive Mechatronics and Assistance Systems		
Instructor		<b>Type</b> Lecture	<b>SWS</b> 3
<b>Course nr.</b> 16-27-5040-ue	<b>Course name</b> Automotive Mechatronics and Assistance Systems		
Instructor		<b>Type</b> Practice	SWS 2

<b>Mo</b> Tut	<b>dule name</b> orial Automoti	ve Engineering						
<b>Mo</b> 16-	<b>dule nr.</b> 27-5080	Credit points 4 CP	Workload 120 h	Self-study 60 h	Module of 1 Term	duration	Module cyc Summer ter	c <b>le</b> rm
Lar Ger	<b>iguage</b> man			Module owner Prof. DrIng. Ste	ven Peters			
1	1 <b>Teaching content</b> The Automotive Engineering Tutorium deepens special topics from the courses Motor Vehicles I+II on the basis of practically performed experiments. The selection of the experiments follows the availability of testing vehicles or current problems.							
2	<b>Learning objectives</b> You are able to make independent experiments with vehicles for a given problem. This comprises the definition of test procedures and measuring devices. Test parameters are defined and varied. You are able to make use of the theoretical knowledge from Motor Vehicles I and II.							
3	Recommended prerequisites for participation Fundamentals of automotive engineering							
4	<ul> <li>Form of examination Module exam:</li> <li>Module exam (Technical examination, Special form, Default RS)</li> </ul>							
5	<b>Prerequisite</b> Passing the fi	for the award of c nal module examin	<b>redit points</b> ation					
6	Grading Module exan • Module	ı: exam (Technical e	xamination, Specia	al form, Weighting	: 100 %)			
7	Usability of	the module						
8	Grade bonus	compliant to §25	(2)					
9	References materials are	handed out to part	icipants					
Cou	ırses							
	<b>Course nr.</b> 16-27-5080-t	t Course name	notive Engineering	5				
	Instructor     Type     SWS       Tutorial     4				SWS 4			

Mo	dule name	ies in Car Lighting					
<b>Mo</b>	dule nr.	Credit points	Workload	Self-study	Module duration	Module cyc	cle
18- Lar	KN-2041	4 CP	120 h	/5 n Module owner	1 Ierm	Summer ter	rm
Ger	man			Prof. DrIng. Tra	n Quoc Khanh		
1	1 <b>Teaching content</b> History and standardisation of car lithing. Description of the oused lighting sources and the function of these(lowbeam, highbeam, bending light, stop lamp, daytime running light), visuell perception, glare, detection, traffic infrastructure, traffic elements, interior lighting, driver assistance systems(GPS, Radar, Lidar), methods of psychophysics, lighting application concepts in future automated vehicles. Voluntary trip planed to an automobile manufacturer						
2	<ul> <li>Learning objectives</li> <li>Upon completion of the module, students will have learned to describe the basics and deepening knowledge of car lighting, to understand the light distribution of head and rear lamps, to learn the basics of standardisation, enlarge glare and detection skills, know the traffic elements, as well as the driver assistance systems.</li> </ul>						
3	Recommended prerequisites for participation Lighting technology 1						
4	<ul> <li>Form of examination Module exam:</li> <li>Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)</li> </ul>						
5	<b>Prerequisite</b> Passing the fi	<b>for the award of c</b> nal module examin	<b>redit points</b> ation				
6	<b>Grading</b> Module exam • Module	: exam (Technical e:	xamination, Oral e	examination, Weigl	nting: 100 %)		
7	Usability of t MSc ETiT, MS	<b>he module</b> Sc WI-ETiT, MSc iS <sup>-</sup>	Г, MSc MEC, MSc	MPE, MSc Physik			
8	Grade bonus	compliant to §25	(2)				
9	<b>References</b> Lecture slides	, Automotive Light	ing and Human Vi	sion, Handbuch Fa	hrassistenzsysteme		
Co	urses						
	<b>Course nr.</b> 18-kh-2041-v	Course namelOptical Technol	ologies in Car Ligh	nting			
	<b>Instructor</b> Prof. DrIng.	Tran Quoc Khanh			<b>Type</b> Lecture		<b>SWS</b> 2
	<b>Course nr.</b> 18-kh-2041-p	r Optische Tech	nologien im KFZ-I	Bereich			
	<b>Instructor</b> Prof. DrIng.	Tran Quoc Khanh			<b>Type</b> Internshi	р	<b>SWS</b> 1

Mo Tec	<b>dule name</b> hnical Mecha	nics for Electrical En	gineering			
<b>Mo</b>	<b>dule nr.</b> 26-6400	Credit points	Workload	Self-study	Module duration	Module cycle
Lan Ger	nguage man		100 11	Module owner DrIng. Nicklas N	Iorrick	
1	<ul> <li>Teaching content         Statics: force, moment (torque), free body diagram, equilibrium equations, center of gravity, truss, beams, adhesion and friction.         Mechanics of elastic bodies: stress and deformation, tension, torsion, bending.         Kinematics: point and rigid body movement.         Kinetics: dynamic force and moment equilibrium equations, energy and work, linear oscillators, momentum and angular momentum conservation laws, impact.     </li> </ul>					
2	2 Learning objectives In this course the students will learn the basic concepts of technical mechanics. They should be able to analyze the statics of simple statically determinate planar systems, to carry out elementary elastomechanical calculations of statically determinate and statically indeterminate structures, to describe and analyze movements, and to solve planar motion problems, oscillation and shock phenomena with the laws of kinetics.					
3	Recommended prerequisites for participation					
4	<ul> <li>Form of examination</li> <li>Module exam:</li> <li>Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)</li> </ul>					
5	Prerequisit Passing the	e for the award of c final module examina	<b>redit points</b> ation			
6	Grading Module exa • Modul	m: le exam (Technical ex	xamination, Exam	ination, Weighting	: 100 %)	
7	Usability of	the module				
8	Grade bonu	is compliant to §25	(2)			
9	<b>References</b> Markert, No Exercises ar	orrick: Einführung in e embodied in the bc	die Technische M ook.	echanik, ISBN 978	-3-8440-3228-4	
	Further reading: Markert: Statik - Aufgaben, Übungs- und Prüfungsaufgaben mit Lösungen, ISBN 978-3-8440-3279-6 Markert: Elastomechanik - Aufgaben, Übungs- und Prüfungsaufgaben mit Lösungen, ISBN 978-3-8440-3280-2 Markert: Dynamik - Aufgaben, Übungs- und Prüfungsaufgaben mit Lösungen, ISBN 978-3-8440-2200-1 Gross, Hauger, Schröder, Wall: Technische Mechanik 1 - 3. Springer-Verlag Berlin (2012-2014). Hagedorn: Technische Mechanik, Band 1 - 3. Verlag Harri Deutsch Frankfurt.					
Ο Οι	ırses					

<b>Course nr.</b> 16-26-6400-vl	<b>Course name</b> Technical Mechanics for Electrical Engineering						
Instructor	<b>Type</b> Lecture	<b>SWS</b> 3					
<b>Course nr.</b> 16-26-6400-ue	<b>Course name</b> Technical Mechanics for Electrical Engineering						
Instructor		<b>Type</b> Practice	SWS 2				
Mo Pro	Module name Project seminar Applications of Lighting Engineering						
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Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle
18-1 Lon	KII-2051	5 CP	150 II	105 II Modulo oumon	1 Ierm	Every Seme	ester
Ger	man/English			Prof. DrIng. Tran Quoc Khanh			
1	<b>Teaching co</b> The project generation, technology;	ontent seminar deals with t perception and cog physical and psycho	he following subje nition of the visu physical light mea	ects: automotive lig al stimulus (lumin surement; illumina	ghting, interior light naires, displays, pro ating engineering, co	ing, exterior l ojection); LEI olor perception	ighting; D/OLED n.
2	Learning of Upon comple independent	<b>jectives</b> etion of the module, a ly in project teams of	students will be al or on their own.	ble to apply interdis	sciplinary thinking in	n lighting engi	neering
3	Recomment Lighting Tec	<b>led prerequisites fo</b> hnology I-II	or participation				
4	<ul> <li>Form of examination</li> <li>Module exam: <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> <li>Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.</li> </ul> </li> </ul>						
5	Prerequisite for the award of credit points Passing the final module examination						
6	Grading Module exar • Modul	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 100 %)		
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> [Sc iST, MSc WI-ETi]	ſ, MSc MEC, MSc	MPE, MSc Phys			
8	Grade bonu	s compliant to §25	(2)				
9	<ul> <li>References         Lecture notes of Lighting Technology I (Khanh); Lecture slides of our Laboratory; Book "LED Lighting: Technology and Perception" (Khanh et al., Wiley); Book "Farbwiedergabe" (Khanh et al., Pflaum-Verlag); specific literature depending on the topic, publications.     </li> </ul>						
<b>Co</b> ι	ırses						
	<b>Course nr.</b> 18-kh-2051-	pj Project semina	ar Applications of	Lighting Engineeri	ng		
	InstructorTypeSWSProf. DrIng. Tran Quoc KhanhProject seminar3						

Mo Pro	Module name Project seminar Advanced Applications of Lighting Engineering							
Mo	dule nr.	Credit points	Workload	Self-study	Module d	luration	Module cy	cle
18-	kh-2052	5 CP	150 h	105 h	1 Term		Every Seme	ester
Lar Ger	<b>iguage</b> man			<b>Module owner</b> Prof. DrIng. Tran Quoc Khanh				
1	Teaching cor For the proje light for the a lighting; gene technology; j virtual reality material acqu project semin	ntent et seminar, a question utomated car, inter- partion, perception a physical and psycho tests for light simu- ired in the course of ar "Lighting Applic	on from the follow ior and exterior lig nd cognition of the physical light mea ilations. The aim o f study in the form ations" are applied	ing topics can be a hting; Smart Light visual stimulus (lu surement technolo of this project semin of a project work. l and deepened.	ddressed: A ing; Humar minaires, d ogy; lightin nar is the p The funda	Automotive n Centric L isplays, pro g technolo practical im mentals of	e lighting tech ighting (HCL ojection); LEI ogy, color pero plementation f the module	nnology, ); plant D/OLED ception, n of the and the
2	<b>Learning objectives</b> Upon completion of the module, students will be able to plan, implement and validate lighting technology issues. In addition, they will have learned how to abstract questions, communicate information in a project-dependent manner, and present their results.							
3	<b>Recommended prerequisites for participation</b> Lighting Technology I-II, Project seminar Applications of Lighting Engineering							
4	<ul> <li>Form of examination</li> <li>Module exam: <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> </ul> </li> <li>Beport and/or Presentation. The type of examination will be announced in the beginning of the lecture.</li> </ul>							
5	<b>Prerequisite</b> Passing the fi	for the award of c nal module examin	<b>redit points</b> ation					
6	Grading Module exan • Module	ı: exam (Study achie	vement, Oral/wri	tten examination, V	Weighting:	100 %)		
7	Usability of	he module						
8	Grade bonus	compliant to §25	(2)					
9	<ul> <li>References         Lecture notes of Lighting Technology I (Khanh); Lecture slides of our Laboratory; Book "LED Lighting: Technology and Perception" (Khanh et al., Wiley); Book "Farbwiedergabe" (Khanh et al., Pflaum-Verlag); specific literature depending on the topic, publications.     </li> </ul>							
Coi	irses							
	<b>Course nr.</b> 18-kh-2052-j	j Course name pj Project semina	ar Advanced Appli	cations of Lighting	Engineerir	ıg		
	<b>Instructor</b> Prof. DrIng.	Tran Quoc Khanh				<b>Type</b> Project se	eminar	<b>SWS</b> 3

Mo Pro	Module name Project seminar Special Applications of Lighting Engineering							
<b>Mo</b> 18-	<b>dule nr.</b> kh-2053	Credit points 8 CP	Workload 240 h	Self-study 195 h	Module d 1 Term	luration	Module cyc Every Seme	<b>cle</b> ester
Lar Ger	<b>iguage</b> man/English		1	<b>Module owner</b> Prof. DrIng. Tra	n Quoc Kha	anh		
1	Teaching co For the projet for autonomo lighting; gen technology; reality tests knowledge a which also ta	ontent ect seminar a question ous cars, interior light neration, perception physical and psychop for light-simulation acquired during the akes up topics beyon	n from the followin ting, exterior lighti and cognition of physical light meas . The objective of study in the form d the lectures.	ng subject areas car ng; smart lighting; visual stimuli (lum surement; illuminar this project semin of research or pro	h be worked human cent inaires, dis ting engine ar is the pr ject work i	l on: Auto tric lighting plays, pro ering, colo ractical im n an inter	motive lightin g (HCL); hort jection); LED or perception, plementation disciplinary o	ng, light iculture )/OLED , virtual n of the context,
2	2 Learning objectives Upon successful completion of the module, students have learned the approach, implementation and validation or investigation of interdisciplinary lighting issues. This requires an introduction into topics that go beyond the subject area of the lectures. Usually, this includes the selection of suitable illuminants, the development of electronic hardware, the use of photometric measuring instruments as well as the conception, execution and evaluation of studies. In addition, students learn to abstract questions, to develop research questions, to communicate information depending on the project, and to present and discuss results.							
3	<b>Recommended prerequisites for participation</b> Lighting Technology I-II, Project seminar Applications of Lighting Engineering							
4	Form of exa Module exar • Modul Report and/	<b>mination</b> n: e exam (Study achie or Presentation. The	vement, Oral/writ	tten examination, I ion will be announ	Default RS) ced in the l	beginning	of the lecture	e.
5	Prerequisite Passing the f	e for the award of c inal module examin	redit points ation					
6	Grading Module exar • Modul	n: e exam (Study achie	vement, Oral/writ	tten examination, V	Veighting:	100 %)		
7	Usability of	the module						
8	Grade bonu	s compliant to §25	(2)					
9	9 References Lecture notes of Lighting Technology I (Khanh); Lecture slides of our Laboratory; Book "LED Lighting: Technology and Perception" (Khanh et al., Wiley); Book "Farbwiedergabe" (Khanh et al., Pflaum-Verlag); specific literature depending on the topic, publications.							
Coι	ırses							
	<b>Course nr.</b> 18-kh-2053-	pj Course name Project semina	ar Special Applicat	ions of Lighting En	gineering			
	InstructorTypeSWSProf. DrIng. Tran Quoc KhanhProject seminar3					<b>SWS</b> 3		

Mo	Module name							
Cor	nbustion Eng	ines II	Γ			T		
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle		
Lar	1911age	0.04	100 11	Module owner	1 101111	Summer term		
Ger	man			Prof. Dr. techn. Christian Beidl				
1	<ul> <li>Electronic motor management: Configuration and structure, actuators and sensors, main functions, application, interfaces.</li> <li>Ignition and combustion of hydrocarbons: Kinetic gas theory, internal combustion, correlation between in-cylinder pressure and heat release, efficiency, basics of the combustion (SI-engine / diesel-engine), abnormal combustion, combustion chamber shape and combustion processes.</li> <li>Emissions: Components, corruptive effects, formation, influence of the operating point, internal motoric methods, aftertreatment, measuring systems, emission tests.</li> <li>Charge cycle: Influence of the charge cycle on engine characteristics, systems, camshaft drivetrains, parameters of the charge cycle, variable valve timing, special solutions.</li> <li>Charging: Characteristics and advantages of charging, different systems, design criterion for turbocharging, multi-stage charging, performed variants.</li> <li>Noise: Basics, sources, measures against noise, regulations</li> <li>Hybrid systems: Basics, functionalities, classification, components, challenges, research methods and certification, performed variants.</li> <li>Acquisition and analysis of engine indication: Measurement chain, measurement of pressure and cylinder capacity, analysis, calculation of heat release, characteristic results</li> <li>Design of experiments.</li> </ul>							
	Design of ex	periments.						
2	<ul> <li>2 Learning objectives</li> <li>On successful completion of this module, students should be able to: <ol> <li>Explain the different internal combustion engines and describe theoretically the processes.</li> <li>Design combustion chambers with the knowledge acquired on the connenction of combustion chamber shape, combustion processes, and ignition.</li> <li>Define the emergence of emissions of engines (exhaust, noise) and describe the avoiding of emissions.</li> <li>Describe the charge chaniging of a combustion engine, identify variants, and advance engines</li> <li>Recognize the importance of charging and the variants.</li> <li>Explain hybrid technology.</li> <li>Reproduce specific measuring methods in the fields of optimizing engines (indication, design of</li> </ol> </li> </ul>							
3	Recommen	ded prerequisites fo	or participation					
4	<ul> <li>Form of examination         Module exam:         <ul> <li>Module exam (Technical examination, Oral/written examination, Default RS)             <li>Written (90 min) or oral exam (90 min, per group of 4 22,5 min per participiant).</li> <li>Will be announced at the beginning of the term depending on the circumstances (number of students, pandemic etc.).</li> </li></ul> </li> </ul>					f students, pandemic		
5	Prerequisite Passing the	e for the award of c	reall points					
6	Passing the examination         Grading         Module exam:         • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)							

7	Usability of the module WPB Master MB II (Kernlehrveranstaltung aus dem Maschinenbau) Master MB II SP CEPE Master MB II SP FAS Master Mechatronik					
8	Grade bonus compliant to §25 (2)					
9	References VKM II - script, available at the secretariat					
Co	urses					
	<b>Course nr.</b> 16-03-5020-vl	Course name Combustion Engines II				
	Instructor		<b>Type</b> Lecture	SWS 3		

<b>Mo</b> Fur	<b>dule name</b> damentals of	Navigation I					
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cyc	cle
Lar	i <b>guage</b> Ish	4 CP	120 11	<b>Module owner</b>	gen Bever	Summer te	1111
1	Teaching co Navigation p DME, ILS), d signal descri systems (RAI	ntent rinciples, Earth mod ead reckoning, func ption and measurer M, GIC, WAAS, LAA	els, Coordinate sy tional principles a nent principles, D S, EGNOS).	rstems, Radio navig nd error analysis, s vilution of Precision	ation, Basics and ins atellite navigation, In 1 (DoP), Differential	truments (AD ntroduction in GPS, Augme	DF, VOR, nto GPS, entation
2	Learning ob On successfu 1. Explain th 2. Classify co 3. Judge the applications.	jectives l completion of this e physics associated ommon coordinate s methods of radio, c	module, students with the navigati ystems and map p oupling, and satel	should be able to: on of the earth. projections. lite navigation with	n respect to performa	ance and	
3	Recommended prerequisites for participation Recommanded: Control Engineering						
4	<ul> <li>Form of examination</li> <li>Module exam: <ul> <li>Module exam (Technical examination, Oral examination, Duration: 20 Min., Default RS)</li> </ul> </li> <li>Oral exam (in a group with 3 students) 60 min: 20 min per participiant</li> </ul>						
5	<b>Prerequisite</b> Passing the e	<b>for the award of c</b> xamination	redit points				
6	<b>Grading</b> Module exan • Module	n: e exam (Technical ex	xamination, Oral e	examination, Weigl	nting: 100 %)		
7	Usability of WPB Master WPB Master WPB Master Master Mech	<b>the module</b> MB III (Wahlfächer AE III Nat_Ing-Bere PST III (Fächer aus atronik	aus Natur- und In ich Natur- und Ingeni	genieurwissenscha	ft) r Papiertechnik)		
8	Grade bonus	s compliant to §25	(2)				
9	References Course notes	available.					
Cot	ırses						
	<b>Course nr.</b> 16-23-5050-v	/l <b>Course name</b> /l Fundamentals	of Navigation I				
	Instructor				<b>Type</b> Lecture		SWS 2
	<b>Course nr.</b> 16-23-5050-1	Le <b>Course name</b> Fundamentals	of Navigation I				
	InstructorTypeSW2Practice1					<b>SWS</b> 1	

Mo Spa	Module name Space Debris - Risks Surveillance and Mitigation							
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle		
Lar Eng	<b>iguage</b> slish	4 CP	120 II	<b>Module owner</b> Dr. Ing. Holger K	rag	Every 2. Semester		
1	<b>Teaching co</b> This lecture lance and m This covers aspects duri all major asp (batch least As well as sp passivation	ontent will provide the scien nitigation of space de risk assessment aspec ng atmospheric re-er pects of space surveill square, Levenberg-M pace debris mitigation methods, shielding co	ntific, technical an bris. ts: source and sind atry and related or ance: ground-base arquardt, Kalmanf n aspects: long-ter oncepts, methods	Id operational back k terms, particle flu n-ground risk assess ed radar and telesco filter), residuals, cov rm environment pro for post mission dis	ground in relation to x models, aerodynan sments; ope systems, orbit de variances, operationa ojection models, inte sposal and verificatio	o the sources, surveil- nics and aerothermal termination methods l collision avoidance; rrnational guidelines, n of measures;		
2	<ul> <li>Learning objectives On successful completion of this module, students should be able to: <ol> <li>name the sources of space debris and describe the human-made particle environment and the consequences of particle impacts;</li> <li>analyse and determine the risks to a space mission due the natural and human-made particle environment and limit this this risk by suitable technical measures;</li> <li>determine the on-ground risk caused by the atmospheric re-entry of a space object;</li> <li>lay-out a space mission according to applicable space debris mitigation guidelines and verify the resulting setup along with international standards; <li>perform the main tasks of flight dynamics in operations (orbit determination and manoeuvre-planning) and explain the operational processes in the context of collision avoidance; </li> <li>Present the main technical aspects of space surveillance, lay-out the required sensor systems and apply the</li> </li></ol></li></ul>							
3	Recomment knowledge o	<b>ded prerequisites fo</b> of the content of "Spac	or participation e Flight Mechanic	s" (module no. 16-2	5-5130) is an asset bi	ut not a pre-requisite.		
4	Form of exa Module exa • Modul	amination m: le exam (Technical e:	amination, Oral e	examination, Durat	ion: 20 Min., Defaul	t RS)		
5	<b>Prerequisit</b> Passing the	e for the award of c examination	redit points					
6	Grading Module exame • Module	m: le exam (Technical ex	xamination, Oral e	examination, Weigh	nting: 100 %)			
7	Usability of WPB Master WPB Master WPB Master	f <b>the module</b> r MB III (Wahlfächer r AE III Nat_Ing-Bere r PST III (Fächer aus	aus Natur- und In ich Natur- und Ingeni	genieurwissenscha eurwissenschaft fü	ft) r Papiertechnik )			
8	Grade bonu	is compliant to §25	(2)					
9	References Klinkrad: Space Debris - Models and Risk Analysis, Springer Springer Praxis Books Astronautical Engineering, 2006, ISBN 978-3-540-37674-3							

Co	Courses							
	<b>Course nr.</b> 16-23-3164-vl	<b>Course name</b> Space Debris - Risks, Surveillance and Mitigation						
	Instructor		<b>Type</b> Lecture	SWS 2				

Mo Tut	Module name Tutorial Advanced Cax Methods							
<b>Mo</b> 16-	<b>dule nr.</b> 07-5100	Credit points 4 CP	Workload 120 h	Self-study 60 h	Module duration 1 Term	Module cy Every Seme	<b>cle</b> ester	
Lar Ger	n <b>guage</b> rman			<b>Module owner</b> Prof. DrIng. Dipl-WirtIng. Benjamin Schleich				
1	<b>Teaching co</b> Students gai course builds	n <b>tent</b> n knowledge of adv on the basic course	vanced CA Methoo 'Einführung in da	ds through the ana	alysis of recent indu tzte Konstruieren (C	ıstrial example AD)'.	es. This	
2	<b>Learning ob</b> The students workflow of practice.	<b>jectives</b> will be familiar with CA Processes. Furtl	advanced CA Met hermore they are	hods. They are able able to transfer th	to recognise, execu eir theoretical know	te and plan the wledge into ind	generic dustrial	
3	<b>Recommend</b> Einführung i Virtuelle Proc	ed prerequisites for n das rechnergestüt duktentwicklung A,	o <b>r participation</b> zte Konstruieren ( B, C	CAD)				
4	<ul> <li>Form of examination</li> <li>Module exam:</li> <li>Module exam (Technical examination, Special form, Default RS)</li> </ul>							
5	<b>Prerequisite</b> Passing the f	for the award of c nal module examin	<b>redit points</b> ation					
6	Grading Module exan • Module	n: e exam (Technical e:	xamination, Speci	al form, Weighting	: 100 %)			
7	Usability of	the module						
8	Grade bonus	s compliant to §25	(2)					
9	References							
Coi	Courses							
	<b>Course nr.</b> 16-07-5100-1	t Tutorial Advan	nced CAx Method	3				
	Instructor				<b>Type</b> Tutoria	l	SWS	

Mo	Module name							
Aut	omated Drivi	ng						
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle		
18- Lar		3 CP	90 h	00 n Module owner	1 Ierm	winter term		
Eng	glish			Prof. DrIng. Jürgen Adamy				
1	Teaching co	ontent						
	<ul> <li>Fistory of Automated Driving</li> <li>Terminology and Paths towards Automated Driving</li> <li>Architectures, Building Blocks, and Components</li> <li>Perception &amp; Environment Models</li> <li>Data Fusion &amp; State Estimation         <ul> <li>Deep Dive: Target Tracking &amp; Traffic Participant Fusion</li> <li>Deep Dive: Grid Fusion &amp; Free Space Estimation</li> <li>Deep Dive: Road Model Fusion</li> </ul> </li> <li>Localization, Digital Maps, and Vehicle-To-X Communication</li> <li>Situation Understanding, Prediction, and Criticality Assessment         <ul> <li>Deep Dive: Probabilistic Driving Maneuver Detection</li> <li>Behavior &amp; Trajectory Planning, Decision Making</li> <li>Automated Driving Software Development &amp; Test</li> <li>Open Challenges &amp; State-of-the-Art Research Topics</li> </ul> </li> </ul>							
2	<ul> <li>2 Learning objectives Upon successful completion of the module, students will be able to: <ul> <li>is familiar with the history and terminology of automated driving systems,</li> <li>knows important architectures, building blocks, and components of automated vehicles,</li> <li>understands different perception, environment model, and data fusion approaches,</li> <li>has an idea about relevant methods (e.g. Bayesian Inference &amp; Probabilistic Graphical Models, State Estimation, Deep Learning, Dempster-Shafer Theory) and knows how they can be beneficially applied in different of automated driving areas (e.g. detection, target tracking &amp; traffic participant fusion, grid fusion, road model fusion, localization),</li> <li>is familiar with the challenges of situation understanding, prediction, and criticality assessment and knows exemplary methods to tackle the problem, <ul> <li>is aware of exemplary behavior &amp; trajectory planning approaches,</li> <li>knows best practices about automated driving software development &amp; test (e.g. continuous integration, verification &amp; validation, test-driven development, key performance indicators), and </li> </ul></li></ul></li></ul>							
3	Recommen	ded prerequisites fo	or participation					
4	Form of exa Module exa • Modul	amination m: e exam (Technical ez	xamination, Exam	ination, Duration:	90 Min., Default RS)			
5	Prerequisite Passing the	e for the award of c	<b>redit points</b> ation					
6	Grading							

	<ul> <li>Module exam:</li> <li>Module exam (Technical examination, Examination, Weighting: 100 %)</li> </ul>					
7	<b>Usability of the module</b> Msc etit, Msc MEC, Msc Wi-etit, Msc ICE, Msc CE, Msc Informatik					
8	Grade bonus compliant to §25 (2)					
9	<ul> <li>References</li> <li>Own lecture slides are distributed in advance of any lecture. For more detailed insights into the topic area, the following books can be recommended: <ul> <li>Eskandarian, A.: Handbook of Intelligent Vehicles. Springer, London, 2012.</li> <li>Siciliano, B.; Khatib, O.: Springer Handbook of Robotics. 2nd Edition, Springer, Berlin Heidelberg 2016.</li> <li>Thrun, S.; Burgard, W.; Fox, D.: Probabilistic Robotics. Intelligent Robotics and Autonomous Agents. The MIT Press, Cambridge, 2006.</li> <li>Watzenig, D.; Horn, M.: Automated Driving. Safer and More Efficient Future Driving. Springer, Switzerland, 2017.</li> <li>Winner, H. et al.: Handbook of Driver Assistance Systems. Basic Information, Components and Systems for Active Safety and Comfort. Springer, Switzerland, 2016.</li> </ul> </li> </ul>					
Co	urses					
	<b>Course nr.</b> 18-ad-2110-vl	Course name Automated Driving				
	<b>Instructor</b> DrIng. Matthias	Schreier	<b>Type</b> Lecture	<b>SWS</b> 2		

# 2.2 Optional Subjects AIS-IA: Intelligent Systems and Algorithms

Mo Int	Module name Introduction to Artificial Intelligence								
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle			
20-	00-1058	5 CP	150 h	105 h	1 Ierm	Every 2. Semester			
Lai Gei	<b>iguage</b> rman			Prof. Dr. techn. Johannes Fürnkranz					
1	<ul> <li>1 Teaching content Artificial Intelligence (Al) is concerned with algorithms for solving problems, whose solution is generally assumed to require intelligence. While research in the early days was oriented on results about human thinking, the field has since developed towards solutions that try to exploit the strengths of the computer. In the course of this lecture we will give a brief survey over key topics of this core discipline of computer science, with a particular focus on the topics search, planning, learning, and reasoning. Historical and philosophical foundations will also be considered. <ul> <li>Foundations</li> <li>Introduction, History of AI (RN chapter 1)</li> <li>Intelligent Agents (RN chapter 2)</li> <li>Search</li> <li>Uninformed Search (RN chapters 3.1 - 3.4)</li> <li>Heuristic Search (RN chapter 3.5, 3.6)</li> <li>Local Search (RN chapter 4)</li> <li>Constraint Satisfaction Problems (RN chapter 5)</li> <li>Planning</li> <li>Planning in State Space (RN chapter 10)</li> <li>Planning in Plan Space (RN chapter 11)</li> <li>Decisions under Uncertainty</li> <li>Uncertainty and Probabilities (RN chapter 13)</li> <li>Bayesian Networks (RN chapter 14)</li> <li>Decision Making (RN chapter 16)</li> <li>Machine Learning</li> </ul> </li> </ul>								
	<ul><li>Neural</li><li>Reinfo</li><li>Philoso</li></ul>	Networks (RN chap rcement Learning (R ophical Foundations	ters 18.1,18.2,18. N chapter 21)	7)					
2	Learning of After a succe • unders • partici • critical	<b>ojectives</b> essful completion of stand and explain fu pate in a discussion a lly judge new develo	this module, stude ndemental technic about the possibili pments in this are	ents are in a positio ques of artificial int ty of an artificial in a	on to elligence ntelligence with well-	-founded arguments			
3	Recomment	ded prerequisites fo	or participation						
4	<ul> <li>Form of examination Course related exam:</li> <li>[20-00-1058-iv] (Technical examination, Oral/written examination, Default RS) Written Exam (90 min.)</li> </ul>								
5	<b>Prerequisite</b> Pass exam (1	e for the award of c 100%)	redit points						

6	Grading Course related ex • [20-00-105	<ul> <li>Grading</li> <li>Course related exam:</li> <li>[20-00-1058-iv] (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>						
7	Usability of the	module						
	B.Sc. Informatik							
	M.Sc. Informatik							
	M.Sc. Autonome	Systeme und Robotik						
	M.Sc. Artificial I	ntelligence and Machine Learning						
	May be used in o	ther degree programs.						
8	Grade bonus co	mpliant to §25 (2)						
9	References							
Co	urses							
	Course nr.	Course name						
	20-00-1058-iv	Introduction to Artificial Intelligence						
	Instructor		Туре	SWS				
	Prof. Dr. techn. J	ohannes Fürnkranz	Integrated course	3				

<b>Mo</b> Info	Module name Information Management							
Mo	Module nr.         Credit points         Workload         Self-study         Module duration         Module cycle           00.00.0015         5 CP         150 h         105 h         1 Terms         Former 2 Connectors							
20-	20-00-0015 5 CP 150 h 105 h 1 Term Every 2. Semester							
<b>Lan</b> Ger	LanguageModule ownerGermanProf. Dr. phil. nat. Marc Fischlin							
1	Teaching co	ontent						

### **Study Content**

Basic concepts of information management: Structured and unstructured data (text) as important data sources. Relevance of information management (operational information systems) Overview of data science and its subfields

## Part 1: Structured data / databases

Data Modeling: Conceptual data models (ER / UML structure diagrams) Conceptual design Logical data model (relational model) Mapping from conceptual to logical model

Relational query languages: SQL (in detail) Relational Algebra

Database theory: Functional dependencies Design theory and normalization

Implementation of database systems: Physical data storage Query processing and optimization Transaction processing

Current trends in databases: Main-memory databases & Column-based data storage NoSQL databases Big Data Systems

### Part 2: Unstructured Data / Text Processing

Basics of unstructured data: Storage and encoding of unstructured text Creating and annotating text corpora Lexical resources and knowledge bases

Natural Language Processing: Segmentation Syntactic and semantic analysis

Other Applications for unstructured data: Information Retrieval Information Extraction

Advanced Topics: Introduction to research data management Data curation and visualization Documentation and archiving

#### 2 Learning objectives

	After successful a of information m They will unders approaches for ir An outlook on fu (e.g., Big Data) w	ttendance of the course, students know the basics of informatio anagement (business information systems but also data science stand the handling of structured and unstructured data and aformation processing. Ther topics (e.g., research data management) and current trer rill be given.	n management and appl ce). corresponding procedu nds in information mana	ications res and gement	
3	Recommended j	prerequisites for participation			
	Recommended: Participation of Datenstrukturen	lecture "Funktionale und Objektorientierte Programmierkon ', respective according knowledge.	zepte" and "Algorithm	en und	
4	Form of examin Course related ex • [20-00-001 Written exam (90	ation kam: 5-iv] (Technical examination, Oral/written examination, Defa ) min.).	ult RS)		
5	<b>Prerequisite for</b> Pass exam (100%	the award of credit points			
6	Grading Course related ex • [20-00-001	am: 5-iv] (Technical examination, Oral/written examination, Weig	chting: 100 %)		
7	Usability of the B. Sc. Informatik B.Sc. Wirtschafts Lehramt an Gym May be used in o	<b>module</b> informatik nasien - Fach Informatik ther degree programs.			
8	<b>Grade bonus co</b> In dieser Veranst Novelle der Allge 14.07.2022 besch	<b>mpliant to §25 (2)</b> altung findet eine Anrechnung von vorlesungsbegleitenden Leis emeinen Prüfungsbestimmungen der TU Darmstadt und den v alossenen Anrechnungsregeln zu einer Notenverbesserung um	tungen statt, die lt. 25(2 70m Fachbereich Inform bis zu 1.0 führen kann.	2) der 6. atik am	
9	<b>References</b> Will be updated	regularly; examples are:			
	<b>Part1 :</b> Kemper, Alfons: "Datenbanksysteme: Eine Einführung" Haerder, Rahm, "Datenbanksysteme - Konzepte und Techniken der Implementierung" Hector Garcia-Molina: "Database Systems"				
	<b>Part 2:</b> Jurafsky, Dan une	d Martin, James H.: "Speech and Language Processing"			
Coι	ırses				
	<b>Course nr.</b> 20-00-0015-iv	Course name			
	Instructor		<b>Type</b> Integrated course	SWS 3	

<b>Mo</b> Effi	<b>dule name</b> cient Graph A	Algorithms					
<b>Mo</b> 20-	<b>dule nr.</b> 00-0110	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module duration 1 Term	Module cycle Every 2. Semester	
Lar Ger	<b>nguage</b> rman			Module owner Prof. DrIng. Hei	iko Mantel		
1	Teaching co - Efficient D - Optimal Tr - Network F - Matching a - Planar Gra - Theory, Ge	ontent eata- Efficient Algorith ees and Branchings low Problems and Assignment phs. eneric Approaches, Im	nms for Graph Sca nprovement by me	anning and Connec eans of Speedup Te	tivity chniques and Structu	ıres	
2	Learning objectives         After successfully attending the course, students         - know fundamental algorithms         - know techniques to improve efficiency         - can analyse graph algorithms         - know methods to exploit particular characteristics (planarity, sparseness)         - can judge practical efficiency of techniques						
3	Recommended prerequisites for participation						
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>• [20-00-0110-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul>						
5	Prerequisit Pass exam (	e for the award of c (100%)	redit points				
6	Grading Course relat • [20-00	ted exam: 0-0110-iv] (Technica	l examination, Ora	al/written examina	tion, Weighting: 100	9%)	
7	Usability of the module B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik						
8	Grade bonus compliant to §25 (2)         In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2) der 5.         Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann						
9	References						

	Will be appointe	d in lecture		
Co	urses			
	<b>Course nr.</b> 20-00-0110-iv	<b>Course name</b> Efficient Graph Algorithms		
	Instructor		<b>Type</b> Integrated course	SWS 4

Ма	dula mama						
Nat	<b>dule name</b> ural Languag	e Processing and the	Web				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
20-	00-0433	6 CP	180 h	120 h	1 Term	Every 2. Semester	
Lar Ger	<b>iguage</b> man/English			Module owner Prof. Dr. techn. Je	ohannes Fürnkranz		
1	<ul> <li>Teaching content <ul> <li>The Web contains more than 10 billion indexable web pages, which can be retrieved via keyword search queries.</li> <li>The lecture will present natural language processing (NLP) methods to automatically process large amounts of unstructured text from the web and analyze the use of web data as a resource for other NLP tasks.</li> <li>Key topics: <ul> <li>Processing unstructured web content</li> <li>NLP basics: tokenization, part-of-speech tagging, stemming, lemmatization, chunking</li> <li>UIMA: principles and applications</li> <li>Web contents and their characteristics, incl. diverse genres such as personal web sites, news sites, blogs, forums, wikis</li> <li>The web as a corpus - innovative use of the web as a very large, distributed, interlinked, growing, and multilingual corpus</li> <li>NLP applications for the web</li> <li>Introduction to information retrieval</li> <li>Web-based question answering</li> <li>Mining Web 2.0 sites such as Wikipedia, Wiktionary</li> <li>Quality assessment of web contents</li> <li>Multilingualism</li> <li>Internet of services: service retrieval</li> <li>Sentiment analysis and community mining</li> <li>Paraphrases, synonyms, semantic relatedness</li> </ul> </li> </ul></li></ul>						
2	Learning ol After attend - understand - reconstruct - construct a - analyze an	bjectives ing this course, stude and differentiate be and explicate the pr nd analyze exemplar d evaluate the poten	ents are in a positi etween methods a rinciple of operation tial of using web c	ion to nd approaches for j on of web search er s for web data, contents to enhance	processing unstructu agines, e NLP applications.	red text,	
3	Recomment Basic knowle Programmir	<b>ded prerequisites fo</b> edge in Algorithms a ng in Java	or participation nd Data Structure				
4	<ul> <li>Form of examination Course related exam:</li> <li>• [20-00-0433-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul>						
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points				
6	Grading Course relat • [20-00	ed exam: )-0433-iv] (Technica	l examination, Ora	al/written examina	tion, Weighting: 100	9%)	
7	Usability of	the module					

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaft B.Sc. Psychologie Joint B.A. Inform B.Sc. Sportwisse M.Sc. Sportwisse	sinformatik e in IT atik nschaft und Informatik nschaft und Informatik			
	Can be used in o	her degree programs.			
8	<b>Grade bonus compliant to §25 (2)</b> In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.				
9	References         - Kai-Uwe Carstensen, Christian Ebert, Cornelia Endriss, Susanne Jekat, Ralf Klabunde: Computerlinguistik und Sprachtechnologie. Eine Einführung. 3. Auflage. Heidelberg: Spektrum, 2009. ISBN: 978-3-8274-20123-7.         - http://www.linguistics.rub.de/CLBuch/         - T. Götz, O. Suhre: Design and implementation of the UIMA Common Analysis System, IBM Systems Journal 43(3): 476-489, 2004.         - Adam Kilgarriff, Gregory Grefenstette: Introduction to the Special Issue on the Web as Corpus, Computational Linguistics 29(3): 333-347, 2003.         - Christopher D. Manning, Prabhakar Raghavan, Hinrich Schütze: Introduction to Information Retrieval, Cam-				
Co	urses				
	<b>Course nr.</b> 20-00-0433-iv	<b>Course name</b> Natural Language Processing and the Web			
	Instructor		<b>Type</b> Integrated course	SWS 4	

Mo Dat	dule name	Machine Learning				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
Lai	<b>nguage</b> rman/English	0 CP	160 11	Module owner Prof. Dr. techn. Jo	ohannes Fürnkranz	Every 2. Semester
1	<b>Teaching co</b> With the rap often contain Data Mining sets, and ma This course	ontent oid development of ir n implicit knowledge g is a research area th achine learning is one offers an introduc	nformation techno , which, if it were nat is concerned w e of the key techni tion into the are	logy bigger and big known, could have ith the search for p iques in this area. ea of machine lea	ger amounts of data significant commerc otentially useful kno rning from the ang	are available. These ial or scientific value. wledge in large data gle of data mining.
	Different tec To operation applications Introd Rule L - L sp - L Evalua Instan Decisio Ensem Pre-Pr Cluste	hniques from various alize this knowledge uction (Foundation, F earning earning of indivicual paces) earning of rule sets ( tion and cost-sensiti ce-Based Learning (H on Tree Learning (ID ble Methods (Bias/V ocessing (Feature Su ring and Learning of	paradigms of mac , a practical part o Learning problem rules (generaliza covering strategy, o ve Learning (Accu kNN, IBL, NEAR, F '3, C4.5, etc.) 'ariance, Bagging, bset Selection, Dis 'Association Rules	hine learning will b f the course is conce s, Concepts, Examp tion vs. specializati evaluation measure racy, X-Val, ROC Cu USE) Randomization, Bo scretization, Sampl (Apriori)"	e introduced with exe erned with the use of eles, Representation) on, structured hypot s for rules, pruning, r urves, Cost-Sensitive posting, Stacking, EC ing, Data Cleaning)	emplary applications. data mining tools in hesis spaces, version multi-class problems) Learning)
2	Learning of After a succe - understand - apply pract - critically ju	<b>ojectives</b> essful completion of t l and explain funden tical data mining syst dge new developmen	this module, stude nental techniques tems and understants in this area	ents are in a positio of data mining and and their strengths	n to machine learning and limitations	
3	Recomment	ded prerequisites fo	or participation			
4	Form of exa Course relat • [20-00 The form of two of the fo Written exa (optional: in	mination ed exam: )-0052-iv] (Technical the examination wil ollowing forms is pos m (duration 60 or cluding tests).	l examination, Ora l be announced at sible. 90 or 120 minut	al/written examina the beginning of t tes), oral exam (d	tion, Default RS) he course. One or a uration 15 or 30 m	combination of max. ninutes), homework
5	<b>Prerequisite</b> Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0052-iv] (Technical	l examination, Ora	al/written examina	tion, Weighting: 100	%)
7	Usability of	the module				

	B. Sc. Informatik M. Sc. Informatik M. Sc. Computer M. Sc. Autonome M. Sc. Artificial I M. Sc. IT Sicherh	c Science Systeme und Robotik ntelligence and Machine Learning eit			
	May be used in o	ther degree programs.			
8	<b>Grade bonus compliant to §25 (2)</b> In this course a crediting of lecture-accompanying achievements takes place, which can lead to a grade improve- ment of up to 1.0 according to 25(2) of the 6th amendment of the General Examination Regulations of the TU Darmstadt and the crediting rules decided by the Department of Computer Science on July 14, 2022.				
9	References - Mitchell: Machi - Ian H. Witten a Implementations	ne Learning, McGraw-Hill, 1997 nd Eibe Frank: Data Mining: Practical Machine Learning To , Morgan-Kaufmann, 1999	ools and Techniques wi	th Java	
Co	urses				
	<b>Course nr.</b> 20-00-0052-iv	<b>Course name</b> Data Mining and Machine Learning	_		
	Instructor		<b>Type</b> Integrated course	SWS 4	

Mo Dee	<b>dule name</b>	r Natural Language	Processing					
Mo	Module nr.         Credit points         Workload         Self-study         Module duration         Module cycle							
20- Lar	00-0947	6 CP	180 h	120 h Module owner	1 Term	Every 2.	Semester	
Ger	man			Prof. Dr. phil. Iry	na Gurevych			
1	<ul> <li>Teaching content         The lecture provides an introduction to the foundational concepts of deep learning and their application to problems in the area of natural language processing (NLP)         Main content:         <ul> <li>foundations of deep learning (e.g. feed-forward networks, hidden layers, backpropagation, activation functions, loss functions)</li> <li>word embeddings: theory, different approaches and models, application as features for machine learning</li> <li>different architectures of neuronal networks (e.g. recurrent NN, recursive NN, convolutional NN) and their application for groups of NLP problems such as document classification (e.g. spam detection), sequence labeling (e.g. POS-tagging, Named Entity Recognition) and more complex structure prediction (e.g. Chunking, Parsing, Semantic Role Labeling)</li> </ul> </li> </ul>							
2	<ul> <li>Learning objectives         After completion of the lecture, the students are able to         - explain the basic concepts of neural networks and deep learning.         - explain the concept of word embeddings, train word embeddings and use them for solving NLP problems.         - understand and describe neural network architectures that are used to tackle classical NLP problems such as classification, sequence prediction, structure prediction.         - implement neural networks for NLP problems using existing libraries in Python.     </li> </ul>							
3	<b>Recommend</b> Basic knowle	<b>led prerequisites fo</b> edge of mathematics	or participation and programming	3				
4	Form of exa Course relat • [20-00	<b>mination</b> ed exam: -0947-iv] (Technica	l examination, Ora	al/written examina	tion, Default R	5)		
5	<b>Prerequisite</b> Pass exam (2	e for the award of c	redit points					
6	Grading Course relat • [20-00	ed exam: -0947-iv] (Technica	l examination, Ora	al/written examina	tion, Weighting	: 100 %)		
7	Usability of	the module						
8	Grade bonu	s compliant to §25	(2)					
9	References							
Cot	ırses							
	<b>Course nr.</b> 20-00-0947-	iv Deep Learning	g for Natural Lang	uage Processing				
	<b>Instructor</b> Prof. Dr. phi	l. Iryna Gurevych			<b>Typ</b> Inte	e grated course	SWS 4	

Mo Fuz	dule name	ral Networks and Ex	olutionary Algorit	hms				
<b>Mo</b>	<b>dule nr.</b> ad-2020	<b>Credit points</b>	Workload	Self-study 75 h	Module o	luration	Module cyc	cle
Lar Ger	nguage rman	101	120 11	Module owner Prof. DrIng. Jür	gen Adamy	7	Whiter term	
1	<b>Teaching content</b> Fuzzy systems: basics, rule based fuzzy logic, design methods, decision making, fuzzy control, pattern recog- nition, diagnosis; Neural networks: basics, multilayer perceptrons, radial basis functions, pattern recognition, identification, control, interpolation and approximation, Neuro-fuzzy: optimization of fuzzy systems, data driven rule generation; Evolutionary algorithms: optimization problems, evolutionary strategies and their applications, genetic programming and its applications							
2	<ul> <li>Learning objectives After attending the module, a student is capable of: <ul> <li>recalling the elements and set-up of standardized fuzzy-logic, neural networks and evolutionary algorithms,</li> <li>discussing the pros and cons of certain set- ups of systems from computational intelligence for solving a given problem, <ul> <li>recognizing situations in which tools taken from computational intelligence can be applied for problem solving,</li> <li>creating programs from algorithms taught in the lecture, and</li> <li>extending the learned standard procedures in order to solve new problems. </li> </ul></li></ul></li></ul>							
3	Recommen	led prerequisites fo	or participation					
4	Form of exa Module exa • Modul	<b>mination</b> n: e exam (Technical e:	xamination, Exam	ination, Duration:	90 Min., D	efault RS)		
5	Prerequisite Passing the	e for the award of c inal module examin	<b>redit points</b> ation					
6	Grading Module exan • Modul	n: e exam (Technical e:	xamination, Exam	ination, Weighting	: 100 %)			
7	<b>Usability of</b> BSc iST, MS	<b>the module</b> c ETiT, MSc MEC, M	Sc WI-ETiT, MSc i	CE, MSc EPE, MSc	CE, MSc I	nformatik		
8	Grade bonu	s compliant to §25	(2)					
9	9 References Adamy: Fuzzy Logik, Neuronale Netze und Evolutionäre Algorithmen, Shaker Verlag (available for purchase at the FG office)							
Co	urses							
	<b>Course nr.</b> 18-ad-2020-	vl Fuzzy Logic, N	Jeuronal Networks	s and Evolutionary	Algorithm	S		
	Instructor Prof. DrIng	. Jürgen Adamy				<b>Type</b> Lecture		SWS 2

<b>Course nr.</b> 18-ad-2020-ue	<b>Course name</b> Fuzzy Logic, Neuronal Networks and Evolutionary Algorithm	IS	
<b>Instructor</b> Prof. DrIng. Jür	gen Adamy	<b>Type</b> Practice	<b>SWS</b> 1

Mo Ma	Module name Matrix Analysis and Computations						
<b>Mo</b> 18-	<b>dule nr.</b> pe-2070	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module duration 1 Term	Module cycle Summer term	
Lar Eng	<b>iguage</b> glish		I	<b>Module owner</b> Prof. DrIng. Ma	rius Pesavento	L	
1	I Teaching content This graduate course is a foundation class on matrix analysis and computations, which are widely used in many different fields, e.g., machine learning, computer vision, systems and control, signal and image processing, communications, networks, optimization, and many more Apart from the theory this course will also cover the design of efficient algorithm and it considers many different examples from the aforementioned fields including examples from social media and big data analysis, image processing and medical imaging, communication network optimization, and written text classification. Specific topics: (i) basic matrix concepts, subspace, norms, (ii) linear least squares (iii) eigendecomposition, singular value decomposition, positive semidenite matrices, (iv) linear system of equations, LU decomposition, Cholesky decomposition (v) pseudo-inverse, QR decomposition (vi) advanced tensor decomposition, advanced matrix calculus, compressive sensing, structured matrix factorization						
2	<b>Learning objectives</b> Students will have learned advanced topics in matrix analysis and related algorithms at an advanced level upon completion of the module.						
3	Recomment Basic knowle	<b>ded prerequisites fo</b> edge in linear algebra	<b>or participation</b> a.				
4	<ul> <li>Form of examination</li> <li>Module exam: <ul> <li>Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS)</li> <li>The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 10 students register, the examination will be an oral examination (duration: 20 min.). The type of available or an estimate of the lecture.</li> </ul> </li> </ul>						
5	Prerequisite Pass module	e for the award of c	redit points				
6	<ul> <li>Grading Module exam:</li> <li>Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>						
7	Usability of	the module					
8	Grade bonu	is compliant to §25	(2)				
9	References						

- Gene H. Golub and Charles F. van Loan, Matrix Computations (Fourth Edition), John Hopkins University Press, 2013.
- Roger A. Horn and Charles R. Johnson, Matrix Analysis (Second Edition), Cambridge University Press, 2012.
- Jan R. Magnus and Heinz Neudecker, Matrix Differential Calculus with Applications in Statistics and Econometrics (Third Edition), John Wiley and Sons, New York, 2007.
- Giuseppe Calaore and Laurent El Ghaoui, Optimization Models, Cambridge University Press, 2014.
- ECE 712 Course Notes by Prof. Jim Reilly, McMaster University, Canada (friendly notes for engineers) http://www.ece.mcmaster.ca/faculty/reilly/ece712/course\_notes.htm

#### Courses

60	41303					
	<b>Course nr.</b> 18-pe-2070-vl	<b>Course name</b> Matrix Analysis and Computations				
	Instructor Prof. DrIng. Marius Pesavento		<b>Type</b> Lecture	<b>SWS</b> 3		
	Course nr.Course name18-pe-2070-ueMatrix Analysis and Computations					
	<b>Instructor</b> Prof. DrIng. Ma	rius Pesavento	<b>Type</b> Practice	<b>SWS</b> 1		

Mo Intr	Module name						
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
18-	st-2070	4 CP	120 h	90 h	1 Term	Summer term	
Lan Ger	iguage			Prof Dr rer nat	Florian Steinke		
1	<ul> <li>Teaching content         Scientific computing is introduced via six case studies. Exemplary engineering problems that are know from basic engineering courses are solved on a computer using fundamental methods from numerical mathematics. Opportunities and limitations of this approach are highlighted.     </li> <li>The required material on numerical mathematics is taught via preparatory scripts for each case study.</li> </ul>						
	<ul> <li>The required material on numerical mathematics is taught via preparatory scripts for each case study.</li> <li>During the practical exercises the methods are implemented in the current computing environment Python under the guidance of suitable teaching personnel.</li> <li>The case studies cover the following numerical topics:</li> <li>Formulation and solution of systems of linear equations, sparse methods.</li> </ul>						
	<ul> <li>Integration of ordinary differential equations (ODE) and their analysis based on eigenvalues</li> <li>Mathematical optimization and automated differentiation</li> <li>Linear regression and approximation, first Machine Learning algorithms</li> <li>Discretization of simple partial differential equations (PDE)</li> </ul>						
2	Learning objectives After completing the module, the students have learned to work on engineering problems with modern computer tools and to use important basic technologies of scientific computing in a targeted manner. In doing so, the students have been taught an algorithmic way of thinking and are able to assess the possibilities and limitations of computer-based computational methods.						
3	Recommen Etit 1 & 2, M	<b>ded prerequisites fo</b> Mathe for etit 1-3	or participation				
4	Form of exa Module exa • Modul The exact for experimenta	amination m: le exam (Study achie orm of the examinati al descriptions and/o	vement, Oral/writion will be annous r a presentation o	tten examination, I nced at the beginn f experimental resu	Default RS) ing of the first cours ılts will be prepared.	e. Either a report of	
5	<b>Prerequisit</b> Passing the	e for the award of c final module examina	<b>redit points</b> ation				
6	<ul> <li>Grading Module exam:</li> <li>Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</li> </ul>						
7	Usability of Etit B.A./M.	f <b>the module</b> .Sc. with all options,	as well as CE, ICE	, IST			
8	Grade bonu	is compliant to §25	(2)				
9	References						
Coι	Courses						

-	Course nr.Course name18-st-2070-prIntroduction to Scientific Computing with Python					
	<b>Instructor</b> Prof. Dr. techn. H Herbert De Gers Sebastian Schöps	<b>Type</b> Internship	<b>SWS</b> 2			

Mo Pro	<b>dule name</b> ject Seminar H	Iardware for Neural	Networks					
<b>Mo</b>	dule nr. zh-2020	<b>Credit points</b>	Workload	Self-study 135 h	<b>Module</b>	duration	Module cyc Every Seme	c <b>le</b>
Lar Eng	<b>iguage</b> glish		100 11	Module owner Prof. DrIng. Li Z	Thang			
1	<b>Teaching content</b> Students will work on their own in this course. Topics and application context will be defined individually for each student. In this course hardware for neural networks will be investigated. This particularly means the improvement of software and hardware methods for efficient hardware for neural networks and the implementation of such hardware with commercial or open-source tools or FPGAs. Usually, the course starts with a literature search to get acquainted with the hardware for neural networks. This is followed by the practical part and finally the results are presented in a written report and a presentation.							
2	<b>Learning objectives</b> Successful students will know how to implement hardware for neural networks within a given application context. They can use tools to train a neural network and know how to realize it on a given hardware architecture. They are capable to evaluate the performance of an application.							
3	Recommended prerequisites for participation							
	<ul> <li>Knowledge of heural network training and interence (cf. course hardware for neural network)</li> <li>Knowledge of digital or analog circuits (cf. course hardware for neural network)</li> <li>Solid programming skills (either in Python or VHDL depending on the application scenario)</li> </ul>							
4	<ul> <li>Form of examination</li> <li>Module exam:</li> <li>Module exam (Study achievement, Oral examination, Duration: 30 Min., Default RS)</li> </ul>							
5	<b>Prerequisite</b> Passing the f	for the award of c	<b>redit points</b> ation					
6	Grading Module exan • Module	n: e exam (Study achie	vement, Oral exar	nination, Weightin	g: 100 %)			
7	<b>Usability of</b> MSc WI-etit,	<b>the module</b> MSc iST, MSc iCE						
8	Grade bonu	s compliant to §25	(2)					
9	<b>References</b> Will be given	to the students dur	ing the individual	seminar kick-off n	neeting.			
Co	ırses							
	<b>Course nr.</b> 18-zh-2020-j	oj Course name Project Semina	ar Hardware for N	eural Networks				
	Instructor Prof. DrIng.	Li Zhang				<b>Type</b> Project se	eminar	SWS 3

Module nar Web-Mining	me 3					
<b>Module nr.</b> 20-00-0101		Credit points 6 CP	Workload 180 h	<b>Self-study</b> 120 h	Module duration 1 Term	Module cycle Every 2. Semester
<b>Language</b> German/English				<b>Module owner</b> Prof. Dr. techn. J	ohannes Fürnkranz	
1 Teachi	ng co	ontent				

The World-Wide Web provides every internet uses access to an ever-growing plentitude of information, which can not be processed without appropriate support. Web Mining is the research area that is tries to solve this problem with machine learning and data mining techniques. In this course, we will discuss foundations of information retrieval and text classification, as well as consider the pecularities of web documents (i.e. their document and graph structure).

- Introduction
- Web Mining Overview
- The Web, HTTP, HTML, DOM, XPath
- Data Mining Overview
- Structured, Semi-Structured and Unstructured Data
- Sample Web Mining Tasks
- Information Retrieval on the Web
- search engines & web crawlers
- document indexing
- the vector space model
- inverted index
- performance measures (recall & precision)
- relevance feedback
- estimating the size of the web
- Text Mining
- text classification
- document representation
- induction of classifiers (k-NN, Naive Bayes, SVMs, Rule Learners)
- Overfitting Avoidance
- Evaluation of Classifiers
- Multi-Label Classification
- feature engineering
- stop words
- feature subset selection
- n-grams
- stemming
- phrases
- latent semantic indexing
- semi- and unsupervised learning
- clustering (k-means, bottom-up agglomerative)
- semi-supervised learning (active learning, self-training, co-training)
- Structure mining
- the Web as a graph
- hyperlink-based relevance ranking (hubs and authorities, page rank)
- hypertext classification (Naive Method, HyperClass, hyperlink ensembles)
- Information Extraction & Wrapper Induction
- conventional information extraction (AutoSlog)
- structured text (LR-Wrappers)
- semi-structured text (SoftMealy, WHISK, SRV, RAPIER)
- Web Usage Mining
- recommender systems
- memory-based collaborative filtering
- model-based collaborative filtering
- web log mining
- 2 Learning objectives

	After attending t - understand and - apply practical i - critically judge	nis course, students are in a position to explain fundemental techniques of information retrieval and v nformation retrieval and web mining systems and understand new developments in this area	web mining their strengths and limi	tations		
3	Recommended	prerequisites for participation				
4	Form of examin Course related ex • [20-00-010	ation cam: 1-iv] (Technical examination, Oral/written examination, Defa	ult RS)			
5	<b>Prerequisite for</b> Pass exam (100%	the award of credit points				
6	Grading Course related ex • [20-00-010	am: 1-iv] (Technical examination, Oral/written examination, Weig	hting: 100 %)			
7	Usability of the B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaft B.Sc. Psychologie Joint B.A. Inform B.Sc. Sportwisse M.Sc. Sportwisse May be used in c	module sinformatik e in IT atik nschaft und Informatik nschaft und Informatik ther degree programs.				
8	<b>Grade bonus co</b> In dieser Vorlesu Novelle der APB u um bis zu 1.0 fül	<b>npliant to §25 (2)</b> ng findet eine Anrechnung von vorlesungsbegleitenden Leistur nd den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsreg ıren kann.	ngen statt, die lt.) 25 (2 geln zu einer Notenverbe:	) der 5. sserung		
9	References         - Soumen Chakrabarti: Mining the Web - Discovering Knowledge from Hypertext Data. Morgan Kaufmann Publishers, 2003.         - Christopher D. Manning, P. Raghavan and H. Schütze, Introduction to Information Retrieval, Cambridge University Press, 2008.					
Cou	ırses					
	<b>Course nr.</b> 20-00-0101-iv	Course name Web Mining				
	Instructor		<b>Type</b> Integrated course	SWS 4		

Mo Pra	<b>dule name</b> ctical Lab Alg	orithms					
<b>Mo</b> 20-	<b>dule nr.</b> 00-0189	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module duration 1 Term	Module cy Every 2. Se	<b>cle</b> mester
Lar Ger	<b>nguage</b> rman			<b>Module owner</b> Prof. DrIng. Hei	ko Mantel		
1	<b>Teaching co</b> Solution of a	ontent an algorithmic proble	em form practice a	and its implementa	tion in software.		
2	<b>Learning of</b> In this cours efficient algo	<b>ojectives</b> e students acquire e orithms	expertise in solving	g algorithmic probl	ems from practice a	nd skill to imp	olement
3	Recommended prerequisites for participation- Knowledge in program language (e.g. Java / C++)- Knowledge about basic algorithms and data structure						
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>[20-00-0189-pr] (Study achievement, Oral/written examination, Default RS)</li> </ul>						
5	Prerequisite for the award of credit points Pass exam (100%)						
6	Grading Course related exam: • [20-00-0189-pr] (Study achievement, Oral/written examination, Weighting: 100 %)						
7	Usability of the module B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik						
8	Grade bonu	s compliant to §25	(2)				
9	<b>References</b> Will be given	n in lecture.					
Co	urses	1					
	<b>Course nr.</b> 20-00-0189-	pr Practical Lab	Algorithms				
	Instructor	· · · · · · · · · · · · · · · · · · ·			<b>Type</b> Internsh	ip	SWS 4

Mo Pra	Module name Practical Course in Artificial Intelligence							
<b>Mo</b> 20-	<b>dule nr.</b> 00-0412	Credit points	Workload 180 h	Self-study 120 h	<b>Module duration</b>	Module cycle		
Lar Ger	nguage	0.01	100 11	Module owner Prof. Dr. techn. J	ohannes Fürnkranz	livery 2. bennester		
1	I       Teaching content         Students have to work on a concrete practical problem in the area of artificial intelligence and solve it with the help of tools and techniques that they developed on their own or that are already publicly available.         Note the announcements on the homepage of the KE group regarding this course (http://www.ke.informatik.tu-darmstadt.de/lehre/)!							
	In semesters projects (ple	s, where this course is ease ask).	s not announced o	n the above pages,	there is often the pos	ssibility of individual		
2	Learning objectives         After completion of this practical course, students should be able to         - recognize potential uses of artificial intelligence tools         - select appropriate tools for a given task and apply them to this task         - evaluate and measure the success of the use of such tools							
3	Recommended prerequisites for participation Basic knowledge in artificial intelligence							
4	Form of examination Course related exam: • [20-00-0412-pr] (Study achievement, Oral/written examination, Default RS)							
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points					
6	Grading Course relat • [20-00	ed exam: )-0412-pr] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %)	)		
7	Usability of the module B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik							
8	Can be used	in other degree prog	grams.					
0			(4)					
9	References							
Cot	Courses							

<b>Course nr.</b> 20-00-0412-pr	<b>Course name</b> Practical Course in Artificial Intelligence					
Instructor		<b>Type</b> Internship	SWS 4			
Mo Ser	<b>dule name</b> ninar Data Mi	ining and Machine L	earning			
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Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
Lar Ger	nguage	5 Gr	90 II	Module owner Prof. Dr. techn. Jo	ohannes Fürnkranz	Every 2. Semester
1	<ul> <li>Teaching content         This seminar serves the purpose of discussing new research papers in the areas of data mining and machine learning. Every participant will present one paper, which will be subsequently discussed by all participants. Grades are based on the preparation and presentation of the paper, as well as the participation in the discussion, in some cases also a written report.     </li> <li>The papers will typically recent publications in relevant journals such as "Data Mining and Knowledge Discovery", ""Machine Learning", as well as ""Journal of Machine Learning Research". Students may also propose their own topics if they fit the theme of the seminar.     </li> </ul>					
	Please note	current announceme	nts to this course	at http://www.ke.i	nformatik.tu-darmst	adt.de/lehre.
2	Learning of After this ser - understand - work out a - make usefu	<b>ojectives</b> minar, students shou l an unknown text in presentation for an l contributions in a s	ld be able to the area of mach audience proficien scientific discussio	ine learning t in this field n in the area of ma	chine learning	
3	Recomment Basic knowle	<b>ded prerequisites fo</b> edge in Machine Lea	or participation rning and Data M	ining		
4	Form of exa Course relat • [20-00	mination red exam: )-0102-se] (Study ac	hievement, Oral/v	vritten examination	n, Default RS)	
5	Prerequisite Pass exam (1	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0102-se] (Study ac	hievement, Oral/v	vritten examinatior	n, Weighting: 100 %)	)
7	<ul> <li>7 Usability of the module</li> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> <li>M.Sc. Wirtschaftsinformatik</li> <li>B.Sc. Psychologie in IT</li> <li>Joint B.A. Informatik</li> <li>B.Sc. Sportwissenschaft und Informatik</li> <li>M.Sc. Sportwissenschaft und Informatik</li> <li>May be used in other degree programs</li> </ul>					
8	Grade bonu	is compliant to §25	(2)			
9	References					
Co	urses					

<b>Course nr.</b> 20-00-0102-se	<b>Course name</b> Seminar Data Mining and Machine Learning		
Instructor		<b>Type</b> Seminar	SWS 2

Mo Sta	dule name	ne Learning					
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
20- Lar	00-0358	6 CP	180 h	120 h Module owner	1 Term	Every 2. Semester	
Eng	glish			Prof. Dr. rer. nat.	Kristian Kersting		
1	<b>Teaching co</b> - Statistical - Refreshers - Bayes Deci - Probability - Non-Param - Mixture Mo - Linear Moo - Statistical 1 - Kernel Met	<ul> <li>Statistical Methods for Machine Learning</li> <li>Refreshers on Statistics, Optimization and Linear Algebra</li> <li>Bayes Decision Theory</li> <li>Probability Density Estimation</li> <li>Non-Parametric Models</li> <li>Mixture Models and EM-Algorithms</li> <li>Linear Models for Classification and Regression</li> <li>Statistical Learning Theory</li> <li>Kernel Methods for Classification and Regression</li> </ul>					
2	Learning of The lecture completion machine lea	<b>Learning objectives</b> The lecture gives a systematic introduction to statistical methods for machine learning. Upon successful completion of this lecture, students will understand the most important methods and approaches of statistical machine learning. They can apply machine learning to solve various new problems.					
3	Recommended prerequisites for participation						
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>• [20-00-0358-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul>						
5	<b>Prerequisit</b> Pass exam (	e for the award of c 100%)	redit points				
6	Grading Course relat • [20-00	ed exam: D-0358-iv] (Technical	l examination, Ora	al/written examina	tion, Weighting: 100	9%)	
7	Usability of the module B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik						
8	Grade bonu In dieser Vo Novelle der A	<b>Is compliant to §25</b> rlesung findet eine A APB und den vom FB 2 0 führen kann	<b>(2)</b> nrechnung von vo 20 am 30.3.2017 b	orlesungsbegleitend eschlossenen Anrec	len Leistungen statt, chnungsregeln zu eine	die lt. 25 (2) der 5. er Notenverbesserung	
9	References						

- 1. C.M. Bishop, Pattern Recognition and Machine Learning (2006), Springer
- 2. K.P. Murphy, Machine Learning: a Probabilistic Perspective (expected 2012), MIT Press
- 3. D. Barber, Bayesian Reasoning and Machine Learning (2012), Cambridge University Press
- 4. T. Hastie, R. Tibshirani, and J. Friedman (2003), The Elements of Statistical Learning, Springer Verlag
- 5. D. MacKay, Information Theory, Inference, and Learning Algorithms (2003), Cambridge University Press
- 6. R.O. Duda, P.E. Hart, and D.G. Stork, Pattern Classification (2nd ed. 2001), Willey-Interscience
- 7. T.M. Mitchell, Machine Learning (1997), McGraw-Hill

## Courses

<b>Course nr.</b> 20-00-0358-iv	<b>Course name</b> Statistical Machine Learning		
<b>Instructor</b> Prof. Dr. rer. nat.	Kristian Kersting	<b>Type</b> Integrated course	SWS 4

Mo	Module name						
Pro Mo	ject Lab Deep dule pr	Learning in Comput	Workload	Solf study	Modulo durat	ion Modula av	clo
20-	00-0980	9 CP	270 h	180 h	1 Term	Every 2. Se	emester
Lar Ger	<b>nguage</b> man/English			Module owner Prof. DrIng. Mic	hael Gösele		
1	1 <b>Teaching content</b> In this project lab groups of students will work on selected topics in deep learning (deep neural networks) for problems in computer vision. This includes the practical implementation with modern deep learning frameworks. Results will be presented in a talk at the end of the lab. Concrete topics follow the current state of the art and change from term to term.						
2	<b>Learning of</b> Through the applications area. Moreo	<b>jectives</b> ir successful particip in computer vision. ver, they practice the	ation, students acc They are able to a eir abilities for pre-	quire in-depth knov nalyze, modify, an senting their result	vledge on deep d apply state-of s and for collab	neural networks a the-art technique oration in teams.	nd their s in this
3	Recommended prerequisites for participation * Solid programming skills in C/C++ or Python or Lua * Prior or concurrent registration for "Computer Vision I"						
4	Form of exa Course relate • [20-00	mination ed exam: -0980-pp] (Study ac	hievement, Oral/v	written examinatio	n, Default RS)		
5	<b>Prerequisite</b> Pass exam (2	e for the award of c 100%)	redit points				
6	Grading Course relate • [20-00	ed exam: -0980-pp] (Study ac	hievement, Oral/v	written examinatio	n, Weighting: 1	00 %)	
7	Usability of	the module					
8	Grade bonu	s compliant to §25	(2)				
9	References						
Cot	ırses						
	<b>Course nr.</b> 20-00-0980-	pp Project Lab De	eep Learning in Co	mputer Vision			
	Instructor Prof. DrIng	. Michael Gösele			<b>Typ</b> Inte	e rnship	<b>SWS</b> 6

Mo Lea	<b>dule name</b> arning and Edu	ucational Technologi	es			
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
20- Lar	00-0773	6 CP	180 h	120 h Module owner	1 Ierm	Every 2. Semester
Ger	rman			Prof. Dr. rer. nat.	Eberhard Mühlhäuse	er
1	<ul> <li>Teaching content         Digital applications and the Internet are changing the way we learn. If digital teaching and learning applications are designed appropriately, they offer a wide range of possibilities. The module aims to impart basic knowledge about the most important aspects of system design and about technologies needed for modern, web-based and mobile learning applications. Important theoretical foundations for the design of learning applications are learning theories. Therefore, learning theories are briefly discussed in the context of this module. The focus of the module is on adaptive learning applications. Different methods for the realization of adaptive learning applications will be presented. Frequently, Natural Language Processing and Artificial Intelligence methods are used for this purpose. In this context, current research work is considered. The module also focuses on the design of learning applications for individual and cooperative learning in various fields of application (e.g. school, university, vocational education and lifelong learning). Examples from current research projects as well as teaching/learning practice are presented. In addition, methods for the evaluation of learning applications are considered.     </li> </ul>					
2	Learning of After complete and learning representation to support presentation techniques of qualities and	bjectives etion of the module, st g based on different on (data level), design platform users conce of adaptation to lean d effects of learning a	udents will be able design patterns ar n of functionalities erning challenges eners needs and v pplications and th	e to analyze and des nd technologies. Th (application level), in the learning pr vill know appropri e algorithms and n	ign applications for k ney will be able to de and selection/config ocess. Students are iate evaluation meth nethods used in the le	nowledge acquisition ecide on information uration of algorithms capable to consider nods to measure the earning applications.
3	Recomment Basic knowled students wh the application	<b>ded prerequisites fo</b> edge of Machine Lear o do not meet these ion-specific mechanis	or participation rning and Natural requirements, we rms.	Language Processi offer short learning	ng is desirable but no g modules that allow	ot a prerequisite. For an understanding of
4	Form of exa Course relat • [20-00	<b>amination</b> red exam: )-0773-iv] (Technical	examination, Ora	ıl/written examina	tion, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0773-iv] (Technical	examination, Ora	ll/written examina	tion, Weighting: 100	%)
7	<ul> <li><sup>7</sup> Usability of the module</li> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> <li>Kann in anderen Studiengängen verwendet werden.</li> </ul>					
8	Grade bonu	is compliant to §25	(2)			
9	References					
Coi	urses					

<b>Course nr.</b> 20-00-0773-iv	<b>Course name</b> Learning and Educational Technologies		
Instructor Prof. Dr. rer. nat.	Eberhard Mühlhäuser	<b>Type</b> Integrated course	SWS 4

Mo	dule name	olling				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
20-	00-0113	6 CP	180 h	120 h	1 Term	Every 2. Semester
Lar Ger	n <b>guage</b> man			Module owner Prof. DrIng. Hei	ko Mantel	
1	<b>Teaching co</b> - Algorithmi - modeling p - modelling a - complex ca	ontent c modeling language roblems as (integer) as combinatorial opti se studies: e.g. applic	s like OPL and ec linear programm mization problem cations in logistics	lipse ing problems .s and manufacturinş	g; deterministic and s	stochastic scheduling
2	Learning objectives After successfully attending the course, - students know modelling strategies for decision, construction, and optimization problems - students can apply two algorithmic modelling languages - student can adequately model complex problems					
3	<b>Recommen</b> Grundzüge wünschensw	<b>led prerequisites fo</b> III der Informatik o <sup>r</sup> ert).	<b>r participation</b> der vergleichbar	(Einführung in Fo	undations of Compu	iting wäre ebenfalls
4	<ul> <li>Form of examination Course related exam:         <ul> <li>[20-00-0113-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul> </li> </ul>					
5	<b>Prerequisite</b> Pass Exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0113-iv] (Technical	examination, Ora	al/written examina	tion, Weighting: 100	%)
7	Usability of the module         B.Sc. Informatik         M.Sc. Informatik         B.Sc. Computational Engineering         M.Sc. Computational Engineering         M.Sc. Wirtschaftsinformatik         B.Sc. Psychologie in IT         Joint B.A. Informatik         B.Sc. Sportwissenschaft und Informatik         M.Sc. Sportwissenschaft und Informatik					
8	Grade bonus compliant to §25 (2)         In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2) der 5.         Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung					
9	References Will be appo	inted in lecture.				
Cou	irses					

<b>Course nr.</b> 20-00-0113-iv	Course name Algorithmic Modelling		
Instructor		<b>Type</b> Integrated course	SWS 4

Mo Pra	<b>dule name</b> ctical Lab Adv	anced Algorithms						
<b>Mo</b> 20-	<b>dule nr.</b> 00-0276	Credit points 6 CP	Workload	Self-study 120 h	Module d	uration	Module cyc Every 2, Se	<b>cle</b> mester
Lar Ger	nguage rman		100 11	Module owner Prof. DrIng. Hei	ko Mantel			
1	<b>Teaching co</b> Solution of a	<b>ntent</b> n advanced algorith	mic problem form	practice and its in	nplementati	ion in soft	ware.	
2	<b>Learning objectives</b> In this course students enhance their expertise in solving algorithmic problems from practice and their skills to implement efficient algorithms							
3	Recommend Based on Lab	<b>led prerequisites f</b> o Algorithms	or participation					
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>• [20-00-0276-pr] (Study achievement, Oral/written examination, Default RS)</li> </ul>							
5	Prerequisite for the award of credit points Pass exam (100%)							
6	Grading Course related exam: • [20-00-0276-pr] (Study achievement, Oral/written examination, Weighting: 100 %)							
7	Usability of the module B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik							
8	Grade bonu	s compliant to §25	(2)					
9	<b>References</b> Will be giver	in lab.						
Co	arses	Courses						
	<b>Course nr.</b> 20-00-0276-j	pr Advanced Alg	orithms					
	Instructor					<b>Type</b> Internship	p	SWS 4

Mo	dule name	1 1				
Cor	dule nr	Credit points	Workload	Big Data Processii	ng Module duration	Module cycle
20-	00-0951	3 CP	90 h	60 h	1 Term	Every 2. Semester
Lar	iguage			Module owner	Diabhana	
Eng 1	Teaching co	ntent		DrIng. Michael	Eichberg	
-	The course provides an overview of recent advances in distributed systems for Big Data processing. The course starts presenting computational models for high throughput batch processing like MapReduce. Next, we will introduce software engineering techniques for distributed systems such as REST and component-based architectures. We will then cover low latency real time stream processing and complex event processing. Finally, we will present advanced topics in distributed data-intensive systems, such as geodistribution and security. The course focuses both on the fundamental concepts as well as on the concrete technologies and applications of the aforementioned techniques to real-world case studies.					
2	Learning objectives     - The students are familiar with basic concepts and technologies on     distributed systems and big data and are able to implement basic cloud     based/distributed applications					
	<ul> <li>The students are familiar with the fundamental computational models behind recent advances in distributed systems, such as models for batch processing of massive data amounts, stream processing and complex event processing.</li> <li>The students are familiar with selected advanced topics on big data, including security and geolocalization.</li> </ul>					
	- The studen concepts and	ts know about real-w 1 the technologies pr	orld case studies esented during the	that apply the e course.		
3	Recommend This course	<b>ded prerequisites fo</b> is targeted at master	<b>r participation</b> students.			
4	Form of exa Course relat • [20-00	mination ed exam: )-0951-iv] (Technical	examination, Ora	ıl/written examina	tion, Default RS)	
5	Prerequisite Pass exam (2	e for the award of c 100%)	redit points			
6	Grading Course related exam: • [20-00-0951-iv] (Technical examination, Oral/written examination, Weighting: 100 %)					
7	Usability of	the module				
8	Grade bonu	s compliant to §25	(2)			

9	References			
Co	urses			
	Course nr.	Course name		
	20-00-0951-iv	Concepts and Technologies for Distributed Systems and Big I	Data Processing	
	Instructor		Туре	SWS
	DrIng. Michael	Eichberg	Integrated course	2

Mo	dule name					
Fou	indations of L	anguage Technology	1	1		1
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle
Lar	101120e	0 CF	100 11	Module owner	1 101111	Every 2. Semester
Ger	rman			Prof. Dr. techn. J	ohannes Fürnkranz	
1       Teaching content         This lecture provides an introduction into the fundamental perspectives, problems, methods, and technique text technology and natural language processing using the example of the Python programming language         Key topics: <ul> <li>Natural language processing (NLP)</li> <li>Tokenization</li> <li>Segmentation</li> <li>Part-of-speech tagging</li> <li>Corpora</li> <li>Statistical analysis</li> <li>Machine Learning</li> <li>Categorization and classification</li> <li>Information extraction</li> <li>Introduction to Python</li> <li>Data structures</li> <li>Structured programming</li> <li>Working with files</li> <li>Usage of libraries</li> <li>NLTK library</li> </ul>					ds, and techniques of nming language.	
	The course the Natural concepts wi	is based on the Py Language Toolkit (I thout the requirement	thon programmin NLTK). NLTK allow It of extensive pro	ng language toget ws explorative and gramming knowled	her with an open-s l problem-solving lea lge.	ource library called arning of theoretical
2	Learning of After attend - define the - specify and - explicate a - transfer the - critically as	bjectives ling this course, stude fundamental termino d explain the central nd implement simple e learned techniques a ssess their merits and	ents are in a position plogy of the langua questions and cha Python programs and methods to pro limitations.	ion to age technology fiel llenges of this field s, actical application s	d, , scenarios of text unde	erstanding, as well as
3	Recommen	ded prerequisites fo	or participation			
4	Form of exa Course relat • [20-00	amination ted exam: D-0546-iv] (Technical	examination, Ora	al/written examina	tion, Default RS)	
5	<b>Prerequisit</b> Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ted exam: 0-0546-iv] (Technical	examination, Ora	al/written examina	tion, Weighting: 100	9%)

7	Usability of the	module					
	B.Sc. Informatik						
	M.Sc. Informatik						
	M.Sc. Wirtschaft	sinformatik					
	B.Sc. Psychologie	in IT					
	Joint B.A. Inform	atik					
	B.Sc. Sportwisse	nschaft und Informatik					
	M.Sc. Sportwisse	nschaft und Informatik					
	Can be used in o	her degree programs.					
8	Grade bonus co	npliant to §25 (2)					
		-					
9	References						
	Steven Bird. Ew	an Klein, Edward Loper: Natural Language Processing with	Python, O'Reilly, 2009	. ISBN:			
	978-0596516499	. http://www.nltk.org/book/	<b>j</b> , , , , , , , , , , , , , , , , , , ,				
Co	urses						
	Course nr	Course name					
	20-00-0546-iv	Foundations of Language Technology					
	20 00 00 10 10	roundations of Language reenhology	-	01410			
	Instructor		Туре	SWS			
	Prot. Dr. phil. Iry	na Gurevych	Integrated course	4			

Mo Bio	dule name						
<b>Mo</b> 10-	<b>dule nr.</b> 30-0036	<b>Credit points</b> 4 CP	Workload 120 h	Self-study 60 h	<b>Module duration</b> 1 Term	Module cycl Every 2. Sen	<b>le</b> nester
Lar Ger	<b>iguage</b> rman			Module owner		<u> </u>	
1	Teaching co	ntent					
2	Learning ob	jectives					
3	Recommended prerequisites for participation						
4	<ul> <li>Form of examination Module exam:</li> <li>Module exam (Technical examination, Oral examination, Default RS)</li> </ul>						
5	Prerequisite for the award of credit points Passing the final module examination						
6	Grading Module exan • Module	n: e exam (Technical ex	camination, Oral e	examination, Weigl	hting: 100 %)		
7	Usability of	the module					
8	Grade bonu	s compliant to §25	(2)				
9	References						
Cot	urses						
	<b>Course nr.</b> 10-01-0036-	VI Bio Informatic	s-Lecture				
	Instructor				<b>Type</b> Lecture		SWS 2
	<b>Course nr.</b> 10-01-0036-s	Se Bio Informatic	s-Exercise				
	Instructor	1			<b>Type</b> Practice		<b>SWS</b> 2

Mo Opt	<b>dule name</b> timization Alg	orithms						
<b>Mo</b> 20-	<b>dule nr.</b> 00-0667	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module d	luration	Module cyc Every 2. Se	c <b>le</b> mester
Lar Ger	<b>iguage</b> man		1	Module owner Prof. Dr. rer. nat.	Karsten W	eihe		
1	<b>Teaching co</b> Algorithmic dynamic pro	ontent standard approaches gramming, branch-a	s to complex discre ind-bound, etc.	ete optimization pr	oblems; for	r example,	evolution str	ategies,
2	<b>Learning of</b> In this cours and the abit	<b>ojectives</b> e students acquire sy iliy to tackle comple:	stematic knowledg x discrete optimiz	ge of generic algori ation problems algo	thmic appro	oaches in c y.	liscrete optin	nization
3	<b>Recommend</b> Funktionale	<b>led prerequisites fo</b> und objektorientiert	or participation e Programmierko	nzepte, Algorithme	n und Date	enstrukture	en or similar.	
4	Form of exa Course relat • [20-00	mination ed exam: )-0667-iv] (Technica	examination, Ora	al/written examina	ition, Defau	ılt RS)		
5	Prerequisite Pass exam (2	e for the award of c 100%)	redit points					
6	Grading Course relat • [20-00	ed exam: )-0667-iv] (Technical	l examination, Ora	al/written examina	ition, Weigl	nting: 100	%)	
7	<ul> <li>7 Usability of the module         B.Sc. Informatik         M.Sc. Informatik         B.Sc. Computational Engineering         M.Sc. Computational Engineering         M.Sc. Wirtschaftsinformatik         B.Sc. Psychologie in IT         Joint B.A. Informatik         B.Sc. Sportwissenschaft und Informatik         M.Sc. Sportwissenschaft und Informatik     </li> </ul>							
8	<ul> <li>8 Grade bonus compliant to §25 (2)</li> <li>In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2) der 5.</li> <li>Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung</li> <li>um bis zu 1 0 führen kann</li> </ul>							
9	<b>References</b> Will be given	n in lecture.						
Coi	urses							
	<b>Course nr.</b> 20-00-0667-	iv Optimization	Algorithms					
	Instructor Prof. Dr. rer.	nat. Karsten Weihe				<b>Type</b> Integrate	d course	SWS 4

Mod Amb	<b>lule name</b> pient Intellige	ence				
Mod	lule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
Lang Gerr	guage nan	0 Cr	100 11	Module owner Prof. Dr. Bernt Sc	hiele	Every 2. Semester
1	1 Teaching content The course will provide an overview of a new vision for Human-Computer-Interaction (HCI) in which people are surrounded by intelligent and intuitive interfaces embedded in the everyday objects around them. In specific the course addresses the emergence of Ambient Mobility and the ubiquitous, pervasive information access, retrieval and display on mobile devices. It will focus on understanding enabling technologies and studying applications and experiments, and, to lesser extent, it will adress the sociocultural impact. Additional topics of the lecture include system architectures for distributed systems, context awareness and management, user models and their implications, sensing and interaction in smart environments. The lecture discusses recent topics and research projects in the domain of Ambient Intelligence.					
2	2 Learning objectives After successfully attending the lecture, the students will be able to describe technology trends and research results in the domain of Ambient Intelligence. The most important concepts to create smart environments - intelligent networks and objects, technologies for mobile, augmented reality, ubiquitous and pervasive information spaces, nomadic communications, real-time communication and related middle ware, embedded systems, sensor networks and wearable computing - can be discussed and classified. After completing the practical part, students will be able to plan and realize the different project phases required to develop an Ambient-Intelligence solution					trends and research mart environments - pervasive information dded systems, sensor actical part, students Intelligence solution.
3	<b>Recommen</b> Master-Stud Participation	<b>ded prerequisites fo</b> ents 1 in lecture "Visual C	or participation omputing" and "M	Iultimodale Interak	tion mit intelligenter	n Umgebungen"
4	Form of exa Course relat • [20-00	amination red exam: )-0390-iv] (Technical	examination, Ora	ıl/written examina	tion, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0390-iv] (Technical	examination, Ora	al/written examina	tion, Weighting: 100	%)
7	<ul> <li>7 Usability of the module</li> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> <li>B.Sc. Computational Engineering</li> <li>M.Sc. Computational Engineering</li> <li>M.Sc. Wirtschaftsinformatik</li> <li>B.Sc. Psychologie in IT</li> <li>Joint B.A. Informatik</li> <li>B.Sc. Sportwissenschaft und Informatik</li> <li>M.Sc. Sportwissenschaft und Informatik</li> </ul>					
8	Can be used Grade bonu	in other degree prog is compliant to §25	grams. (2)			

	In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.					
9	<b>References</b> Will be given according to actual topics.					
Co	urses					
	<b>Course nr.</b> 20-00-0390-iv	Course name Ambient Intelligence				
	Instructor Type SWS Integrated course 4					

Mo Aut	<b>dule name</b> comata, Forma	l Languages and De	cidability			
<b>Mo</b> 04-	<b>dule nr.</b> 10-0120/de	<b>Credit points</b>	Workload	Self-study 105 h	Module duration	Module cycle
Lar Gei	nguage rman	0.01	100 11	Module owner Prof. Dr. rer. nat.	Martin Otto	livery 2. bennebter
1	Teaching co introduction automata an tions, Kleene grammars au models of co hierarchy	ntent : transition systems d regular languages : Theorem, Myhill-Ne nd the Chomsky hier omputation: PDA and	, words, languag determinism and erode Theorem, p rachy, context-free d Turing machine	es; basic mathema nondeterminism, o umping lemma; e languages, pump s; decidability and	tical methods and p closure properties and ing lemma, CYK algo recursive enumerab	proof patterns; finite d automata construc- prithm; ility in the Chomsky
2	<ul> <li>2 Learning objectives         Schöning: Theoretische Informatik – kurz gefasst             \newline             Hopcroft, Motwani, Ullman: Einführung in die Automatentheorie, formale Sprachen und Komplexitätstheorie             \newline             Wegener: Theoretische Informatik – eine algorithmenorientierte Einführung             \newline             Skript (elektronisch unter www.mathematik.tu-darmstadt.de/~otto)     </li> </ul>					
3	Recomment none	led prerequisites fo	or participation			
4	Form of exa Module exar • Module • Module Fachprüfung number of po decision abo during the fi Studienleist the homewo communicat	mination n: e exam (Study achie e exam (Technical ex g: Usually the exam i otential participants. ut the form of the ex rst two weeks of the ung: Usually this rk assignments. The ed by the instructor	vement, Oral/writ camination, Oral/ s taken in form of In this case, the e cam is taken and c lecture, based on means that the precise proportio during the first lec	tten examination, p written examinatio a written test (90 xam can be taken i communicated the prospective nu student successfu n of necessary assig	o/np RS) n, Default RS) min), except when th n the form of an oral mber of students tak lly completes a ce gnments and the man	here are only a small exam (30 min). The ing the exam. rtain proportion of rking scheme will be
5	<b>Prerequisite</b> Passing the f	e for the award of c	redit points ation			
6	<ul> <li>6 Grading Module exam:</li> <li>Module exam (Study achievement, Oral/written examination, Weighting: 0 %)</li> <li>Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>					)
7	Usability of	the module				
8	Grade bonu	s compliant to §25	(2)			
9	References					
Co	urses					

<b>Course nr.</b> 04-00-0091-vu	<b>Course name</b> Automata, Formal Languages and Decidability		
<b>Instructor</b> Prof. Dr. rer. nat.	Martin Otto	<b>Type</b> Lecture and practice	SWS 3

Mo Pro	Module name Propositional Logic and Predicate Logic						
<b>Mo</b>	<b>dule nr.</b> 10-0121/de	Credit points	Workload	Self-study	Module duration	Module cycle	
Lar	iguage	5.01	130 11	Module owner		Livery 2. Demester	
Ger	man Teaching co	ontent		Prof. Dr. rer. nat.	Martin Otto		
	Freaching content syntax and semantics of propositional logic, functional completeness and normal forms, compactness, complete proof calculi: resolution and a sequent calculus; \newline syntax and semantics of first-order logic, structures and assignments, normal forms, Skolemization, Herbrand theorem, compactness, complete proof calculi: (ground) resolution and a sequent calculus, Gödel's Completeness Theorem; undecidability of first-order logic; \newline optional: digressions on expressiveness and model checking						
2	Learning of	ojectives					
3	Recommend	ded prerequisites fo	or participation				
4	Form of exa Module exar Module exar Modul Solution Fachprüfung number of p decision abo during the fi Studienleist the homewo communicat	mination n: e exam (Study achie e exam (Technical ex g: Usually the exam i otential participants. out the form of the ex rst two weeks of the ung: Usually this ork assignments. The ed by the instructor	vement, Oral/writ camination, Oral/ s taken in form of In this case, the e cam is taken and c lecture, based on means that the precise proportio during the first lec	tten examination, p written examinatio a written test (90 xam can be taken i communicated the prospective nu student successfu n of necessary assig	o/np RS) n, Default RS) min), except when tl n the form of an oral mber of students tak illy completes a ce gnments and the man	here are only a small exam (30 min). The ing the exam. rtain proportion of rking scheme will be	
5	Prerequisite Passing the f	e <b>for the award of c</b> final module examination	redit points ation				
6	<ul> <li>Grading Module exam:</li> <li>Module exam (Study achievement, Oral/written examination, Weighting: 0 %)</li> <li>Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>						
7	Usability of	the module					
8	Grade bonu	s compliant to §25	(2)				
9	References						

	Burris: Logic for \newline Schöning: Logik \newline Boolos, Burgess, \newline Skript (2 Teile, el	Mathematics and Computer Science für Informatiker Jeffrey: Computability and Logic lektronisch unter www.mathematik.tu-darmstadt.de/~otto)
Co	ırses	
	<b>Course nr.</b> 04-00-0090-vu	<b>Course name</b> Propositional Logic and Predicate Logic

	1	0				
Instructor			Туре		SWS	
Prof. Dr. rer. nat.	Martin Otto		Lecture and	practice	3	

Mo Dee	<b>dule name</b>	Architectures & Meth	ods			
<b>Mo</b>	<b>dule nr.</b> 00-1034	Credit points	Workload	Self-study	Module duration	Module cycle
Lar Eng	<b>iguage</b> glish	0.01	100 11	Module owner Prof. Dr. techn. Je	ohannes Fürnkranz	livery 2. bennester
1	<ul> <li>Teaching content <ul> <li>Review of machine learning background</li> <li>Deep Feedforward Networks</li> <li>Regularization for Deep Learning</li> <li>Optimization for Training Deep Models</li> <li>Convolutional Networks</li> <li>Sequence Modeling: Recurrent and Recursive Nets</li> <li>Linear Factor Models</li> <li>Autoencoders</li> <li>Representation Learning</li> <li>Structured Probabilistic Models for Deep Learning</li> <li>Monte Carlo Methods</li> <li>Approximate Inference</li> <li>Deep Generative Models</li> <li>Deep Learning in Vision</li> <li>Deep Learning in NLP</li> </ul> </li> </ul>					
2	Learning of This course independent or Master's t deep learnin	<b>ojectives</b> provides students wi ly carry out research thesis. In particular, ng algorithms and the	th the required ac projects on the ho this class aims at e architecture of d	lvanced backgroun ot topic of deep lear providing the stud- eep networks.	d on machine learni ning, e.g. within the ents with fundament	ng the knowledge to scope of a Bachelor's tal understanding of
3	Recommend 20-00-0358- 20-00-0052-	<b>ded prerequisites fo</b> iv Statistical Machin iv Data Mining and 1	<b>or participation</b> e Learning Machine Learning			
4	Form of exa Course relat • [20-00	mination red exam: )-1034-iv] (Technical	examination, Ora	al/written examina	tion, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	<ul> <li>Grading Course related exam:</li> <li>[20-00-1034-iv] (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>					%)
7	Usability of B.Sc. Inform M.Sc. Inform May be used	<b>the module</b> natik natik l in other degree pro	grams.			
8	Grade bonu In dieser Vo Novelle der A um bis zu 1.	<b>Is compliant to §25</b> rlesung findet eine A APB und den vom FB 2 .0 führen kann.	(2) nrechnung von vo 20 am 30.3.2017 b	orlesungsbegleitenc eschlossenen Anrec	len Leistungen statt, hnungsregeln zu eine	die lt. 25 (2) der 5. er Notenverbesserung

9	References					
Co	Courses					
	<b>Course nr.</b> 20-00-1034-iv	<b>Course name</b> Deep Learning: Architectures & Methods				
	Instructor Prof. Dr. techn. J	ohannes Fürnkranz	<b>Type</b> Integrated course	SWS 4		

Mo Rei	<b>dule name</b> nforcement L	earning: From Found	ations to Deep Ap	proaches		
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle
Lar Ger	nguage man/English	0.01	100 11	Module owner Prof. Dr. rer. nat.	Oskar von Stryk	Every 2. Semester
1	<ul> <li>Teaching content <ul> <li>Review of machine learning background</li> <li>Black box Reinforcement Learning</li> <li>Modeling as bandit, Markov Decision Processes and Partially Observable Markov Decision Processes</li> <li>Optimal control</li> <li>System identification</li> <li>Learning value functions</li> <li>Policy search</li> <li>Deep value functions methods</li> <li>Deep policy search methods</li> <li>Exploration vs exploitation</li> <li>Hierarchical reinforcement learning</li> <li>Intrinsic motivation</li> </ul> </li> </ul>					
2	Learning ol This course independen of a Bachelo understandi	<b>ojectives</b> provides students v tly carry out researc or's or Master's thesi ng of reinforcement	vith the required h projects on the s. In particular, t learning algorithm	basic background hot topic of reinfo his class aims at p hs and the applicat	on machine learnin prcement learning, e. roviding the student ion within deep learr	g the knowledge to .g. within the scope is with fundamental hing.
3	<b>Recommen</b> Good progra Lecture Stat	<b>ded prerequisites fo</b> amming in Python. istical Machine Learn	<b>r participation</b> ning is helpful but	not mandatory.		
4	Form of exa Course relat • [20-00	<b>mination</b> ed exam: )-1047-iv] (Technical	examination, Ora	ıl/written examina	tion, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-1047-iv] (Technical	examination, Ora	ıl/written examina	tion, Weighting: 100	%)
7	<ul> <li>7 Usability of the module</li> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> <li>May be used in other degree programs.</li> </ul>					
8	Grade bonu	is compliant to §25	(2)			
9	References					
Cot	ırses					

<b>Course nr.</b> 20-00-1047-iv	<b>Course name</b> Reinforcement Learning: From Foundations to Deep Approac	ches	
<b>Instructor</b> Prof. Dr. rer. nat.	Oskar von Stryk	<b>Type</b> Integrated course	SWS 4

Mo Tex	<b>dule name</b> tt Analytics							
<b>Mo</b> 20-	<b>dule nr.</b> 00-0596	Credit points	Workload 2P 90 h	Self-study 60 h	Module d	uration	Module cyc Every 2. Se	c <b>le</b> mester
Lar Ger	nguage man/English			Module owner Prof. Dr. phil. Iry	na Gurevyc	h		
1	<b>Teaching co</b> The seminar state-of-the- Further info	ontent introduces curren art technology in rmation: https://v	ıt topics in natural l text analytics. The r www.ukp.tu-darmst	anguage processing nain focus of the se adt.de/teaching/co	g. It provide minar chan urses/regul	s a thorou ges each s ar-semina	igh introducti semester. ur/	ion into
2	<ul> <li>2 Learning objectives         After attending this course, students are in a position to         - name and explain state-of-the-art research questions in the area of the seminar,         - understand, critically assess, and discuss scientific publications,         - independently comprehend and work out a research topic and         - present it to the group and react on questions and discussion threads.     </li> </ul>							
3	Recomment	aed prerequisites	; for participation					
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>• [20-00-0596-se] (Study achievement, Oral/written examination, Default RS)</li> </ul>							
5	<b>Prerequisit</b> Pass exam (	e for the award o 100%)	f credit points					
6	Grading Course relat • [20-00	ed exam: )-0596-se] (Study	achievement, Oral/	written examinatio	n, Weightin	g: 100 %)	)	
7	<ul> <li><sup>7</sup> Usability of the module         B.Sc. Informatik         M.Sc. Informatik          </li> <li>M.Sc. Wirtschaftsinformatik         B.Sc. Psychologie in IT          </li> <li>Joint B.A. Informatik         </li> <li>B.Sc. Sportwissenschaft und Informatik         </li> <li>M.Sc. Sportwissenschaft und Informatik         </li> </ul>							
8	Grade bonu	is compliant to §	25 (2)					
9	<ul> <li>References</li> <li>Will be given in seminar</li> </ul>							
Co	urses							
	<b>Course nr.</b> 20-00-0596-	se Text Analyt	ne ics					
	<b>Instructor</b> Prof. Dr. phi	l. Irvna Gurevvch				<b>Type</b> Seminar		SWS 2

Mo Ext	<b>dule name</b> ended Semin	ar - Systems and Mac	chine Learning			
<b>Mo</b> 20-	<b>dule nr.</b> 00-1057	Credit points 4 CP	Workload 120 h	Self-study 75 h	Module duration	Module cycle Every 2. Semester
Lar Eng	<b>iguage</b> glish		120 11	Module owner Prof. Dr. techn. Jo	ohannes Fürnkranz	
1	<ul> <li>Teaching content         This seminar serves the purpose of discussing new research papers in the intersection of hardware/software-systems and machine learning. The seminar aims to elicit new connections amongst these fields and discusses important topics regarding systems questions machine learning including topics such as hardware accelerators for ML, distributed scalable ML systems, novel programming paradigms for ML, Automated ML approaches, as well as using ML for systems.     </li> <li>Every participant will present one research paper, which will be subsequently discussed by all participants. In addition, summary papers will be written in groups and submitted to a peer review process. The papers will typically be recent publications in relevant research venues and journals.</li> <li>The seminar will be offered as a block seminar. Further information can be found at: http://binnig.name</li> </ul>					
2	<ul> <li>2 Learning objectives         After this seminar, the students should be able to             - understand a new research contribution in the areas of the seminar             - prepare a written report and present the results of such a paper in front of an audience             - participate in a discussion in the areas of the seminar         </li> </ul>					,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
3	<b>Recommen</b> Basic knowl	<b>ded prerequisites fo</b> edge in Machine Lea	or participation rning, Data Manag	gement, and Hardv	vare-/Software-Syste	ems.
4	Form of exa Course relat • [20-00	amination ted exam: D-1057-se] (Study acl	hievement, Oral/v	vritten examination	n, Default RS)	
5	Prerequisit Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ted exam: D-1057-se] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %)	)
7	<ul> <li>7 Usability of the module</li> <li>B. Sc Informatik</li> <li>M.Sc. Informatik</li> <li>May be used in other degree programs.</li> </ul>					
8	Grade bonu	is compliant to §25	(2)			
9	References					
Cot	urses					

<b>Course nr.</b> 20-00-1057-se	<b>Course name</b> Extended Seminar - Systems and Machine Learning		
Instructor Prof. Dr. techn. J	ohannes Fürnkranz	<b>Type</b> Seminar	<b>SWS</b> 3

Mo Alg	<b>dule name</b> orithmic mod	leling for creating sch	nedules			
<b>Mo</b>	<b>dule nr.</b> 00-0391	Credit points	Workload 90 h	Self-study 60 h	<b>Module duration</b>	Module cycle Every 2. Semester
Lar Ger	nguage rman			Module owner Prof. DrIng. Hei	ko Mantel	
1	<b>Teaching co</b> - Modeling of - Respecting - robustness - timetable i	ontent of periodic schedules infrastructural const of schedules nformation systems	especially for rail rains in schedule	ways creation		
2	2 Learning objectives After successfully attending the course, students have gained skills in algorithmic modelling in the field of railway optimization					
3	B         Recommended prerequisites for participation           Algorithms and data structure         Algorithms and data structure					
4	<ul> <li>Form of examination Course related exam:         <ul> <li>[20-00-0391-se] (Study achievement, Oral/written examination, Default RS)</li> </ul> </li> </ul>					
5	<b>Prerequisit</b> Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ted exam: D-0391-se] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %)	)
7	Usability of B.Sc. Inform M.Sc. Inform B.Sc. Comp M.Sc. Comp M.Sc. Wirts B.Sc. Psycho Joint B.A. In B.Sc. Sports M.Sc. Sports	f <b>the module</b> natik natik utational Engineering outational Engineerin chaftsinformatik ologie in IT nformatik wissenschaft und Info wissenschaft und Info	g g prmatik ormatik			
	Can be used	l in other degree prog	grams.			
8	Grade bonu	is compliant to §25	(2)			
9	<b>References</b> Will be give	n in seminar.				
Cot	urses					

<b>Course nr.</b> 20-00-0391-se	<b>Course name</b> Algorithmic modelling for creating schedules		
Instructor		<b>Type</b> Seminar	SWS 2

Mo Ma	<b>dule name</b> chine Learnin	g and Deep Learning	g for Automation S	Systems		
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
18- Lar	ad-2100	3 CP	90 h	60 h Module owner	1 Term	Summer term
Ger	man			Prof. DrIng. Jürg	gen Adamy	
1	Teaching co	ontent				
	<ul> <li>Concepts of machine learning</li> <li>Linear methods</li> <li>Support vector machines</li> <li>Trees and ensembles</li> <li>Training and assessment</li> <li>Unsupervised learning</li> <li>Neural networks and deep learning</li> <li>Convolutional neuronal networks (CNNs)</li> <li>CNN applications</li> <li>Recurrent neural networks (RNNs)</li> </ul>					
2	2 Learning objectives Upon completion of the module, students will have a broad and practical view on the field of machine learning. First, the most relevant algorithm classes of supervised and unsupervised learning are discussed. After that, the course addresses deep neural networks, which enable many of today's applications in image and signal processing. The fundamental characteristics of all algorithms are compiled and demonstrated by programming examples. Students will be able to assess the methods and apply them to practical tasks.					of machine learning. liscussed. After that, in image and signal ted by programming
3	Recomment Fundamenta Preferred: L	<b>ded prerequisites fo</b> al knowledge in linea ecture "Fuzzy logic, :	or participation or algebra and stat neural networks a	istics nd evolutionary alរ្	gorithms"	
4	Form of exa Module exam • Modul The examina 7 students r will be anno	amination m: e exam (Technical ex ation takes place in fo egister, the examinat ounced in the beginni	kamination, Oral/ orm of a written ex ion will be an ora ing of the lecture.	written examinatio am (duration: 90 n l examination (dur	n, Duration: 90 Min. ninutes). If one can es ation: 30 min.). The	, Default RS) stimate that less than type of examination
5	Prerequisite Passing the	e for the award of c final module examination	<b>redit points</b> ation			
6	Grading Module exan • Modul	m: e exam (Technical ez	kamination, Oral/ <sup>,</sup>	written examinatio	n, Weighting: 100 %	)
7	Usability of	the module				
8	Grade bonu	is compliant to §25	(2)			
9	References					

- T. Hastie et al.: The Elements of Statistical Learning. 2. Aufl., Springer, 2008
- I. Goodfellow et al.: Deep Learning. MIT Press, 2016
- A. Géron: Hands-On Machine Learning with Scikit-Learn, Keras and TensorFlow. 2. Aufl., O'Reilly, 2019

## Courses

<b>Course nr.</b> 18-ad-2100-vl	<b>Course name</b> Machine Learning and Deep Learning for Automation System	15	
Instructor DrIng. Michael	Vogt	<b>Type</b> Lecture	<b>SWS</b> 2

Mo	dule name	Models						
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module of	luration	Module cyc	cle mester
Lar	nguage		100 11	Module owner Prof. DrIng. Mic	chael Gösel	e		
1	<b>Teaching co</b> Generative M Adversarial 1	<b>ntent</b> Models, Implicit and networks, Numerical	Explicit Models, I Optimization for	Maximum Likelihoo Generative models	od, Variatio	onal AutoF ons in med	ncoders, Ger lical Imaging	ierative
2	<ul> <li>Learning objectives         After students have attended the module, they can         Explain the structure and operation of Deep Generative Models (DGM)         Critically scrutinize scientific publications on the topic of DGMs and thus assess them professionally         independently construct / implement basic DTMs in a high-level programming language designed for this purpose         Transfer the implementation and application of DTMs to different applications     </li> </ul>							
3	<ul> <li>Recommended prerequisites for participation</li> <li>Python Programming</li> <li>Linear Algebra</li> <li>Image Processing/Computer Vision I</li> <li>Statistical Machine Learning</li> </ul>							
4	Form of exa Course relat • [20-00	m <b>ination</b> ed exam: )-1035-iv] (Technica	l examination, Ora	al/written examina	ition, Defau	ılt RS)		
5	Prerequisite Pass exam (2	e for the award of c 100%)	redit points					
6	Grading Course relat • [20-00	ed exam: )-1035-iv] (Technica	l examination, Ora	al/written examina	ition, Weigl	nting: 100	%)	
7	Usability of B,Sc, Inform M.Sc. Inform May be used	<b>the module</b> atik natik l in other degree pro	grams.					
8	<ul> <li>8 Grade bonus compliant to §25 (2)         In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2) der 5.         Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.     </li> </ul>							
9	<b>9 References</b> No textbooks as such. Online materials will be made available during the course.							
Cot	ırses							
	<b>Course nr.</b> 20-00-1035-	iv Deep Generat	ive Models					
	Instructor Prof. DrIng	. Michael Gösele				<b>Type</b> Integrate	d course	SWS 4

<b>Mo</b> Fur	<b>dule name</b> adamentals of	Reinforcement Learn	ning			
<b>Mo</b> 18-	<b>dule nr.</b> kl-2070	<b>Credit points</b> 4 CP	Workload 120 h	Self-study 75 h	Module duration 1 Term	Module cycle Summer term
Lar Eng	<b>iguage</b> glish			<b>Module owner</b> Prof. DrIng. Anj	a Klein	I
1	<ul> <li>Teaching content</li> <li>Review of Probability Theory</li> <li>Markov Property and Markov Decision Processes</li> <li>The Multi-Armed Bandit Problem vs. the Full Reinforcement Learning Problem</li> <li>Taxonomy of Multi-Armed Bandit Problems (e.g., Stochastic vs. Adversarial Rewards, Contextual MAB)</li> <li>Algorithms for Multi-Armed Bandit Problems (e.g., Upper Confidence Interval (UCB), Epsilon-Greedy, SoftMax, LinUCB) and their Application to Cyber-Physical Networking</li> <li>Fundamentals of Dynamic Programming and Bellman Equations</li> <li>Taxonomy of Approaches for the Full Reinforcement Learning Problem (e.g., Temporal-Difference Learning, Policy Gradient and Actor-Critic)</li> <li>Algorithms for the Full Reinforcement Learning Problem (e.g., Q-Learning, SARSA, Policy Gradient, Actor-Critic) and their Application to Cyber-Physical Networking</li> <li>Linear Function Approximation</li> <li>Non-linear Function Approximation</li> </ul>					
2	Learning of The student • define be able • detern teristic • detern makin • differe • choose • formu • detern • detern	<b>ojectives</b> s are able to the Markov property e to use these concep- nine the characteristic s of the Full Reinforce nine under which con- g problems. ntiate the main MAB e appropriate MAB st late and solve Contex- nine under which con- n the difference betw- ntiate between Temp fy the limitations of M n the need for general e appropriate approxinal gorithmic technique the reasonableness an	and identify the e ots to model decisi cs of the Multi-Arr cement Learning ( nditions the MAB strategies, e.g., Up rategies for the so ctual-MAB probler iditions Dynamic Fo ocral-Difference, F MAB and full RL p alization in MAB a mation techniques es to solve MAB a nd consistency of	elements that consti on-making problem ned Bandit (MAB) I (RL) Problem. or the full RL form oper Confidence Int lution of MAB prob ns. Programming can b gramming and RL i Policy Gradient and roblems. and full RL problem and use them in con nd full RL problem the obtained soluti	tute a Markov decisions in Cyber-Physical Problem and compare sulation should be use erval (UCB), Epsilon- olems. e used to solve decisist methods. Actor-Critic RL tech as. nbination with MAB as s and obtain valid so ons.	on process. They will Networking. e them to the charac- eed to solve decision- Greedy and Softmax. on-making problems. niques. and full RL strategies. lutions.
3	Recomment	<b>ded prerequisites fo</b> 1 or Matlab: basic kno	or participation			
4	• Engine	eering mathematics a	nd probability the	eory		
4	Form of exa	imination				

	<ul> <li>Module exam:</li> <li>Module exam (Technical examination, Oral/written examination, Duration: 60 Min., Default RS)</li> <li>The examination takes place in form of a written exam (duration: 60 minutes). If one can estimate that less than 21 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture.</li> </ul>					
5	Prerequisite for the award of credit points Passing the final module examination					
6	<ul><li>Grading</li><li>Module exam:</li><li>Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</li></ul>					
7	Usability of the module					
8	Grade bonus compliant to §25 (2)					
9	References					
	<ul> <li>Richard S. Sutton and Andrew G. Barto, "Reinforcement Learning: An Introduction", A Bradford Book, Cambridge, MA, USA, 2018.</li> <li>Aleksandrs Slivkins, "Introduction to Multi-Armed Bandits", Foundations and Trends in Machine Learning, Vol. 12: No. 1-2, 2019.</li> </ul>					
Courses						
	Course nr.Course name18-kl-2070-vlFundamentals of Reinforcement Learning					
	Instructor DrIng. Andrea Jimenez, Dr. rer. nat. Sabrina Klos		<b>Type</b> Lecture	SWS 2		
	Course nr.Course name18-kl-2070-ueFundamentals of Reinforcement Learning					
	Instructor Dr. rer. nat. Sabrina Klos		<b>Type</b> Practice	<b>SWS</b> 1		
Mo	dule name					
-----	----------------------------------------------	----------------------------------------------------	-------------------------------------------	---------------------------------------------	-----------------------------------------------	------------------------------------------------
Int	Introduction to Artificial Intelligence					
Mo	dule nr. $1058$	Credit points	Workload	Self-study	Module duration	Module cycle
20-	00-1056	5 GP	150 11	Module owner	1 Ieiiii	Every 2. Semester
Gei	rman			Prof. Dr. techn. J	ohannes Fürnkranz	
1	Teaching co	ontent				
	Artificial Inte	elligence (AI) is conce itelligence. While rese	erned with algorith earch in the early	ms for solving prob days was oriented of	lems, whose solution on results about hums	is generally assumed an thinking, the field
	lecture we v	vill give a brief surve	y over key topics	of this core discipli	ne of computer scien	in the course of this ice, with a particular
	focus on the	topics search, planni	ing, learning, and	reasoning. Historic	al and philosophical	foundations will also
	be considere	ed. ations				
	<ul> <li>Introd</li> </ul>	uction, History of AI	(RN chapter 1)			
	Intellig	gent Agents (RN chaj	pter 2)			
	<ul> <li>Search</li> <li>Uninfo</li> </ul>	ormed Search (RN ch	apters 3.1 - 3.4)			
	• Heuris	stic Search (RN chapt	ters 3.5, 3.6)			
	Local      Constr	Search (RN chapter 4	1) blems (RN chapte	r 6)		
	Games	s: Adversarial Search	(RN chapter 5)	[ 0)		
	• Planni	ng	-			
	<ul> <li>Planni</li> <li>Planni</li> </ul>	ng in State Space (R	N chapter 10) J chapter 11)			
	Decisio	ons under Uncertaint	y			
	• Uncert	tainty and Probabiliti	ies (RN chapter 13	3)		
	<ul> <li>Bayesi</li> <li>Decision</li> </ul>	an Networks (RN chapter) on Making (RN chapter)	apter 14) ter 16)			
	• Machi	ne Learning				
	Neura	l Networks (RN chap	ters 18.1,18.2,18.	7)		
	Reinio     Philose	ophical Foundations	in chapter 21)			
2	Learning of	bjectives				
	After a succe	esstul completion of f	tnis module, stude ndemental technic	ents are in a positio	n to elligence	
	<ul> <li>partici</li> </ul>	pate in a discussion a	about the possibili	ty of an artificial ir	ntelligence with well-	founded arguments
	• critica	lly judge new develo	pments in this are	a		
3	Recommen	ded prerequisites fo	or participation			
4	Form of exa	amination				
	Course relat	ed exam:	avamination Or	1/writton	tion Default DC)	
	Written Exa	m (90 min.)	examination, Ora	u/ written examina	uoli, Delault KS)	
5	Prerequisit	e for the award of c	redit points			
	Pass exam (	100%)				
6	Grading					

	Course related e • [20-00-105	ourse related exam: • [20-00-1058-iv] (Technical examination, Oral/written examination, Weighting: 100 %)					
7	Usability of the	module					
	B.Sc. Informatik						
	M.Sc. Informatil	ζ.					
	M.Sc. Autonome	Systeme und Robotik					
	M.Sc. Artificial I	ntelligence and Machine Learning					
	May be used in o	other degree programs.					
8	Grade bonus co	mpliant to §25 (2)					
9	References						
Co	urses						
	Course nr.	Course name					
	20-00-1058-iv Introduction to Artificial Intelligence						
	Instructor	Instructor Type SWS					
	Prof. Dr. techn.	Johannes Fürnkranz	Integrated course	3			

Mo	dule name	Juantum Computing				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
20-	00-1136	6 CP	180 h	120 h	1 Term	Every 2. Semester
Lar Eng	<b>iguage</b> glish			Module owner Prof. DrIng. Ern	nira Mezini	
1	1       Teaching content         General introduction and motivation         Introduction to Quantum mechanics (states, measurements, evolution, a short review of linear algebra )         Elementary quantum gates and circuit model         Universal quantum computation         Quantum parallelism and Deutsch-Jozsa Algorithm         Simon's Algorithm         The Fourier Transform         Shor's Factoring Algorithm         Hidden Subgroup Problem         Grover's Search Algorithm         Quantum Error-Correction and Fault-Tolerance         Entanglement and Nonlocality         A basic introduction to quantum key distribution         Overview of quantum computing platforms and claims of quantum advantage					
2	Learning of After compl information language Q connect the most recent interests in	bjectives leting the module, s processing and com iskit. They will learr m to computational developments in indu the field	tudents will be fa puting and will h the most import and cryptographi ustry and academi	amiliar with all of be able to program ant 'peculiarities' c c tasks. Finally, at a will be provided,	f the fundamental control of the fundamental control of the quantum work the end of the lectur allowing students to	oncepts of quantum antum programming d and will be able to re, a summary of the navigate their future
3	<b>Recommen</b> Basic knowl mended.	<b>ded prerequisites fo</b> edge of elementary l	or participation inear algebra (ma	trix multiplication	, determination of ei	genvalues) is recom-
4	Form of exa Course relat • [20-00 The form of two of the for Written exa	amination ted exam: D-1136-iv] (Technica the examination wil ollowing forms is pos (duration 60 or	l examination, Ora l be announced at sible. 90 or 120 minut	al/written examina the beginning of t tes), oral exam (c	ntion, Default RS) the course. One or a duration 15 or 30 n	combination of max. ninutes), homework
5	(optional: in Prerequisit	e for the award of c	redit points			
6	<ul> <li>Pass exam (100%)</li> <li>6 Grading Course related exam: <ul> <li>[20-00-1136-iv] (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul> </li> </ul>					
7	Usability of the module         B.Sc. Informatik         M.Sc. Informatik         May be used in other degree programs.					
8	Grade bonu	is compliant to §25	(2)			

9	References			
Co	urses			
	<b>Course nr.</b> 20-00-1136-iv	<b>Course name</b> Introduction to Quantum Computing		
	<b>Instructor</b> Prof. DrIng. Err	nira Mezini	<b>Type</b> Integrated course	SWS 4

## 2.3 Optional Subjects AIS-IE: Information Processing in Electrical Power Engineering

<b>Mo</b> Ele	<b>dule name</b> ctrical Power I	Engineering				
Мо	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
18-	bi-1010	6 CP	180 h	120 h	1 Term	Summer term
Lar Ger	n <b>guage</b> man			Module owner Prof. DrIng. Yve	s Burkhardt	
1	German       Prof. DrIng. Yves Burkhardt         1       Teaching content         The lecture gives an introduction to the technical processes for the use of energy for the human civilization in general and to the basic tasks and challenges of the electrical energy in particular. Biochemical energy processes such as the human metabolism are therefore not subject of the course.         First, the physical basics of the term "energy" are repeated and the different forms of energy (mechanical, thermal, electromagnetic, chemical and nuclear) are explained in terms of the technical use of energy as heat, mechanical movement and electricity.         Then, an overview of the energy resources is given, starting from the solar radiation and its direct and indirect impact, such as the solar heat and the motion of air mass, surface water and sea waves. Next, the energy source of biomass due to solar radiation and the fossil energy sources oil, natural gas and coal will be discussed. The energy sources of nuclear fission (uranium deposits) and nuclear fusion (heavy water), and geothermal energy due to nuclear effects in the Earth's interior are explained as well as the tidal effects caused by planetary motion. The increasing energy demand of the rapidly growing world population and the geographic distribution of energy sources (deposits, acreage, solar radiation, wind maps, tidal currents,) are briefly presented. In another section, energy conversion processes in power plants are discussed mainly, but also marginal processes such as thermal cycles or hydraulic processes in power plants are discussed mainly, but also marginal processes such as therminoin converters are addressed. Afterwards, a specialization takes place on the subject of electric generator to the consumer with an overview of the required resources, the hiring electrical load flow and its stability is					
2	<ul> <li>Learning objectives         Students know the physically based energy basics and have an overview of the energy resources of our planet Earth.         They understand the fundamental energy conversion processes on the technical use of energy in the form of heat as well as mechanical and electrical work.         They have acquired basic knowledge of electrical engineering in the chain of effects from electric power producer to the consumer and are able to educate themselves about current issues of energy use and its future development. They are able to perform basic calculations for energy content, energy conversion, efficiencies, storage, and for conversion and transportation losses. They are prepared for advanced lectures on energy components and systems, energy industry and on future forms of energy supply.     </li> </ul>					
3	<ul> <li>Recommended prerequisites for participation</li> <li>Basic knowledge of physics (mechanics, thermodynamics, electrical engineering, structure of matter) and chemistry (binding energy) are desirable and facilitate understanding of the energetic processes.</li> </ul>					
4	Form of exa Module exar • Module	<b>mination</b> n: e exam (Technical ex	amination, Exam	ination, Duration:	120 Min., Default RS	3)

5	Prerequisite for the award of credit points Passing the final module examination					
6	Grading Module exam: • Module exa	Grading Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)				
7	<b>Usability of the</b> BSc ETiT, BSc W	<b>module</b> -ETiT, BSc MEC, BSc iST, BSc CE, MSc ESE				
8	<b>Grade bonus co</b> At the beginning lecture that will	<b>npliant to §25 (2)</b> of the semester, it will be announced whether there will be how enable an improvement in grades.	nework tests accompany	ving the		
9	References Lecture notes (sl Practice documes Additional and m • Grothe/Fel ders: Kapit • Sterner/Sta • Rummich: • Strauß: Kr Berlin, 200 • Hau: Wind 5. Aufl. • Heuck/Det • Quaschning	des) hts (examples, solutions) ore detailed literature: lhusen: Dubbel-Taschenbuch für den Maschinenbau, Springer el "Energietechnik und Wirtschaft" idler: Energiespeicher - Bedarf, Technologien, Integration, Spr Energiespeicher, expert-verlag, Renningen, 2015, 2. Aufl. aftwerkstechnik zur Nutzung fossiler, nuklearer und regenera 6, 5. Aufl. kraftanlagen -Grundlagen, Technik, Einsatz, Wirtschaftlichkeit mann/Schulz: Elektrische Energieversorgung, Springer-Viewer g: Regenerative Energiesystem, Hanser, München, 2001, 7. Au	; Berlin, 2007, 22. Aufl.; inger-Vieweg, Berlin, 20 ativer Energiequellen, Sj , Springer-Vieweg, Berlir eg, Berlin, 2014, 9. Aufl. fl.	; beson- 11 pringer, 1, 2014,		
Cot	ırses					
	<b>Course nr.</b> 18-bi-1010-vl	<b>Course name</b> Electrical Power Engineering				
	InstructorTypeSWSProf. DrIng. Yves Burkhardt2					
	<b>Course nr.</b> 18-bi-1010-ue	Course name Electrical Power Engineering				
	Instructor Prof. DrIng. Yve	s Burkhardt	<b>Type</b> Practice	SWS 1		

Mo Pov	<b>dule name</b> ver Systems I							
<b>Mo</b> 18-	<b>dule nr.</b> hs-1010	Credit points 5 CP	Workload 150 h	Self-study 90 h	<b>Module d</b> 1 Term	uration	Module cyc Winter tern	cle n
Lar Ger	nguage man			Module owner Prof. DrIng. Jut	ta Hanson		1	
1	<b>Teaching co</b> Three-phase circuit curre	ontent e network and symm nts; switch equipme	etrical component nt; switchgears	ts; overhead lines;	cables; tran	sformers;	calculation o	of short-
2	<ul> <li>Learning objectives</li> <li>Upon completion of the module, students will have learned: <ul> <li>Presentation of components of power system</li> <li>Functional elaboration of equipment</li> <li>Calculation of the component rating</li> <li>Impact on the electrical power system</li> </ul> </li> </ul>							
3	Recomment comparable	ded prerequisites for competences to the	or participation module "Power En	gineering"				
4	Form of exa Module exa • Modul	mination n: e exam (Technical ex	xamination, Exam	ination, Duration:	90 Min., De	efault RS)		
5	<b>Prerequisite</b> Passing the	e <b>for the award of c</b> final module examination	<b>redit points</b> ation					
6	Grading Module exan • Modul	m: e exam (Technical e:	xamination, Exam	ination, Weighting	: 100 %)			
7	Usability of BSc ETiT, BS	the module Sc/MSc WI-ET, BSc E	EPE, BSc/MSc CE,	BSc/MSc iST, MSc	: Informatik			
8	Grade bonu	s compliant to §25	(2)					
9	<b>References</b> Script, lectu	re slides, guiding qu	estions, excercises					
Co	urses							
	<b>Course nr.</b> 18-hs-1010-	vl Course name Power Systems	s I					
	Instructor M.Sc. Felix I	Korff, Prof. DrIng. J	utta Hanson, M.S	c. Manuel Schwenl	ĸe	<b>Type</b> Lecture		SWS 2
	<b>Course nr.</b> 18-hs-1010-	ue Power Systems	s I					
	Instructor Prof. DrIng	. Jutta Hanson				<b>Type</b> Practice		SWS 2

<b>Mo</b> Ele	dule name	nes and Drives				
<b>Mo</b> 18-	<b>dule nr.</b> bt-1020	Credit points 5 CP	Workload 150 h	Self-study 90 h	Module duration 1 Term	Module cycle Winter term
Lar Ger	<b>iguage</b> rman	1	I	Module owner Prof. DrIng. Yve	s Burkhardt	1
1	<b>Teaching co</b> Construction field within and inverter	ontent a and function of indu machines, armature c-fed drives. Significa	action machine, sy windings, steady-s nce for electric po	nchronous machine state performance a wer generation, bo	, direct current mach s motor/generator, a th to the grid and in	ine. Electromagnetic pplication as line-fed stand-alone version.
2	<ul> <li>and inverter-fed drives. Significance for electric power generation, both to the grid and in stand-alone version.</li> <li>Learning objectives         <ul> <li>Upon successful completion of the module, students will be able to:                 <ul> <li>calculate and explain the stationary operation performance of the three basic types of electric machine sin motor and generator mode,</li> <li>understand the application of electrical machines in modern drive systems and to design simple drive applications by yourself,</li> <li>understand and explain the function and physical background of the components of electrical machines</li> <li>understand and explain the impact of basic electromagnetic field and force theory on the basic function of electrical machines.</li> </ul> </li> </ul></li></ul>					
3	Recommen Mathematic	<b>ded prerequisites fo</b> s I to III, Electrical Eng	or participation gineering and Info	rmation Technology	/ I and II, Physics, Me	chanical Engineering
4	Form of exa Module exa • Modul	amination m: le exam (Technical ex	xamination, Exam	ination, Duration:	120 Min., Default RS	3)
5	<b>Prerequisit</b> Passing the	e for the award of c final module examina	<b>redit points</b> ation			
6	Grading Module exa • Modul	m: le exam (Technical ex	xamination, Exam	ination, Weighting:	: 100 %)	
7	<b>Usability of</b> BSc ETiT, B	f <b>the module</b> Sc/MSc Wi-ETiT, BEc	1			
8	Grade bonu At the begin that will ena	<b>is compliant to §25</b> ning of the semester, able an improvement	(2) it will be announce in grades.	ed whether there w	ill be short tests acco	mpanying the lecture
9	References Detail A. Bin A. Bin E. Bol R. Fisc J. Pyrh G. Mü HO.	ed textbook and colle der: El. Maschinen u der: El. Maschinen u te: Elektrische Masch cher: Elektrische Mas nönen, T. Jokinen, V. ller, B. Ponick: El. Ma ödefeld, H. Sequenz: Seinsch: Grundlagen	ection of exercices . Antriebe: Grund . Antriebe: Übung ainen, Springer Vie cchinen, Carl Hans Hrabovcova: Desi aschinen: 1: Grun Elektrische Masch el. Maschinen u.	; Complete set of P lagen, Betriebsverh sbuch, Springer Vie eweg, 2018 ser Verlag, 2017 gn of Rotating Elec dlagen, 2014; 2: Be inen, Springer View Antriebe, Springer	owerPoint presentati alten, Springer View eweg, 2017 trical Machines, 201 erechnung, 2007, Wi weg, 1971 Vieweg, 1993	ions reg, 2017 3, Wiley iley-VCH

Co	urses			
	<b>Course nr.</b> 18-bt-1020-vl	<b>Course name</b> Electrical Machines and Drives		
	<b>Instructor</b> Prof. DrIng. Yv	es Burkhardt	<b>Type</b> Lecture	SWS 2
	<b>Course nr.</b> 18-bt-1020-ue	<b>Course name</b> Electrical Machines and Drives		
	<b>Instructor</b> Prof. DrIng. Yv	es Burkhardt	<b>Type</b> Practice	<b>SWS</b> 2

Mo Pov	<b>dule name</b> ver Electronic	S				
Мо	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
18-	gt-1010	5 CP	150 h	90 h	1 Term	Winter term
LanguageModuleGermanProf. Dr.					d Griepentrog	
1	<ul> <li>Teaching content         Power electronic devices convert the energy from the distribution network to the form required by the load. This conversion does not wear out, can be controlled very fast and has a high efficiency. In lecture "Power Electronics" the most important circuits required for the energy conversion are treated, using ideal switches. The main chapters are         I.) Line commutated converters in order to understand the basic concepts of power electronic systems.         II.) Self- commutated converters (one, two and four quadrant converters, 3-phase- VSI)         </li> </ul>					
2	<ul> <li>2 Learning objectives The module teaches students after successful completion: <ul> <li>Understand the ideal concept of power semiconductors</li> <li>Calculate and sketch the time-characteristics of all currents and voltages in a line-commutated converter using defined simplifications as well as represent the behavior of currents and voltages during commutation in line-commutated converters for center -tapped as well as for bridge circuits. <ul> <li>Specify the basic circuit diagrams for one, two and four quadrant DC/DC converters and calculate the characteristics of voltages and currents in these circuits.</li> <li>Explain the function of single-phase and three-phase voltage source inverters and calculate the currents and voltages in these circuits using defined simplifications.</li> <li>Understand the concept und operation of HVDC converter</li> </ul></li></ul></li></ul>					
3	Recomment Mathe I und	<b>led prerequisites fo</b> II, ETiT I und II, Ene	or participation ergietechnik			
4	Form of exa Module exa • Modul	mination n: e exam (Technical ex	- xamination, Exam	ination, Duration:	90 Min., Default RS)	
5	Prerequisite Passing the	e for the award of c	redit points ation			
6	<ul> <li>6 Grading Module exam:</li> <li>• Module exam (Technical examination, Examination, Weighting: 100 %)</li> </ul>					
7	7 Usability of the module MSc ETiT, MSc MEC, Wi-ETiT					
8	Grade bonu	s compliant to §25	(2)			
9	References					

Lecture notes, instructions for exercises are available for download in Moodle. Literature:

- Probst U.: "Leistungselektronik für Bachelors: Grundlagen und praktische Anwendungen", Carl Hanser Verlag GmbH & Co. KG, 2011
- Jäger, R.: "Leistungselektronik: Grundlagen und Anwendungen", VDE-Verlag; Auflage 2011
- Heumann, K.: "Grundlagen der Leistungselektronik"; Teubner; Stuttgart; 1985
- Lappe, R.: "Leistungselektronik"; Springer-Verlag; 1988
- Mohan, Undeland, Robbins: Power Electronics: Converters, Applications and Design; John Wiley Verlag; New York; 2003

## Courses Course nr. **Course name** 18-gt-1010-vl **Power Electronics** Instructor Type SWS Prof. Dr.-Ing. Gerd Griepentrog Lecture 2 Course nr. Course name 18-gt-1010-ue **Power Electronics** Instructor Туре SWS Prof. Dr.-Ing. Gerd Griepentrog, M.Sc. Milad Khani Practice 2

Mo Hig	<b>dule name</b> h Voltage Teo	chnology I				
Mo	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle
Lan	nguage man	5.61	130 11	Module owner Prof. Dr. Myriam	Koch	whiter term
1	<b>Teaching co</b> Calculation potential co generation a	ontent of electrostatic fields ntrol measures, break and measurement of	s, voltage distribu ‹down of gases, su high voltages.	tion in insulating s urface discharge and	ystems and layered d pollution flashover,	dielectrics, field and vacuum breakdown,
2	<ul> <li>2 Learning objectives         After participating in the module, students will be able to explain fundamental phenomena and principles related to high electric fields and they will be able to identify critical, highly stressed regions in electric field maps. They will be able to perform field optimizations through specific design of the dielectric materials and field-controlling geometries.     </li> <li>They understand the various mechanisms that lead to failure of a gas-insulated systems, know which parameters affect their electrical strength, and can apply design criteria. They can identify weak points in the insulation system and propose improvements. They will be able to make an estimation of the breakdown or flashover voltage, respectively. Students will be able to identify regions with potential surface discharges and know how pollution flashover develops and how it can be avoided. Students will be able to explain the processes involved in vacuum breakdown and how it differs from gas breakdown. Furthermore, the students are able to explain the most important designs for high-voltage generators and to name suitable measuring equipment.     </li> </ul>					
3	Recommen	ded prerequisites fo	or participation			
4	Form of exa Module exa • Modul With up to 2 written exar	amination m: le exam (Technical ex 20 participants the ex n (duration: 120 min	xamination, Oral/ xamination will ta a). The type of exa	written examinatio ke place as an oral umination will be au	n, Duration: 120 Mir exam (duration: 30 nnounced at the begi	n., Default RS) min), otherwise as a inning of the lecture.
5	<b>Prerequisit</b> Passing the	e for the award of c	<b>redit points</b> ation			
6	Grading Module exa • Modul	m: le exam (Technical ex	xamination, Oral/	written examinatio	n, Weighting: 100 %	))
7	<b>Usability of</b> BSc ETiT	the module				
8	Grade bonu Grade impr internship.	<b>is compliant to §25</b> ovements up to 0.4	(2) according to API	3 25 (2) through b	oonus for successful	participation in the
9	References					
	<ul><li>Küchle</li><li>Beyer,</li></ul>	er, A.: High Voltage T M.; Boeck, W.; Mölle	<sup>C</sup> echnology, Spring er, K.; Zaengl, W.:	er Hochspannungstee	hnik, Springer-Verla	g
Coi	ırses					

<b>Course nr.</b> 18-kc-1010-vl	<b>Course name</b> High Voltage Technology I		
<b>Instructor</b> Prof. Dr. Myriam	Koch	<b>Type</b> Lecture	SWS 2
<b>Course nr.</b> 18-kc-1010-ue	<b>Course name</b> High Voltage Technology I		
<b>Instructor</b> Prof. Dr. Myriam	Koch	<b>Type</b> Practice	<b>SWS</b> 1
<b>Course nr.</b> 18-kc-1010-pr	<b>Course name</b> High Voltage Technology I		
<b>Instructor</b> Prof. Dr. Myriam	Koch	<b>Type</b> Internship	<b>SWS</b> 1

Mo Adv	dule name	Electronics				
<b>Mo</b>	dule nr. gt-2010	Credit points 5 CP	Workload 150 h	Self-study 90 h	Module duration	Module cycle Winter term
Lan Eng	<b>iguage</b> glish			Module owner Prof. DrIng. Ger	d Griepentrog	
1	1 Teaching content Switch mode power supplies (insulating DC/DC-converters) Realistic behavior of power semiconductors: Basics of semiconductor physics; Behavior of diode, bipolar transistor, SCR, GTO, MOSDFET and IGBT, Importa circuits for switching real semiconductors with low losses Thermal design and thermo mechanical aging of power electronics systems Reliability of Power electronic systems Forced commutation of SCRs, Loss reducing snubbers, quasi- resonant circuits, resonant switching. Topologies and control strategies for multilevel converter					emiconductors: and IGBT, Important witching.
2	Learning of Upon succes 1. Explain tors (d	<b>ojectives</b> sful completion of th n und understand the	e module, studen e cross sectional la Mosfat and IGBT	ts will be able to: yers and the basic i	nodes of operation fo	or power semiconduc-
	<ul> <li>tors (diode, thyristor, GTO. Mosfet and IGBT). Describe the steady state and dynamic behavior of these devices.</li> <li>Identify the circuit diagrams for isolating DC/DC converters, especially for use in switched mode power supplies. Calculate the currents and voltages in these circuits using defined simplifications.</li> <li>Describe the functions of gate dive-circuits for ITGBTs.</li> <li>Calculate the thermal behavior and design the cooling equipment for a voltage source inverter equipped with IGBT modules.</li> <li>Describe the stress reliving circuits to reduce switching losses in IGBTs.</li> <li>Calculate the current and voltage characteristics in quasi-resonant and resonant circuits used in power electronics.</li> <li>Explain multilevel converters such as 3L-NPC and MMC</li> <li>Know the main concepts for cooling of power electronics incl. the ability to design a cooling concept and</li> </ul>					witched mode power cations. ce inverter equipped rcuits used in power cooling concept and
3	Recomment BSc ETiT or	<b>ded prerequisites fo</b> equivalent, especiall	or participation y Power Electronic	cs and Basics of Set	miconductors	
4	Form of exa Module exa • Modul	mination n: e exam (Technical ex	xamination, Exam	ination, Duration:	90 Min., Default RS)	
5	<b>Prerequisite</b> Passing the f	e for the award of c	redit points ation			
6	<ul> <li>Grading Module exam:</li> <li>Module exam (Technical examination, Examination, Weighting: 100 %)</li> </ul>					
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> ISc EPE, Wi-ETiT				
8	Grade bonu	s compliant to §25	(2)			
9	References					

Script available in Moodle for download Literature:

- Schröder, D.: "Leistungselektronische Schaltungen", Springer-Verlag, 1997
- Mohan, Undeland, Robbins: Power Electronics: Converters, Applications and Design; John Wiley Verlag; New York; 2003
- Luo, Ye: "Power Electronics, Advanced Conversion Technologies", Taylor and Francis, 2010

## Courses Course nr. Course name 18-gt-2010-vl Advanced Power Electronics Instructor Туре SWS Prof. Dr.-Ing. Gerd Griepentrog Lecture 2 Course nr. Course name 18-gt-2010-ue Advanced Power Electronics Туре SWS Instructor Prof. Dr.-Ing. Gerd Griepentrog Practice 2

Mo	dule name	notions and Commun	igntion with Migro	controllors and Dry	ogrammable Logic D	ovices
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
18-	gt-2040	4 CP	120 h	75 h	1 Term	Every Semester
Ger	man			Prof. DrIng. Ger	d Griepentrog	
1	<ul> <li>Teaching content         Microcontroller and programmable logic devices are being used for a variety of control tasks for industrial and residential products and systems. For the control of drives and power electronics, those devices are used for the control of frequency converters or DC/DC converters.         In most of these applications, real time requirements have to be met. Simultaneously a communication interface has to be served.         The module will impart knowledge and expertise on how to realize successfully control task.         More in detail, the following content will be taught:         <ul> <li>Architecture of microcontroller</li> <li>Structure and function of FPGAs, tools and programming languages</li> <li>Typical peripheral components for microcontrollers</li> <li>Capture &amp; Compare, PWM, A/D-converter</li> <li>I2C, SPI, CAN, Ethernet</li> <li>Programming of microcontrollers in C</li> <li>Software: real-time properties, interrupt handling, interrupt latency</li> <li>Control of inductive components</li> <li>Basic of circuit design for power electronics, Power-MOSFETS, IGBTsNumerical methods</li> </ul> </li> </ul>					
2	Learning of Students wi • Separa • Specif • Evalua system softwa	<b>Djectives</b> Il be able to: ate a digital control t y the HW-content in a te the real-time capa a Transfer the develop are onto the target sy	ask into HW and s HW description la bilities of a progra bed solution to the stem.	SW parts inguage and impler m and to determin- target system by n	nent the SW by mean e upper limits for the neans of a developme	s of a microcontroller response time of the ent kit and debug the
3	Recommen Basic knowl	<b>ded prerequisites fo</b> edge in programmig	or participation language C (synta	ax, operators, point	ter)	
4	Form of exa Module exa • Modul	amination m: e exam (Technical ez	xamination, Exam	ination, Duration:	120 Min., Default RS	5)
5	<b>Prerequisit</b> Passing the	e for the award of c	<b>redit points</b> ation			
6	<ul> <li>6 Grading Module exam:</li> <li>• Module exam (Technical examination, Examination, Weighting: 100 %)</li> </ul>					
7	Usability of MSc MEC, N	<b>the module</b> //Sc ETiT				
8	Grade bonu	is compliant to §25	(2)			
9	References					

	Script, Instruction for practical lab courses, ppt-Slides; either in hard-copy or for download; User Manuals of the used devices and development kits					
Coi	ırses					
	Course nr.Course name18-gt-2040-vlReal Time Applications and Communication with Microcontrollers and programmable Logic Devices					
	<b>Instructor</b> Prof. DrIng. Ger	rd Griepentrog	<b>Type</b> Lecture	<b>SWS</b> 1		
	Course nr.       Course name         18-gt-2040-pr       Real Time Applications and Communication with Microcontrollers and programmable         Logic Devices       Logic Devices					
	<b>Instructor</b> Prof. DrIng. Ger	rd Griepentrog, Prof. DrIng. Christian Hochberger	<b>Type</b> Internship	SWS 2		

Mo	dule name					
Ene Mo	ergy Converte dule nr.	Trs - CAD and System	Dynamics Workload	Self-study	Module duration	Module cycle
18-	bt-2010	7 CP	210 h	135 h	1 Term	Winter term
Lar Eng	<b>nguage</b> glish			Module owner Prof. DrIng. Yve	s Burkhardt	
1	1 Teaching content Design of cage-rotor and wound-rotor induction machines: Calculation of forces, torque, losses, efficiency, cooling and temperature rise. Transient machine performance of converter-fed dc machines and line-fed and inverter-fed ac machines. Theory is illustrated by examples: Sudden short circuit, load step, run up. For control design transfer functions of machines are derived. In the exercise lessons demonstration examples of power transformer and induction motor design are given. The students design one induction machine in small groups by themselves. Transient performance calculation is trained by using Laplace-Transformation and MATLAB.					
2	<ul> <li>2 Learning objectives Upon successful completion of the module, students will be able to: <ul> <li>do and explain the electromagnetic design of an induction machine both analytically and with use of computer program,</li> <li>understand and predict the thermal performance of electrical drives in a simplified way,</li> <li>calculate the instationary performance of separately excited DC drives</li> <li>to predict the dynamical performance of AC polyphase machines with space vector theory and use the MATLAB/Simulink package for this purpose.</li> </ul></li></ul>					
3	Recommen Bachelor of	<b>ded prerequisites fo</b> Science in Electrical	or participation Engineering, Powe	er Engineering or s	imilar	
4	Form of exa Module exa • Modu	<b>amination</b> m: le exam (Technical ex	xamination, Exam	ination, Duration:	120 Min., Default RS	3)
5	<b>Prerequisit</b> Passing the	e for the award of c	<b>redit points</b> ation			
6	Grading Module exa • Modu	m: le exam (Technical ex	xamination, Exam	ination, Weighting	: 100 %)	
7	<b>Usability of</b> MSc ETiT, N	f <b>the module</b> ⁄ISc MEC, MSc EPE				
8	Grade bonu At the begin lecture that	<b>is compliant to §25</b> ning of the semester, will enable an impro	(2) it will be annound wement in grades.	ced whether there w	vill be homework tes	ts accompanying the
9	InterviewInter					

Co	Courses						
	<b>Course nr.</b> 18-bt-2010-vl						
	<b>Instructor</b> Prof. DrIng. Yve	<b>Type</b> Lecture	<b>SWS</b> 3				
	<b>Course nr.</b> 18-bt-2010-ue	<b>Course name</b> Energy Converters - CAD and System Dynamics					
	<b>Instructor</b> Prof. DrIng. Yve	es Burkhardt	<b>Type</b> Practice	SWS 2			

Mo	dule name					
Ар <u>р</u> Мо	dule nr.	Credit points	Workload	c Systems Self-study	Module duration	Module cycle
18-	gt-2030	8 CP	240 h	180 h	1 Term	Every Semester
Lar Ger	<b>nguage</b> man/English			<b>Module owner</b> Prof. DrIng. Ger	d Griepentrog	
1	<ul> <li>1 Teaching content         <ul> <li>In an introductory meeting topics according to power electronics and control of drives are given to the students. During the seminary problems can be treated concerning the following topics:                 <ul> <li>Simulation of power electronic systems plus analysis and evaluation of the models</li> <li>Implementing and startup of power electronic systems, test stand development plus measurement of characteristic parameters</li> <li>Modeling and simulation in the field of control of electrical drives</li> <li>Implementing and startup of controlled drive systems</li> <li>Suggested topics from the students are welcome</li> </ul> </li> </ul> </li> </ul>					
2	<ul> <li>2 Learning objectives <ul> <li>Upon completion of the module, students will have learned:</li> <li>Autonomous familiarization with a given problem</li> <li>Selection and evaluation of appropriate development tools</li> <li>Familiarization with the used development tools</li> <li>Practical experience in power electronics and control of drives</li> <li>Logical presentation of the results in a report</li> <li>Presentation skills</li> </ul> </li> </ul>					
3	Recommen Lecture "Lei	<b>ded prerequisites fo</b> istungselektronik 1" o	or participation or "Einführung En	ergietechnik" and	ggf. "Regelungstechn	ıik I" or similar
4	Form of exa Module exa • Modul Report and/ the lecture.	amination m: le exam (Study achie or Presentation and/o	vement, Oral/wri or Colloquium. Th	tten examination, I le type of examinat	Default RS) ion will be announce	d in the beginning of
5	<b>Prerequisit</b> Passing the	e for the award of c final module examina	<b>redit points</b> ation			
6	Grading Module exa • Modul	m: le exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 100 %)	
7	<b>Usability of</b> MSc ETiT, N	f <b>the module</b> ASc Wi-ETiT, MSc ME	EC			
8	Grade bonu	is compliant to §25	(2)			
9	<b>References</b> Definition o	f project task				
Co	ırses					

<b>Course nr.</b> 18-gt-2030-se	<b>Course name</b> Application, Simulation and Control of Power Electronic Syst	ems	
<b>Instructor</b> Prof. DrIng. Gen	rd Griepentrog, M.Sc. Pavel Makin	<b>Type</b> Seminar	SWS 4

<b>Mo</b> Ene	<b>dule name</b> ergy Managen	nent and Optimizatio	n				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
18-:	st-2010	6 CP	180 h	120 h   1 Term   Summer term			
Lan Ger	<b>iguage</b> man/English			Prof Dr rer nat	Florian Steinke		
1	1Teaching contentThe lecture reviews the different levels of energy management. It then focuses on economic dispatch and discusses its different use cases like optimization of self-consumption, virtual power plants, electric vehicle load management or multi-modal neighborhood optimization. Relevant knowledge about the components to be controlled as well as the markets to be addressed is explained. After this introduction to economic dispatch's application environment, the lecture focuses on the methods employed. The underlying mathematical formulations as different types of optimization problems (LP, MILP, QP, stochastic optimization) are reviewed. In parallel, a practical introduction to numerical optimization is given (descent algorithms, convergence, convexity, programming languages for the formulation of optimization problems). Moreover, an introduction into simple methods for the prognosis of future values (linear regression) is provided. All methodological learning is accompanied by hands-on exercises using Python and the mathematical modeling language GAMS.						
2	Learning ol Students kno of the typica Moreover, st Python and	<b>ojectives</b> ow the different use o ally employed optimiz tudents are independ GAMS.	cases and formulat zation methods ar lently able to form	tions of economic d ad are able to judge aulate (energy) opt	lispatch. They have a e the quality of the ac timization problems	basic understanding chieved results. and solve them with	
3	Recomment Standard kn is required.	<b>ded prerequisites fo</b> owledge of linear alg Knowledge of the mo	<b>r participation</b> ebra and multivar odules "Kraftwerke	iate analysis as we e & EE" or "Energie	ll as basic knowledge ewirtschaft" is helpfu	in the use of Python l but not necessary.	
4	Form of exa Module exam • Modul The examina 8 students r will be anno	amination m: e exam (Technical ex ation takes place in fo egister, the examinat ounced in the beginni	amination, Oral/ rm of a written ex ion will be an ora ng of the lecture.	written examinatio am (duration: 90 n l examination (dur	on, Duration: 90 Min. ninutes). If one can es ation: 25 min.). The	, Default RS) stimate that less than type of examination	
5	Prerequisite Passing the	e for the award of cr	redit points ation				
6	<ul> <li>Grading Module exam:</li> <li>Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>					)	
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> ISc iST, MSc Wi-ETiT	r, MSc CE				
8	Grade bonu Improvement and practica	<b>is compliant to §25</b> It of grades up to 0.4 c Il courses	(2) compliant to APB 2	25(2) through bonu	s system for re-gular	attention of exercises	
9	References						

- Boyd, Vandenberghe: Convex Optimization, Cambridge University Press, 2004
  A GAMS Tutorial by Richard E. Rosenthal https://www.gams.com/24.8/docs/userguides/userguide/\_u\_g\_\_tutorial.html

## Courses

000	arbeb						
	<b>Course nr.</b> 18-st-2010-vl	Course name Energy Management and Optimization					
	<b>Instructor</b> Prof. Dr. rer. nat.	Florian Steinke	<b>Type</b> Lecture	SWS 2			
	<b>Course nr.</b> 18-st-2010-ue	<b>Course name</b> Energy Management and Optimization					
	<b>Instructor</b> Prof. Dr. rer. nat.	Florian Steinke	<b>Type</b> Practice	<b>SWS</b> 1			
	<b>Course nr.</b> 18-st-2010-pr	<b>Course name</b> Energy Management and Optimization Lab		-			
	<b>Instructor</b> Prof. Dr. rer. nat.	Florian Steinke	<b>Type</b> Internship	<b>SWS</b> 1			

Mo	dule name	)ata-Based Modelling				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
Lan Eng	i <b>guage</b> Jish	0.01	100 11	Module owner Prof. Dr. rer. nat.	Florian Steinke	
1	Teaching co	ontent				
	<ul> <li>Data-based modelling (aka machine learning) principles: role of models, different metrics &amp; validation criteria</li> <li>Standard settings &amp; basic methods (deterministic and probabilistic approaches): Regression (k-NN, linear regression / LASSO, deep neural networks) Classification (trees &amp; forests, logistic regression, deep neural networks) Unsupervised learning (k-means, PCA, mixture models, autoencoder)</li> <li>Advanced topics: experiment design, dynamic models</li> <li>Application examples from the electrical engineering domain (energy systems, control &amp; communication tasks)</li> <li>Outlook to probabilistic graphical models as a unifying framework</li> <li>Practical exercises with Python deepen the understanding and support students' skills to independently solve new problems.</li> </ul>					
2	<ul> <li>2 Learning objectives</li> <li>Students understand the key data-based modelling / machine learning settings and important algorithms for each task. Moreover, the students are able to discover a suitable standard setting of data-based modelling behind many typical applications in the electrical engineering domain. They can then independently apply and adapt standard methods to solve these problems</li> </ul>					
3	Recomment Mathematics Using Pytho	<b>ded prerequisites fo</b> s I/II/III, Statistics/Pa n for programming th	<b>r participation</b> robability Theory, ne practical exam	Scientific Comput ples should pose no	ing (etit bases course difficulty.	s)
4	Form of exa Module exa • Modul	<b>mination</b> n: e exam (Technical ex	amination, Exam	ination, Duration:	90 Min., Default RS)	
5	Prerequisite Passing the	e for the award of cr final module examina	<b>redit points</b> ation			
6	Grading Module exan • Modul	m: e exam (Technical ex	amination, Exam	ination, Weighting	: 100 %)	
7	<b>Usability of</b> BSc etit	the module				
8	Grade bonu Grade impro appointmen	as compliant to §25 wements up to 0.4 acc ts and independent w	<b>(2)</b> cording to APB 25 vork on a case stu	(2) through bonus dy.	for regularly attended	d practice/internship
9	References					
<b>Co</b> ι	ırses					

<b>Course nr.</b> 18-st-1030-vl	<b>Course name</b> Introduction to Data-Based Modelling		
<b>Instructor</b> Prof. Dr. techn. H	<b>Type</b> Lecture	<b>SWS</b> 2	
<b>Course nr.</b> 18-st-1030-ue	<b>Course name</b> Introduction to Data-Based Modelling		
Instructor Prof. Dr. techn. H	Heinz Köppl, Prof. Dr. rer. nat. Florian Steinke	<b>Type</b> Practice	<b>SWS</b> 1
<b>Course nr.</b> 18-st-1030-pr	<b>Course name</b> Introduction to Data-Based Modelling		
<b>Instructor</b> Prof. Dr. techn. H	Heinz Köppl, Prof. Dr. rer. nat. Florian Steinke	<b>Type</b> Internship	<b>SWS</b> 1

3.5	4							
Mo Elel	<b>dule name</b> ktrische Energ	gieversorgung II / Po	wer Systems II					
Mo	dule nr.	Credit points	Workload	Self-study	Module	duration	Module cyc	cle
18-1 Lon	115-2030	5 CP	150 fi	90 h 1 Ierm Winter term				
Ger	man/English			Prof. DrIng. Jutt	ta Hanson			
1	<ul> <li>Teaching content         The lecture Power Supply II deals with the dynamic behavior of electrical power systems. For this the stationary behavior of the equipment is extended by the dynamic behavior, in order to show the resulting network behavior. With this background in-depth insights into the stability of the electrical power supply network are provided. The influence of controlled generation plants on stability is addressed. Finally, power quality is considered, which is gaining importance for steady-state and dynamic behavior with the increased use of power electronics. The following topics will be covered:         <ul> <li>Steady-state and dynamic behavior of synchronous generators and renewable generation plants (grid behavior and control of power electronic converters)</li> <li>Time curve of short-circuit currents and their quasi-stationary calculation</li> <li>Stability types (static stability, transient stability, voltage stability, frequency stability, resonance stability &amp; inverter-driven stability)</li> <li>Power quality</li> </ul> </li> </ul>							
2	<b>Learning ol</b> After success stability of e the control of	<b>yjectives</b> Iful completion of the lectrical power system of generation plants,	e module, the stud ms. They have gai as well as power o	ents have a profour ned a basic underst quality.	nd underst anding of	tanding of dynamic n	the different t etwork behav	types of vior and
3	Recomment Knowledge of using symm	<b>led prerequisites fo</b> omparable to "Energi etrical components.	or participation ieversorgung I" or	basic knowledge of	power sys	tem equipn	nent and calcı	llations
4	Form of exa Module exa • Modul	<b>mination</b> n: e exam (Technical ex	xamination, Exam	ination, Duration:	90 Min., I	Default RS)		
5	Prerequisite Passing the	• for the award of c	<b>redit points</b> ation					
6	Grading Module exan • Modul	n: e exam (Technical ex	xamination, Exam	ination, Weighting	: 100 %)			
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> ISc EPE, MSc Wi-ETi	Т					
8	Grade bonu	s compliant to §25	(2)					
9	<b>References</b> Lecture slide	es, tutorials and past	exams are availab	ble via Moodle.				
Coι	ırses							
	<b>Course nr.</b> 18-hs-2030-	vl Elektrische En	ergieversorgung I	I / Power Systems I	II			
	Instructor Prof. DrIng	. Jutta Hanson, M.S.	c. Soham Choudh	ıry, M.Sc. Anna Pfe	endler	<b>Type</b> Lecture		SWS 2

	Course nr.Course name18-hs-2030-ueElektrische Energieversorgung II / Power Systems II					
	Instructor Prof. DrIng. Jut	ta Hanson, M.Sc. Soham Choudhury, M.Sc. Anna Pfendler	<b>Type</b> Practice	<b>SWS</b> 2		

Mo Pov	<b>dule name</b> ver Laborator	y I						
<b>Mo</b>	<b>dule nr.</b> ht-2091	<b>Credit points</b>	Workload	Self-study	Module duration	Module cycle		
Lar Ger	nguage man/English	0.01	100 11	Module owner Prof. DrIng. Yve	s Burkhardt			
1	Teaching content         Safety instructions for laboratory; Topic of experiments:         • Electrical energy conversion         • Power electronics         • High voltage technology         • Electrical energy supply         • Renewable energies							
2	<b>Learning ol</b> After compl electrical po	<b>bjectives</b> etion of the module, wer engineering.	the students have	e learned to work j	practically in small g	roups on tasks from		
3	Recommen Power Engir	<b>ded prerequisites fo</b> neering or similar	or participation					
4	<ul> <li>Form of examination         Module exam:         <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> <li>Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in             the herein a of the herein         </li> </ul></li></ul>							
5	Prerequisite Passing the	e for the award of c final module examina	redit points ation					
6	Grading Module exa • Modul	m: le exam (Study achie	vement, Oral/wri	tten examination, V	Veighting: 100 %)			
7	Usability of MSc ETiT, M	the module ISc MEC, MSc WI-ET	ïΤ					
8	Grade bonu	is compliant to §25	(2)					
9	<ul> <li>9 References</li> <li>A. Binder et al.: Textbook with detailed description of experiments;</li> <li>A. Binder et al.: Skript zur Lehrveranstaltung mit Versuchsanleitungen;</li> <li>J. Hindmarsh: Electrical Machines and their Application, Pergamon Press, 1991</li> <li>S. A. Nasar, C. Trutt: Electric Power systems, Taylor &amp; Francis, 1998</li> <li>N. Mohan et al.: Power Electronics, Converters, Applications and Design, Wiley, 2002</li> <li>D. Kind, H. Kärner: High-Voltage Insulation Technology, Vieweg &amp; Teubner, 1985</li> </ul>							
Co	Courses							

<b>Course nr.</b> 18-bt-2091-pr	Course nr.Course name18-bt-2091-prPower Laboratory I				
Instructor		<b>Type</b>	<b>SWS</b>		
Prof. DrIng. Yves Burkhardt, M.Sc. Alexander Möller		Internship	3		
<b>Course nr.</b> 18-bt-2090-tt	<b>Course name</b> Laboratory Briefing		·		
Instructor		<b>Type</b>	<b>SWS</b>		
Prof. DrIng. Yves Burkhardt		Tutorial	0		

Mo Pov	Module name Power Laboratory II							
Module nr. Credit points Workloa			Workload	Self-study	Module duration	Module cy	cle	
18-	bi-2092	- 5 CP	150 h	105 h	1 Term	Summer ter	rm	
Lar Ger	n <b>guage</b> man/English			Module owner Prof. DrIng. Yve	s Burkhardt			
1	<b>Teaching content</b> Practical course on power engineering - Distribution and Application. About 50% of the units are devoted to power distribution and high voltage engineering; About 50% are dealing with application in drive systems, concerning "field-oriented control" of variable speed drives, encoder systems							
2	<b>Learning ob</b> After comple electrical po	<b>jectives</b> etion of the module, wer engineering in a	, the students hav practical and ind	ve learned to work ependent manner.	in small groups on	in-depth tasl	ks from	
3	<b>Recommend</b> Power Engin	led prerequisites for eering or similar	or participation					
4	Form of exa Module exar • Module Report (inclu and/or Collo the beginnin	mination n: e exam (Study achie ding submission of p quium (testate), but g of the lecture.	vement, Oral/writ programming code t never more than	tten examination, I ) and/or Presentati two out of it. The t	Default RS) ion and/or Oral exan type of examination	nination (25 n will be annou	ninutes) nced in	
5	<b>Prerequisite</b> Passing the f	e <b>for the award of c</b> inal module examina	<b>redit points</b> ation					
6	Grading Module exar • Module	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 100 %)			
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> Sc MEC, MSc WI-ET	ΪT					
8	Grade bonu	s compliant to §25	(2)					
9	References Text book w	ith detailed laborato	ry instructions					
Coi	ırses							
	Course nr.Course name18-bi-2092-prPower Laboratory II							
	Instructor Prof. DrIng	Yves Burkhardt			<b>Type</b> Internsh	ip	SWS 3	
	<b>Course nr.</b> 18-bt-2090-t	t Course name	iefing					
	Instructor Prof. DrIng	Yves Burkhardt			<b>Type</b> Tutorial		<b>SWS</b> 0	

Mo Eleo	Module name Electromagnetic Compatibility							
<b>Mo</b> 18-	<b>dule nr.</b> kc-2070	Credit points 4 CP	Workload 120 h	Self-study 75 h	Module duration 1 Term	Module cycle Winter term		
Lar Ger	<b>guage</b> man	1		<b>Module owner</b> Prof. Dr. Myriam	Koch	1		
1	1 <b>Teaching content</b> Fundamentals of Electromagnetic Compatibility, sources of emission, coupling mechanisms and counter measures, components for noise suppression, electromagnetic shields, EMC measuring and test techniques, excursion to VDE Offenbach							
2	2 Learning objectives The students know that from every electromagnetic system a interaction is possible and that every electromagnetic (and also biological) system can be effected; they can differ between typical interference sources and sinks; they know the typical coupling paths and can identify and describe them mathematically; they know the basic methods to avoid interference at the source side and can derive their own actions against interference from this basic understanding; they know the basic actions to avoid interference at the sink side and can also derive actions to avoid interference; they have the ability to recognize coupling paths and can systematically influence or interrupt them completely; they know the situation of the EMC standardization and know basically which requirements have to be fulfilled and how to do this (also i.e. how to give a device a CE-label); they have learned the most important EMC testing and measurement techniques theoretically and practically know on the field							
3	Recommen	ded prerequisites fo	or participation					
4	<ul> <li>Form of examination</li> <li>Module exam: <ul> <li>Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS)</li> <li>The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 20 students register, the examination will be an oral examination (duration: 20 min.). The type of preminential preminential is the heritaging of the between</li> </ul></li></ul>							
5	Prerequisite Passing the	e for the award of c	<b>redit points</b> ation					
6	Grading Module exan • Modul	m: e exam (Technical ez	kamination, Oral/	written examinatio	n, Weighting: 100 %	)		
7	<b>Usability of</b> MSc ETiT, M	<sup>2</sup> <b>the module</b> ISc MEC, MSc Wi-ET	ïT, MSc ESE, MSc	CE				
8	Grade bonu	is compliant to §25	(2)					
9	References							
	<ul><li> All lec</li><li> Adolf .</li><li> Clayto</li></ul>	ture slides (ca. 500 p J. Schwab: Elektroma n R. Paul: Introduction	ocs.) available for agnetische Verträg on to Electromagr	download ;lichkeit, Springer-\ etic Compatibility,	/erlag Wiley & Sons			
Coι	ırses							

<b>Course nr.</b> 18-kc-2070-vl	Course nr.Course name18-kc-2070-vlElectromagnetic Compatibility				
Instructor		<b>Type</b>	<b>SWS</b>		
Dr. Ing. Torsten Psotta		Lecture	2		
<b>Course nr.</b> 18-kc-2070-ue	<b>Course name</b> Electromagnetic Compatibility				
Instructor		<b>Type</b>	<b>SWS</b>		
Dr. Ing. Torsten Psotta		Practice	1		

Mo Lar	Module name Large Generators and High Power Drives						
<b>Mo</b> 18-	<b>dule nr.</b> bt-2020	Credit points 4 CP	Workload 120 h	Self-study 75 h	Module duration	Module cy Winter term	<b>cle</b> n
Lar Ger	<b>iguage</b> man/English		I	<b>Module owner</b> Prof. DrIng. Yve	s Burkhardt		
1	<b>Teaching content</b> Design of large electric generators: Special cooling methods with air, hydrogen and water, loss evaluation, especially eddy current losses, and measures to reduce the additional losses. Design of big hydrogenerators up to 800 MVA and turbo generators up to 2000 MVA with design examples. Application of power electronics in large variable speed drives with synchronous motors: Synchronous converter and cyclo-converter. Numerous photographs to illustrate applications, excursion with students to special firms or plants.						
2	<b>Learning ob</b> Upon comple design princi	<b>jectives</b> tion of the module, s ples and operating o	students will have characteristics of l	developed an unde arge generators an	rstanding of the des d drives.	ign of cooling s	systems,
3	Recommend Physics, Elec	ed prerequisites for trical Machines and	or participation Drives, Electrical	Power Engineering			
4	Form of exam Module exam • Module	<b>mination</b> n: e exam (Technical e:	xamination, Exam	ination, Duration:	60 Min., Default RS	;)	
5	<b>Prerequisite</b> Passing the f	for the award of c nal module examination	<b>redit points</b> ation				
6	Grading Module exan • Module	n: e exam (Technical e:	xamination, Exam	ination, Weighting	100 %)		
7	<b>Usability of</b> MSc EPE, MS	<b>the module</b> Sc ETiT, MSc MEC, N	MSc WI-ETiT				
8	Grade bonus	s compliant to §25	(2)				
9	<ul> <li>P References</li> <li>Detailed textbook with calculated examples;</li> <li>A. Binder: El. Maschinen u. Antriebe: Grundlagen, Betriebsverhalten, Springer Vieweg, 2017</li> <li>A. Binder: El. Maschinen u. Antriebe: Übungsbuch, Springer Vieweg, 2017</li> <li>J. Pyrhönen, T. Jokinen, V. Hrabovcova: Design of Rotating Electrical Machines, 2013, Wiley</li> <li>A. Fitzgerald, C. Kingsley, A. Kusko: Electric machinery, McGraw-Hill, 2003</li> <li>W. Leonhard: Control of electrical drives, Springer Vieweg, 2001</li> <li>P. Vas: Parameter estimation, condition monitoring, and diagnosis of electrical machines, Clarendon Press, 1993</li> </ul>						
Cot	irses	Course north					
	18-bt-2020-v	l Large Generat	ors and High Pow	er Drives			
	<b>Instructor</b> Prof. Dr. Geo	rg Traxler-Samek			<b>Type</b> Lecture		<b>SWS</b> 2

	<b>Course nr.</b> 18-bt-2020-ue	<b>Course name</b> Large Generators and High Power Drives		
	<b>Instructor</b> Prof. Dr. Georg T	'raxler-Samek	<b>Type</b> Practice	<b>SWS</b> 1

Mo Hig	Module name High Voltage Switchgear and Substations							
Mo	dule nr.	Credit points	Workload	Self-study	Module o	duration	Module cy	cle
18-	kc-2020	3 CP	90 h	60 h	1 Term		Summer te	rm
Lan Ger	i <b>guage</b> man			Module owner Prof. Dr. Claus No	eumann			
1	<ul> <li>Teaching content</li> <li>This lecture covers the basic designs of high voltage substations as well as the design and working principles of high voltage switchgear: <ul> <li>Switching processes and stresses induced by switching</li> <li>Arc behaviour in air, SF6 and vacuum</li> <li>Types of switchgear: earthing switches, disconnectors and circuit breakers</li> <li>Design and working principles of earthing switches and disconnectors in air and SF6</li> <li>Design and working principles of circuit breakers: vacuum breakers, pressured air and SF6 breakers (thermal blast and self-blast chambers)</li> <li>Stresses on earthing switches and disconnectors in the event of short circuit</li> <li>Testing of switchgear</li> <li>Reliability of switchgear</li> <li>Future developments: Intelligent control of switchgear, static switches, superconducting switchgear</li> </ul> </li> </ul>							
2	<b>Learning ol</b> The student usage in hig	<b>ojectives</b> should understand t h voltage substations	the purpose and w s.	orking principles o	of high volt	age switch	ngear as well	as their
3	Recomment Prior attend	ded prerequisites for ance of the lectures I	or participation High Voltage Tech	nology I and II is r	ecommend	led		
4	Form of exa Module exa • Modul	<b>mination</b> m: e exam (Technical e:	xamination, Oral e	examination, Durat	ion: 45 Mi	n., Default	t RS)	
5	Prerequisite Passing the	e for the award of c	<b>redit points</b> ation					
6	Grading Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)							
7	Usability of MSc etit, BS	the module c/MSc iST, MSc Wi-0	etit, MSc ESE					
8	Grade bonus compliant to §25 (2)							
9	<b>9 References</b> A script of the lecture (in German) and the lecture slides will be provided.							
Coι	irses							
	<b>Course nr.</b> 18-kc-2020-	vl High Voltage S	Switchgear and Su	Ibstations				
	Instructor M.Sc. Manu	el Philipp, Prof. Dr. (	Claus Neumann			<b>Type</b> Lecture		SWS 2

Mo Hig	Module name High Voltage Technology II								
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle			
18-	kc-2010	4 CP	120 h	75 h	1 Term	Summer term			
Lar Ger	<b>iguage</b> man			Module owner Prof. Dr. Myriam	Koch				
1	1 Teaching content Layered Dielectrics, Methods of Field Control and Potential Control, Breakdown in Gases (air and SF6), Breakdown in Vacuum, Surface Discharges, Lightnings and Lightning Protection, Travelling Waves on Conductors; Excursion to a substation								
2	2 Learning objectives After successful completion of the module, the students are able to optimize insulation systems by choice of the dielectrics, by capacitive, refractive or resistive internal grading systems or by external geometrical/capacitive grading elements; they have understood why equipment is designed as it is and how and where it can or has to be optimized if requirements from service are changing; they have understood the physical phenomena behind the dielectric breakdown of gases and do know which are the main influencing parameters; they know the effect of strongly inhomogeneous electrode configurations and of extremely large gaps; they know the time dependencies of a dielectric breakdown and their impact on dielectric strength under impulse voltage stress; they are able to identify critical surface discharge configurations, know about the problems under severe external pollution of insulators and how to solve them; they are thus qualified to predict the dielectric strength of any electrode configuration under any kind of voltage stress and to design a particular required dielectric strength of equipment; they are particularly enabled to realize the demands of emerging UHV systems and to manage them; they have understood the mechanism of thunderstorms and lightning flashes and are able to derive protective measures for buildings, substations and overhead lines; they are skilled to calculate travelling wave effects and								
3	<b>Recommend</b> High Voltage	<b>ded prerequisites fo</b> e Technology I	or participation						
4	Form of exa Module exa • Modul	<b>mination</b> n: e exam (Technical ez	xamination, Exam	ination, Duration:	120 Min., Default RS	3)			
5	<b>Prerequisite</b> Passing the f	e <b>for the award of c</b> final module examina	<b>redit points</b> ation						
6	Grading Module exar • Modul	n: e exam (Technical ex	xamination, Exam	ination, Weighting	: 100 %)				
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> ISc Wi-ETiT							
8	Grade bonu	is compliant to §25	(2)						
9	References								
	<ul> <li>all lecture slides (ca. 460 pcs.) available for download</li> <li>Kind, Feser: High-voltage test techniques, SBA publications</li> <li>Kind, Kärner: High-voltage insulation technology, Vieweg</li> </ul>								
Cot	Courses								
Course nr.Course name18-kc-2010-vlHigh Voltage Technology II									
--------------------------------------------------------------	--------------------------------------------------	-------------------------	-----------------						
Instructor Prof. Dr. Myriam Koch		<b>Type</b> Lecture	<b>SWS</b> 2						
<b>Course nr.</b> 18-kc-2010-ue	<b>Course name</b> High Voltage Technology II		·						
<b>Instructor</b> Prof. Dr. Myriam	Koch	<b>Type</b> Practice	<b>SWS</b> 1						

Mo	dule name					
Nev Mo	w Technologie dule nr.	es of Electrical Energy	Workload	Actuators Self-study	Module duration	Module cvcle
18-	bi-2040	4 CP	120 h	75 h	1 Term	Summer term
Lar Ger	<b>iguage</b> man∕English			Module owner Prof. DrIng. Yve	s Burkhardt	
1	<ul> <li>Teaching content Goal: The application of new technologies, i.e. super conduction, magnetic levitation techniques and magneto-hydrodynamic converter principles, are introduced to the students. The physical operation mode in principle, implemented prototypes and the current state of the development are described in detail. Content: Application of the superconductors for electrical energy converters: <ul> <li>rotating electrical machines (motors and generators),</li> <li>solenoid coils for the fusion research,</li> <li>locomotive- and railway transformers,</li> <li>magnetic bearings.</li> </ul> Active magnetic levitation technique, <ul> <li>magnetic bearings ("magnetic levitation"):</li> <li>basics of the magnetic levitation technique,</li> <li>application for high-speed trains with linear drives.</li> </ul> Magneto-hydrodynamic energy conversion: <ul> <li>physical principle,</li> <li>state of the art and perspectives.</li> </ul> Fusion research: <ul> <li>magnetic field arrangements for contactless plasma inclusion,</li> <li>state of the current research.</li> </ul> </li> </ul>					
2	Learning of After compl systems as v	<b>bjectives</b> letion of the module well as magnetic levit	students have bas ation, magnetohy	ic knowledge of ag drodynamics and f	oplication of superco usion technology.	nductivity in energy
3	Recommen Physics, Ele	ded prerequisites for ctrical Machines and	<b>or participation</b> Drives, Electrical	Power Engineering		
4	Form of exa Module exa • Modu	amination m: le exam (Technical ex	xamination, Exam	ination, Duration:	60 Min., Default RS)	
5	<b>Prerequisit</b> Passing the	e for the award of c final module examina	redit points ation			
6	Grading Module exa • Modu	m: le exam (Technical ex	kamination, Exam	ination, Weighting	: 100 %)	
7	<b>Usability of</b> MSc EPE, M	f <b>the module</b> ISc ETiT, MSc MEC, N	MSc WI-ETiT			
8	Grade bonu	is compliant to §25	(2)			
9	References					

Detailed textbook

- Komarek, P.: Hochstromanwendungen der Supraleitung, Teubner, Stuttgart, 1995
- Buckel, W.: Supraleitung, VHS-Wiley, Weinheim, 1994
  Schweitzer, G.; Traxler, A.; Bleuler, H.: Magnetlager, Springer, Berlin, 1993
  Schmidt, E.: Unkonventionelle Energiewandler, Elitera, 1975

## Courses

CO	11303			
	Course nr.Course name18-bi-2040-vlNew Technologies of Electrical Energy Converters and Actuators			
	InstructorTypeSProf. DrIng. Yves BurkhardtLecture2			<b>SWS</b> 2
	<b>Course nr.</b> 18-bi-2040-ue	<b>Course name</b> New Technologies of Electrical Energy Converters and Actuat	tors	
	InstructorTypeSVProf. DrIng. Yves BurkhardtPractice1			

Mo Des	Module name Design of Electrical Machines and Actuators with Numerical Field Calculation							
<b>Mo</b> 18-	<b>dule nr.</b> bi-2110	Credit points 5 CP	Workload 150 h	Self-study 120 h	Module of 1 Term	luration	Module cyc Summer ter	c <b>le</b> rm
Lar Ger	<b>iguage</b> man/English			<b>Module owner</b> Prof. DrIng. Yve	es Burkhard	lt	L	
1	1 <b>Teaching content</b> Introduction to Finite Element Method (FEM), Basic examples of electromagnetic devices designed in 2D with FEM, 2D electromagnetic Design of transformers, AC machines, permanent magnet devices; eddy current applications such as squirrel-cage machines (Example: Wind generator); Cooling systems and thermal design: Calculation of temperature distribution within power devices							
2	Learning of Upon comple package to b	<b>jectives</b> etion of the module, pasic field problems.	students will have	a good knowledge	in applyin	g FEMAG a	and ANSYS s	oftware
3	Recommend Strongly rec CAD and Sys	<b>led prerequisites fo</b> ommended is the att stem Dynamics"	or participation endance of lecture	e and active co-ope	eration in th	ne tutorial	"Energy Conv	verters -
4	<ul> <li>Form of examination         Module exam:         <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> <li>Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of             the leature</li> </ul> </li> </ul>							
5	Prerequisite Passing the f	e for the award of c	<b>redit points</b> ation					
6	Grading Module exar • Modul	n: e exam (Study achie	vement, Oral/writ	ten examination, V	Weighting:	100 %)		
7	<b>Usability of</b> MSc EPE, M	<b>the module</b> Sc ETiT, MSc MEC						
8	Grade bonu	s compliant to §25	(2)					
9	9 References Detailed textbook; User manual FEMAG and ANSYS. Müller, C. Groth: FEM für Praktiker - Band 1: Grundlagen, expert-Verlag, 5. Aufl., 2000							
Coi	ırses							
	<b>Course nr.</b> 18-bi-2110-s	Course namebeDesign of Elect	trical Machines an	d Actuators with N	Numerical F	Field Calcu	lation	
	<b>Instructor</b> DrIng. Bog	dan Funieru				<b>Type</b> Seminar		SWS 2

Mo	dule name					
Ma	chine Learnin	g & Energy	I			1
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
Lar	19112920	0.Cr	100 11	Module owner	1 101111	Every 2. Semester
Eng	glish			Prof. Dr. rer. nat.	Florian Steinke	
1	<b>1</b> Teaching content The analysis and interpretation of data becomes ever more important, also for engineers. Digitalization and Smart Grids are terms to describe a host of novel data-based services in the field of generation, distribution, consumption, and marketing of (renewable) energy. The lecture presents the recent developments and their underlying machine learning methods. For a start we describe the different problem settings of machine learning methods, review recent developments in the field, and evaluate the impact of machine learning on the energy sector. After such an introductory overview, we review the basics of linear algebra and numerical optimization. We then introduce supervised learning problems and study different model classes to solve such problems (linear models, trees, random forests, nearest neighbor, kernel methods, deep learning). We then turn to a probabilistic view and study unsupervised learning problems. Finally, we give an introduction to probabilistic graphical models. Throughout the semester we discuss exemplary applications of machine learning in the energy domain (e.g. renewable forecasting, predictive maintenance, state estimation, probabilistic load flow). Practical exercises with Python deepen the understanding and support students' actively usable skills.					
2	Learning ol Students un know comm those metho	bjectives derstand important ion applications there ods independently to	machine learning eof in the energy on new applications	problem settings a domain. Moreover, (not only from the	ndsome key method the students are able energy domain).	s for each task. They e to apply and adapt
3	• Good I • Basic I • Using	knowledge of linear a knowledge of statistic Python for programr	or participation algebra required cs and numerical on ning the practical	optimization will be examples should p	e helpful ose no difficulty	
4	Form of exa Module exam • Modul The examina 8 students r will be anno	amination m: e exam (Technical ex ation takes place in fo egister, the examinat ounced in the beginn	xamination, Oral/ orm of a written ex ion will be an ora ing of the lecture.	written examinatio am (duration: 90 m l examination (dur	n, Duration: 90 Min. ninutes). If one can es ation: 25 min.). The	., Default RS) stimate that less than type of examination
5	Prerequisite Passing the	e for the award of c final module examin	<b>redit points</b> ation			
6	<ul> <li>6 Grading Module exam:</li> <li>• Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>					
7	<b>Usability of</b> MSc etit, MS	t <b>he module</b> Sc iST, MSc Wi-etit, I	MSc CE			
8	Grade bonu Notenverbes /Praktikums	<b>is compliant to §25</b> sserungen bis zu stermine und mindes	<b>(2)</b> 0,4 nach APB tens einmaliges Ve	25(2) durch Bon orrechnen in den Ü	us für regelmäßig bungen	besuchte Übungs-
9	Keierences					

- K.P. Murphy: Machine Learning. A Probabilistic Perspective.C.M. Bishop: Pattern Recognition & Machine Learning

- J. Friedman, T. Hastie, R. Tibshirani: The elements of statistical learning
  D. Koller, N. Friedmann: Probabilistic Graphical Models. Principles and Techniques

Co	urses				
	Course nr.Course name18-st-2020-vlMachine Learning & Energy				
	InstructorTypeSWSProf. Dr. rer. nat. Florian Steinke, M.Sc. Allan Santos, M.Sc. Tim JankeLecture2			<b>SWS</b> 2	
	Course nr.Course name18-st-2020-ueMachine Learning & Energy				
	Instructor Prof. Dr. rer. nat.	Florian Steinke, M.Sc. Allan Santos, M.Sc. Tim Janke	<b>Type</b> Practice	<b>SWS</b> 1	
	Course nr.Course name18-st-2020-prMachine Learning & Energy Lab				
	InstructorTypeSWSProf. Dr. rer. nat. Florian Steinke, M.Sc. Allan Santos, M.Sc. Tim JankeInternship1				

Mo Ele	Module name Electric Railways					
Мо	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
18-	bt-2140	5 CP	150 h	105 h	1 Term	Winter term
Ger	<b>iguage</b> man/English			Module owner Prof. DrIng. Yve	s Burkhardt	
1	<ul> <li>Teaching content         The basics of electrical railway traction systems as well as the generation and distribution of electrical power for rail systems will be presented. This includes:             <ul></ul></li></ul>					
2	2 Learning objectives After completing the module, students will have developed an understanding of the basic concepts of electric traction units and electric traction current systems.					c concepts of electric
3	<b>Recommend</b> Basic knowle	<b>ded prerequisites fo</b> edge in electrical ma	or participation chines and drives			
4	Form of exa Module exar • Modul The examina	<b>mination</b> n: e exam (Technical ex ition takes place in for	xamination, Oral∕ rm of a written exa	written examinatio m (duration: 90 mi	n, Duration: 90 Min. nutes) in combinatior	., Default RS) 1 with a presentation.
5	Prerequisite Passing the f	e <b>for the award of c</b> r final module examina	redit points ation			
6	<b>Grading</b> Module exar • Modul	n: e exam (Technical ex	xamination, Oral/	written examinatio	n, Weighting: 100 %	))
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> ISc MEC, MSc Wi-ET	ïT			
8	Grade bonu	s compliant to §25	(2)			
9 Сот	<ul> <li>9 References</li> <li>Text book for the lecture.</li> <li>Bendel, H. u.a.: Die elektrische Lokomotive. Transpress, Berlin, 1994.</li> <li>Filipovic, Z: Elektrische Bahnen. Springer, Berlin, Heidelberg, 1995.</li> <li>Steimel, A.: Elektrische Triebfahrzeuge und ihre Energieversorgung. Oldenburg Industrieverlag, 2006.</li> <li>Bäzold, D. u.a.: Elektrische Lokomotion deutscher Eisenbahnen. Alba, Düsseldorf, 1993.</li> <li>Obermayer, H. J.: Internationaler Schnellverkehr. Franckh-Kosmos, Stuttgart, 1994.</li> <li>Guckow, A.; Kiessling, F.; Puschmann, R.: Fahrleitungen el. Bahnen. Teubner, Stuttgart, 1997.</li> <li>Schaefer, H.: Elektrotechnische Anlagen für Bahnstrom. Eisenbahn-Fachverlag, Heidelberg, 1981.</li> </ul>					

<b>Course nr.</b> 18-bt-2140-vl	<b>Course name</b> Electric Railways		
Instructor		<b>Type</b> Lecture	<b>SWS</b> 3

Mo Phy	dule name	nology of Accelerato	ors				
<b>Mo</b> 05-	<b>dule nr.</b> 21-2514	Credit points 5 CP	Workload 150 h	Self-study 60 h	Module duration	Module cycl Every 2. Sen	<b>le</b> nester
Lar Ger	<b>iguage</b> rman		1	Module owner	I		
1	Teaching co	ntent					
2	Learning ob	jectives					
3	Recommend	led prerequisites fo	or participation				
4	<ul> <li>Form of examination Module exam: <ul> <li>Module exam (Study achievement, Study achievement, p/np RS)</li> <li>Course related exam:</li> <li>[05-25-6302-pr] (Study achievement, Study achievement, p/np RS)</li> </ul></li></ul>						
5	<b>Prerequisite</b> Passing the f	e <b>for the award of c</b> inal module examin	<b>redit points</b> ation				
6	Grading Module exan • Module Course relate • [05-25	n: e exam (Study achie ed exam: -6302-pr] (Study ac	evement, Study ac	hievement, Weight achievement, Weig	ing: 100 %) ghting: 0 %)		
7	Usability of	the module					
8	Grade bonu	s compliant to §25	(2)				
9	References						
Cot	urses						
	<b>Course nr.</b> 18-bf-2010-v	Course name Accelerator Ph	iysics				
	InstructorTypeSWSProf. Dr. Oliver Boine-FrankenheimLecture2						
	<b>Course nr.</b> 05-25-6302-	pr Vocational Lab	ooratory: Introduc	tion to Accelerator	Physics		
	Instructor				<b>Type</b> Internshi	p	<b>SWS</b> 2
	<b>Course nr.</b> 05-21-2502-	Course namekuIntroduction to	o Accelerator Phys	sics			
	Instructor				<b>Type</b> Course		SWS 2

Mo Virt	dule name	ng of Flectric Drives				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
18-	dg-2190	6 CP	180 h	120 h	1 Term	Summer term
Lan Eng	<b>iguage</b> Ilish			Module owner Prof. DrIng. Her	bert De Gersem	
1	1 Teaching content					
	<ul> <li>Basics of electric machine theory</li> <li>lassification of electric machine types</li> <li>Basic principles of electric machine modelling and simulation</li> <li>Embedding material models</li> <li>Geometry approximation and field modelling</li> <li>Field-circuit coupling and transient simulation</li> <li>Finite elements for multiphysics</li> <li>Optimization methods</li> <li>Simulation environments</li> <li>Laboratory measurements on electric machines</li> </ul>					
2	Learning of The students They know to results. They are able to sp and eventual	<b>ojectives</b> s get acquainted with the strengths and we v consider electromag pecify the virtual pro lly solve the problem	modern technique eaknesses of availa gnetic fields and th totyping problem as, including appli	es for modelling, sir able design tools as neir coupling to str , choose the approp cation of modern o	nulating and optimizind are able to critica uctural, thermo- and priate simulation tool ptimization technique	ing electric machines. lly assess simulation fluiddynamics. They ls, set up the models, les.
3	<b>Recommend</b> Basics of fiel linear algebr	<b>ded prerequisites fo</b> d and circuit simula <sup>r</sup> a.	<b>r participation</b> tion, electromagn	etic field theory, ba	asics of partial differ	ential equations and
4	Form of exa Module exar • Modul The grade co	<b>mination</b> n: e exam (Technical ex onsists of a report an	amination, Oral/ d a presentation f	written examinatio ollowed by a quest	n, Default RS) ion and answer session	on.
5	Prerequisite Passing the f	e for the award of c	redit points			
6	<ul> <li>6 Grading Module exam:</li> <li>• Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>					
7	7 Usability of the module MSc etit, BSc/Msc iST, MSc MEC, MSc CE					
8	Grade bonu	s compliant to §25	(2)			
9	References					

- Lecture slides.
- J.P. Bastos, Electromagnetic Modeling by Finite Element Methods, Marcel Dekker Ltd. 2003.
- N. Bianchi, Electrical Machine Analysis Using Finite Elements, Taylor & Francis, 2005.
- J. Frochtze, Finite-Elemente-Methode, Hanser, 2021.
- M. Kaltenbacher, Numerical Simulation of Mechatronic Sensors and Actuators: Finite Elements for Computational Multiphysics, Springer, 2015.
- S. Salon, Finite Element Analysis of Electrical Machines, Kluwer, 1995.

## Courses

000	1000			
	Course nr.Course name18-dg-2190-vlVirtual Prototyping of Electric Drives - Lecture			
InstructorTypeProf. DrIng. Herbert De Gersem, Prof. Dr. rer. nat. Sebastian SchöpsLecture				SWS 2
	<b>Course nr.</b> 18-dg-2190-pr	<b>Course name</b> Virtual Prototyping of Electric Drives - Laboratory		
	<b>Instructor</b> Prof. Dr. Annette Manfred Kaltenb	<b>Type</b> Internship	SWS 2	

## 2.4 Optional Subjects AIS-MT: Medical Technics

Mo Vist	Module name Visualization in Medicine					
<b>Mo</b> 20-	<b>dule nr.</b> 00-0467	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module duration 1 Term	Module cycle Every 2. Semester
Lan Ger	<b>iguage</b> man	I	I	Module owner Prof. Dr. Bernt Sc	hiele	
1	1 <b>Teaching content</b> Medical Image Data; Image Processing; Medical Visualization with VTK; Indirect Volume Visualization; Direct Volume Visualization; Transfer Functions; Interactive Volume Visualization; Illustrative Rendering; Example: Visualization of Tensor Image Data; Example: Visualization of Tree Structures; Example: Virtual Endoscopy; Image-guided Surgery					
2	<ul> <li>2 Learning objectives         After successfully attending the course, students are familiar with volume visualization techniques. They understand the necessity of image enhancement for the visualization. They can use the "Visualization Toolkit" (VTK) to apply the techniques to implement computing systems for the visualization of medical image data for diagnosis, planning and therapy.     </li> </ul>					
3	<b>Recommen</b> Useful but n	<b>ded prerequisites fo</b> ot mandatory: GDV	or participation I, (Medical) Image	e processing		
4	Form of exa Course relat • [20-00	<b>mination</b> ed exam: )-0467-iv] (Technical	examination, Ora	al/written examina	tion, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0467-iv] (Technical	examination, Ora	al/written examina	tion, Weighting: 100	%)
7	<ul> <li>7 Usability of the module <ul> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> <li>B.Sc. Computational Engineering</li> <li>M.Sc. Computational Engineering</li> <li>M.Sc. Wirtschaftsinformatik</li> <li>B.Sc. Psychologie in IT</li> <li>Joint B.A. Informatik</li> <li>B.Sc. Sportwissenschaft und Informatik</li> <li>M.Sc. Sportwissenschaft und Informatik</li> </ul></li></ul>					
0	Can be used	in other degree prog	grams.			
8	<ul> <li>Grade bonus compliant to §25 (2)</li> <li>In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2) der 5.</li> <li>Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.</li> </ul>					
9	<b>References</b> Preim, Both	a: Visual Computing	for Medicine			

Co	Courses							
	<b>Course nr.</b> 20-00-0467-iv	Course name Medical Visualization						
	Instructor		<b>Type</b> Integrated course	SWS 4				

Mo Me	Module name Measurement Technology						
<b>Mo</b> 18-	<b>dule nr.</b> kn-1010	Credit points 4 CP	Workload 120 h	Self-study 75 h	Module duration	Module cy Summer te	<b>cle</b> rm
Lar Ger	<b>iguage</b> man			<b>Module owner</b> Prof. Dr. Mario K	upnik		
1	ITeaching contentExtent and Meaning of electrical measurement technology, units and measurement systems, description of measurement systems and signals, systematic and stochastic errors, relative and reduced errors, measurement uncertainty, analogue measurement of electrical parameter, power measurement in single- and three-phase systems, impedance measurements, use of oscilloscopes, measurement amplifier and filter, signal conversion (ADC, DAC), frequency and time measurements, data handling, digital data acquisition.						
2	Learning objectives Students know the configuration and properties of electric and electronic measurement equipment and circuits and are able to apply them to measurement tasks. They know the basics of data aquisition, handling, transmission and storage and are able to describe and quantify measurement errors.						
3	<b>Recommend</b> ETiT I & II, N	<b>led prerequisites fo</b> Aathematics I-III	or participation				
4	Form of exa Module exar • Module	<b>mination</b> n: e exam (Technical ex	xamination, Exam	ination, Duration:	90 Min., Default RS)	)	
5	<b>Prerequisite</b> Passing the f	for the award of c	<b>redit points</b> ation				
6	Grading Module exan • Module	n: e exam (Technical ez	xamination, Exam	ination, Weighting	: 100 %)		
7	Usability of BSc ETiT, BS	<b>the module</b> c WI-ETiT, BSc MEC	2				
8	Grade bonu	s compliant to §25	(2)				
9	<b>References</b> Slides, Textb	ook Lerch: "Elektris	che Messtechnik",	Springer			
Co	urses						
	<b>Course nr.</b> 18-kn-1011-	vl Course name Measuring Tec	hnique				
	Instructor Prof. Dr. Mai	io Kupnik			<b>Type</b> Lecture		SWS 2
	<b>Course nr.</b> 18-kn-1011-	Course name ue Measuring Tec	hnique				
	Instructor Prof. Dr. Mai	io Kupnik			<b>Type</b> Practice		<b>SWS</b> 1

Mo	dule name	1 1 7 1				
Me	asurement Te	chnology Lab	Martilaad	Colf atu da	Modulo duration	Madula avala
18-1	<b>dule nr.</b> kn-1031	3 CP	90 h	Self-study 60 h	1 Term	Summer term
Lar Ger	i <b>guage</b> man			Module owner Prof. Dr. Mario Kupnik		
1	Teaching co	ontent				
	<ul> <li>Measuring signals in the time domain using digital storage oscilloscopes, trigger constraints</li> <li>Measuring signals in the frequency domain using digital storage oscilloscopes, measuring errors (alias- ing/under sampling, leackage) and window functions</li> <li>Measuring mechanical quantities with appropriate sensors, sensor electronics/amplifier circuits</li> <li>Computer-based measurements and ultrasound sensors</li> <li>Read and process sensor signals and control an automated process using a programmable logic controller (PLC)</li> <li>First experiments with robotic and medical robots for insertion of needles</li> </ul>					
2	Learning objectives         After having successfully completed the course participants are familiar with the use of measuring devices, sensors and electronics. They know about restrictions and possible measuring errors. Also, participants enhance their knowledge of time- and frequency-domain and the connections between both by the oscilloscope measurements. Regarding methodical skills participants are able to record measurement results during laboratory work and to interpret the measured data afterwards.         Resemmended processing					
3	Recomment Electrical En	ded prerequisites for a second s	or participation nation Technology	/ I and II		
4	Form of exa Module exam • Modul The examina and/or an C beginning or	mination n: e exam (Study achie ation has the form of oral examination and, f the lecture.	vement, Oral/wri a Report (includi /or a Colloquium	tten examination, p ng submission of p (testate). The type	o/np RS) rogramming code) ar of examination will	nd/or a Presentation be announced in the
5	Prerequisite Passing the	e <b>for the award of c</b> final module examina	<b>redit points</b> ation			
6	Grading Module exan • Modul	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Veighting: 100 %)	
7	Usability of BSc ETiT, BS	the module Sc MEC, BSc CE, BSc	WI-ETiT			
8	Grade bonu	is compliant to §25	(2)			
9	References					
	<ul> <li>Script of the practical course</li> <li>Lerch, Reinhard: Elektrische Messtechnik : Analoge, digitale und computergestützte Verfahren. 5. neu bearbeitete Auflage. Berlin: Springer, 2010 ISBN 978-3642054549</li> </ul>					
Coι	ırses					

<b>Course nr.</b> 18-kn-1031-pr	<b>Course name</b> Measuring Technique Lab		
<b>Instructor</b> Prof. Dr. Mario K	upnik	<b>Type</b> Internship	<b>SWS</b> 2

Mo Bio	dule name						
<b>Mo</b> 10-	<b>dule nr.</b> 30-0036	<b>Credit points</b> 4 CP	Workload 120 h	Self-study 60 h	<b>Module duration</b> 1 Term	Module cycl Every 2. Sen	<b>le</b> nester
Lar Ger	<b>nguage</b> rman			Module owner		<u> </u>	
1	Teaching co	ntent					
2	Learning ob	jectives					
3	Recommend	led prerequisites fo	or participation				
4	Form of exa Module exan • Module	mination n: e exam (Technical ex	camination, Oral e	examination, Defau	ılt RS)		
5	Prerequisite for the award of credit points Passing the final module examination						
6	Grading Module exan • Module	n: e exam (Technical ex	camination, Oral e	examination, Weigl	hting: 100 %)		
7	Usability of	the module					
8	Grade bonu	s compliant to §25	(2)				
9	References						
Cot	urses						
	<b>Course nr.</b> 10-01-0036-	Course namevlBio Informatic	s-Lecture				
	Instructor				<b>Type</b> Lecture		SWS 2
	<b>Course nr.</b> 10-01-0036-s	Se Bio Informatic	s-Exercise				
	Instructor	Instructor Type SWS Practice 2					

Mo Cui	<b>dule name</b> rrent Trends i	n Medical Computing	y			
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
Lar	nguage	3 (P	90 h	Module owner		
1	<ul> <li>Teaching content         <ul> <li>Participants independently familiarize themselves with a chosen seminar topic by working with the provided initial scientific papers (usually English-language texts)</li> <li>Deeper and/or wider library research originating from the initially provided papers</li> <li>Critical discussion of the provided topic</li> <li>Preparation of a presentation (written text and slides) about the topic</li> <li>Giving a talk in front of a heterogenous (mixed prior knowledge) audience</li> <li>Interactive discussion after the presentation</li> <li>Medical application areas include oncology, orthopedics and navigated surgery.</li> <li>Learning about methods related to medical image processing: segmentation, registration, visualization, simulation, navigation, tracking and others.</li> </ul> </li> <li>Learning objectives</li> </ul>					
2	2 Learning objectives Successful participation in the course enables students to become acquainted with an unfamilar topic by working with scientific papers. They recognize the essential aspects of the examined works and are able to concisely present them to an audience with mixed prior knowledge on the subject. They apply a number of presentation techniques in the process. The students are able to actively guide and participate in a scientific discussion on the presented topic.					
3	<b>Recommen</b> Bachelor fro	ded prerequisites for om 4. Semester or Ma	or participation aster students.			
4	Form of exa Course relat • [20-00	amination ted exam: D-0468-se] (Study ac	hievement, Oral/v	vritten examination	n, Default RS)	
5	<b>Prerequisit</b> Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ted exam: D-0468-se] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %)	)
7	Usability of B.Sc. Inform M.Sc. Inform B.Sc. Comp M.Sc. Comp M.Sc. Wirts B.Sc. Psycho Joint B.A. In B.Sc. Sporty M.Sc. Sporty Can be used	f <b>the module</b> natik natik utational Engineering outational Engineerin chaftsinformatik ologie in IT nformatik wissenschaft und Info wissenschaft und Info	g g ormatik ormatik grams.			
8	Grade bonu	is compliant to §25	(2)			

9	<b>References</b> Will be announced in seminar.				
Co	Courses				
	<b>Course nr.</b> 20-00-0468-se	<b>Course name</b> Aktuelle Trends im Medical Computing			
	Instructor		<b>Type</b> Seminar	SWS 2	

Mo Mic	Module name Microsystem Technology						
<b>Mo</b>	<b>dule nr.</b> bu-2010	Credit points 4 CP	Workload 120 h	Self-study 75 h	Module duration	Module cyc Winter tern	cle
Lar Ger	nguage rman		120 11	Module owner Prof. Ph.D. Thomas Burg			
1	1 <b>Teaching content</b> Students are able to explain the structure and function of microsystemes for common applications (e.g. pressure sensors, accelerometers, biological and chemical sensors, micro-optical systems), calculate design parameters to achieve given specifications, and to judge the impact of scaling on the device performance. They can select appropriate materials, devise basic fabrication process flows, and identify compatibility issues between processes and/or materials.						
2	2 Learning objectives Students are able to explain the structure and function of microsystemes for common applications (e.g. pressure sensors, accelerometers, biological and chemical sensors, micro-optical systems), calculate design parameters to achieve given specifications, and to judge the impact of scaling on the device performance. They can select appropriate materials, devise basic fabrication process flows, and identify compatibility issues between processes and/or materials.						
3	Recommend	led prerequisites fo	or participation				
4	Form of exa Module exan • Module	<b>mination</b> n: e exam (Technical e:	xamination, Exam	ination, Duration:	90 Min., Default RS)		
5	<b>Prerequisite</b> Passing the f	for the award of c	<b>redit points</b> ation				
6	Grading Module exam • Module	n: e exam (Technical e:	xamination, Exam	ination, Weighting	: 100 %)		
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> Sc MEC, MSc WI-ET	TiT, MSc Medizinte	echnik			
8	Grade bonu Up to 1.0 de	s compliant to §25 pending on problem	(2) sets and course p	articipation			
9	References Lecture note	s, Moodle course					
Co	urses	·					
	<b>Course nr.</b> 18-bu-2010-	Course namevlMicrosystem T	echnology				
	<b>Instructor</b> Prof. Ph.D. T	homas Burg			<b>Type</b> Lecture		SWS 2
	<b>Course nr.</b> 18-bu-2010-	Le Microsystem T	echnology				
	<b>Instructor</b> Prof. Ph.D. T	homas Burg			<b>Type</b> Practice		<b>SWS</b> 1

Se	Module name Sensor Technique						
<b>M</b> o 18	odule nr. -kn-2120	Credit points 4 CP	Workload 120 h	Self-study 75 h	Module duration 1 Term	Module cycle Winter term	
La Ge	<b>nguage</b> rman	1		<b>Module owner</b> Prof. Dr. Mario K	upnik	1	
1	<ul> <li>Teaching content         The module teaches basic principles of different sensors and the required knowledge for correct application of sensors. With regard to the measurement chain, the focus of the course is on the conversion of any, generally non-electrical quantities into electrically evaluable signals.     Resistive, capacitive, inductive, piezoelectric, optical, and magnetic measurement principles are covered in the module to provide knowledge of the measurement of important quantities such as force, torque pressure, acceleration, velocity, displacement, and flow. In addition to a phenomenological description of the principles and a derived technical description, the main elements of primary and secondary electronics for each measurement principle will also be presented and understood.     In addition to the measurement principles, the description of errors will be dealt with. In addition to static and dynamic errors, errors in signal processing and error consideration of the entire measurement chain will be discussed. In the exercises the method of peer instruction is utilized.     </li> </ul>						
2	Learning objectives The Students acquire knowledge of the different measuring methods and their advantages and disadvantages. They can understand error in data sheets and descriptions interpret in relation to the application and are thus able to select a suitable sensor for applications in electronics and information, as well process technology and to apply them correctly.						
3	Recomment Measuring T	<b>ded prerequisites fo</b> Technique	r participation				
4	Form of exa Module exa • Modul	amination m: le exam (Technical ex	amination, Exam	ination, Duration:	90 Min., Default RS)		
5	Prerequisite Passing the	e for the award of c final module examina	r <b>edit points</b> ation				
6	Grading Module exa • Modul	m: le exam (Technical ex	amination, Exam	ination, Weighting	: 100 %)		
7	Usability of MSc ETiT, N	<b>the module</b> ISc WI-ETiT, MSc ME	EC, MSc Medizinte	echnik			
8	Grade bonu	is compliant to §25	(2)				
9 Co	<ul> <li>References</li> <li>Slide set of lecture</li> <li>Script of lecture</li> <li>Textbook Tränkler "Sensortechnik", Springer</li> <li>Exercise script</li> </ul>						

<b>Course nr.</b> 18-kn-2120-vl	Course name Sensor Technique		
<b>Instructor</b> Prof. Dr. Mario Kupnik		<b>Type</b> Lecture	<b>SWS</b> 2
<b>Course nr.</b> 18-kn-2120-ue	Course name Sensor Technique		
Instructor Prof. Dr. Mario K	Tupnik	<b>Type</b> Practice	<b>SWS</b> 1

Mo Dee	Module name Deep Learning for Medical Imaging							
Mo	dule nr.	Credit points	Workload	Self-study	Module o	duration	Module cyc	cle
Lar	nguage	5 Cr	150 11	Module owner				illester
Eng	glish			Prof. DrIng. Mic	chael Gösel	e		
1	<b>Teaching co</b> Formulating Problems, De Planning fro videos using Medical Ima	ontent Medical Image Segm eep Learning for Med m pre-surgical image g Deep learning, Adv ging.	entation, Compute ical Image Segmen s using Deep Learn rersarial Examples	er Aided Diagnosis a tation, Deep Learni ing, Tool presence s for Medical Imag	and Surgica ing for Com detection a ing, Genera	ll Planning Iputer Aide nd localiza ative Adve	as Machine Lo d Diagnosis, S tion from end rsarial Netwo	earning Surgical oscopic orks for
2	2 Learning objectives After successful completion of the course, students should be able to understand all components of formulating a Medical Image Analysis problem as a Machine Learning problem. They should also be able to make informed decision of choosing a general purpose deep learning paradigm for given medical image analysis problem.							
3	Recommended prerequisites for participation         - Programming skills         - Understanding of Algorithmic design         - Linear Algebra         - Image Processing / Computer Vision I         - Statistical Machine Learning							
4	Form of exa Course relat • [20-00	mination ed exam: )-1014-iv] (Technica	l examination, Ora	al/written examina	ition, Defai	ult RS)		
5	Prerequisite Pass exam (2	e for the award of c 100%)	redit points					
6	Grading Course relat • [20-00	ed exam: )-1014-iv] (Technica	l examination, Ora	al/written examina	tion, Weig	hting: 100	%)	
7	<b>Usability of</b> B.Sc. Inform M.Sc. Inform May be used	<b>the module</b> natik natik l in other degree pro	grams.					
8	<b>Grade bonu</b> In dieser Vor Novelle der A um bis zu 1.	is compliant to §25 rlesung findet eine A APB und den vom FB 0 führen kann.	(2) Inrechnung von vo 20 am 30.3.2017 b	orlesungsbegleitend eschlossenen Anrec	den Leistur chnungsreg	ngen statt, eln zu eine	die lt. 25 (2 er Notenverbe	) der 5. sserung
9	References							
Cou	urses							
	<b>Course nr.</b> 20-00-1014-	iv Deep Learning	g for Medical Imag	ing				
	Instructor Prof. DrIng	. Michael Gösele				<b>Type</b> Integrate	d course	<b>SWS</b> 3

Mo Art	Module name Artificial Intelligence in Medicine Challenge						
<b>Mo</b>	<b>dule nr.</b> ha-2010	Credit points	Workload 240 h	Self-study	Module duration	Module cyc	<b>cle</b>
Lar	nguage man	0.01	21011	Module owner Prof. DrIng. Chr	istoph Hoog Antink		
1	<b>Teaching content</b> Within this module, students will work independently in small groups on a given problem from the realm of artificial intelligence (AI) in medicine. The nature of the problem can be the automatic classification or prediction of a disease from medical signals or data, the extraction of a physiological parameter, etc. All groups will be given the same problem but will have to develop their own algorithms, which will be evaluated on a hidden dataset. In the end, a ranking of the best-performing algorithms is provided.						
2	Learning ob Students car have success Graduates ar	<b>jectives</b> a independently app fully independently e enabled to apply r	oly current AI / m developed, optimi nethodological con	achine learning m ized and tested coc mpetencies, such as	ethods to solve med le that has withstood s teamwork, in every	lical problem: l external eva ⁄day professio	s. They lluation. mal life.
3	Recommended prerequisites for participation         • Basic programming skills in Python         • 18-zo-1030 Fundamentals of Signal Processing						
4	Form of exam Module exam • Module Report and/o	<b>mination</b> n: e exam (Study achie or Presentation. The	vement, Oral/writ type of examinat	tten examination, I ion will be announ	Default RS) ced in the beginning	g of the lecture	е.
5	<b>Prerequisite</b> Passing the f	for the award of c	<b>redit points</b> ation				
6	Grading Module exan • Module	n: e exam (Study achie	vement, Oral/writ	tten examination, V	Weighting: 100 %)		
7	<b>Usability of</b> MSc (WI-) et	<b>the module</b> it, BSc/MSc iST, MS	Sc iCE, MSc MEC,	MSc MedTec			
8	Grade bonus	s compliant to §25	(2)				
9	References						
	<ul> <li>Friedman, Jerome, Trevor Hastie, and Robert Tibshirani. The elements of statistical learning. Vol. 1. No. 10. New York: Springer series in statistics, 2001.</li> <li>Bishop, Christopher M. Pattern recognition and machine learning. springer, 2006.</li> </ul>						
Cot	urses	Courses					
	Course nr. 18-ha-2010-j	oj Artificial Intell	igence in Medicin	e Challenge			
	Instructor Prof. DrIng.	Christoph Hoog An	tink		<b>Type</b> Project s	eminar	SWS 4

Module nr. 18-fr-2020         Credit points 8 CP         Workload 240 h         Self-study 180 h         Module duration 1 Term         Module cy Every Sem           Language German/English         Module owner Prof. Dr. habil. Torsten Frosch         Every Sem           1         Teaching content This module is based on practical work on current, promising and trend-setting topics in biophotonics. J on applications of optical spectroscopy and microscopy in medical technology. Students will gain a deepe into practical work with lasers, optics, spectrometers, microscopes, etc. Participation in current research are possible, depending on the number of participants. The experimental results are evaluated using a techniques and methods of data processing and statistics and are documented in reports following s standards.           2         Learning objectives After successful completion of this module, students will be able to analyze and evaluate biophotonic: and techniques. In addition, they have learned to plan and implement their own projects independe collaborate in teams. They are able to apply experimental skills and advanced techniques and method analysis. Depending on the task, students learn to independently analyze, improve, or build up optic from scratch. In addition, it is possible to program software for controlling devices and to analyze in relevant samples. Furthermore, the measurement results are evaluated, presented, and interpreted in a context. With the gained knowledge, students are able to critically analyze existing setups or instrum develop their own approaches. In addition, students gain experience in preparing written reports acc scientific standards. They also practice presenting their work results to a professional or lay audience.           3         Recommended prerequisit	<b>Modu</b> Projec	ule name ect Seminar l	Biophotonics				
18-11-2020       0 CP       240 it       18-11 Tellin       Evely Sen         Language       Module owner       Prof. Dr. habil. Torsten Frosch         1       Teaching content       This module is based on practical work on current, promising and trend-setting topics in biophotonics. I on applications of optical spectroscopy and microscopy in medical technology. Students will gain a deeper into practical work with lasers, optics, spectrometers, microscopes, etc. Participation in current research are possible, depending on the number of participants. The experimental results are evaluated using a techniques and methods of data processing and statistics and are documented in reports following standards.         2       Learning objectives         After successful completion of this module, students will be able to analyze and evaluate biophotonic : and techniques. In addition, they have learned to plan and implement their own projects independe collaborate in teams. They are able to apply experimental skills and advanced techniques and method analysis. Depending on the task, students learn to independently analyze, improve, or build up optics from scratch. In addition, it is possible to program software for controlling devices and to analyze a context. With the gained knowledge, students are able to critically analyze existing setups or instrum develop their own approaches. In addition, students gain experience in preparing written reports acc scientific standards. They are participation         Module Basics of Optics for Biomedical Engineering       4         Form of examination       Module exam:         • Module exam:       • Module exam (Study achievement, Oral/written examination, Default RS	Modu	ule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
German/English       Prof. Dr. habil. Torsten Frosch         1       Teaching content         This module is based on practical work on current, promising and trend-setting topics in biophotonics. I on applications of optical spectroscopy and microscopy in medical technology. Students will gain a deepe into practical work with lasers, optics, spectrometers, microscopes, etc. Participation in current research are possible, depending on the number of participants. The experimental results are evaluated using a techniques and methods of data processing and statistics and are documented in reports following standards.         2       Learning objectives         After successful completion of this module, students will be able to analyze and evaluate biophotonic: and techniques. In addition, they have learned to plan and implement their own projects independe collaborate in teams. They are able to apply experimental skills and advanced techniques and method analysis. Depending on the task, students learn to independently analyze, improve, or build up optics from scratch. In addition, it is possible to program software for controlling devices and to analyze a context. With the gained knowledge, students are able to critically analyze existing setups or instrum develop their own approaches. In addition, students gain experience in preparing written reports acc scientific standards. They also practice presenting their work results to a professional or lay audience.         3       Recommended prerequisites for participation Module exam:         •       Module dexam:         •       Module exam:         •       Module exam:         •       Module exam (Study achievement, Oral/written exami	Lang	-2020 uage	8 CP	240 II	Module owner		
<ul> <li>Teaching content         <ul> <li>The module is based on practical work on current, promising and trend-setting topics in biophotonics. I on applications of optical spectroscopy and microscopy in medical technology. Students will gain a deepe into practical work with lasers, optics, spectrometers, microscopes, etc. Participation in current research are possible, depending on the number of participants. The experimental results are evaluated using a techniques and methods of data processing and statistics and are documented in reports following standards.</li> </ul> </li> <li>Learning objectives         <ul> <li>After successful completion of this module, students will be able to analyze and evaluate biophotonic : and techniques. In addition, they have learned to plan and implement their own projects independe collaborate in teams. They are able to apply experimental skills and advanced techniques and method analysis. Depending on the task, students learn to independently analyze, improve, or build up optic from scratch. In addition, it is possible to program software for controlling devices and to analyze an context. With the gained knowledge, students are able to critically analyze existing setups or instrum develop their own approaches. In addition, students gain experience in preparing written reports accessicatific standards. They also practice presenting their work results to a professional or lay audience.</li> </ul> </li> <li>Recommended prerequisites for participation Module exam:         <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> <li>Report and/or Presentation. The type of examination will be announced in the beginning of the lectum Passing the final module examination</li> <li>Grading</li> <li>Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</li> </ul> </li> <li>Vasability of the module                 M</li></ul>	Germ	an/English			Prof. Dr. habil. To	orsten Frosch	
<ul> <li>2 Learning objectives         After successful completion of this module, students will be able to analyze and evaluate biophotonic i and techniques. In addition, they have learned to plan and implement their own projects independe collaborate in teams. They are able to apply experimental skills and advanced techniques and method, analysis. Depending on the task, students learn to independently analyze, improve, or build up optica from scratch. In addition, it is possible to program software for controlling devices and to analyze n relevant samples. Furthermore, the measurement results are evaluated, presented, and interpreted in a context. With the gained knowledge, students are able to critically analyze existing setups or instrumidevelop their own approaches. In addition, students gain experience in preparing written reports accossicientific standards. They also practice presenting their work results to a professional or lay audience.     </li> <li>3 Recommended prerequisites for participation         <ul> <li>Module Basics of Optics for Biomedical Engineering</li> <li>4 Form of examination                 Module exam (Study achievement, Oral/written examination, Default RS)                 Report and/or Presentation. The type of examination will be announced in the beginning of the lectus         </li> </ul> </li> <li>5 Prerequisite for the award of credit points         <ul> <li>Passing the final module examination</li> <li>6 Grading                 Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</li> </ul> </li> <li>7 Usability of the module         <ul> <li>Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</li> </ul> </li> <li>9 References         <ul> <li>Current scientific literature is recommended separately for the individual experiments. The following beserve as a general reference:                <ul></ul></li></ul></li></ul>	1 T T o iii a t s	<b>Teaching co</b> This module on applicatio into practica are possible, techniques <i>a</i> standards.	ontent is based on practical ons of optical spectros l work with lasers, op depending on the nu and methods of data	work on current, copy and microsco otics, spectrometer umber of participa processing and s	promising and tren opy in medical techn rs, microscopes, etc. ants. The experiment tatistics and are do	d-setting topics in bio nology. Students will . Participation in curr ntal results are evalu ocumented in reports	ophotonics. We focus gain a deeper insight ent research projects ated using advanced s following scientific
<ul> <li>3 Recommended prerequisites for participation Module Basics of Optics for Biomedical Engineering</li> <li>4 Form of examination Module exam: <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture</li> </ul> </li> <li>5 Prerequisite for the award of credit points Passing the final module examination</li> <li>6 Grading Module exam: <ul> <li>Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</li> </ul> </li> <li>7 Usability of the module MSc etit, WI-etit, MSc MEC, MSc Physics, MSc Chemistry, MSc Biomolecular Engineering</li> <li>8 Grade bonus compliant to §25 (2)</li> <li>9 References Current scientific literature is recommended separately for the individual experiments. The following beserve as a general reference: <ul> <li>Kramme, Medizintechnik - Kapitel Biomedizinische Optik (Biophotonik), Springer</li> <li>Gerd Keiser, Biophotonics: Concepts to Applications, Springer</li> </ul> </li> </ul>	2 I A a c c a f f r r c d d s	After successful completion of this module, students will be able to analyze and evaluate biophotonic methods and techniques. In addition, they have learned to plan and implement their own projects independently and collaborate in teams. They are able to apply experimental skills and advanced techniques and methods of data analysis. Depending on the task, students learn to independently analyze, improve, or build up optical setups from scratch. In addition, it is possible to program software for controlling devices and to analyze medically relevant samples. Furthermore, the measurement results are evaluated, presented, and interpreted in a scientific context. With the gained knowledge, students are able to critically analyze existing setups or instruments and develop their own approaches. In addition, students gain experience in preparing written reports according to scientific standards. They also practice presenting their work results to a professional or lay audience. <b>Recommended prerequisites for participation</b> Module Basics of Optics for Biomedical Engineering					
<ul> <li>Form of examination Module exam: <ul> <li>Module exam:</li> <li>Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture</li> </ul> </li> <li>Prerequisite for the award of credit points Passing the final module examination</li> <li>Grading Module exam: <ul> <li>Module exam:</li> <li>Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</li> </ul> </li> <li>7 Usability of the module MSc etit, WI-etit, MSc MEC, MSc Physics, MSc Chemistry, MSc Biomolecular Engineering</li> <li>8 Grade bonus compliant to §25 (2)</li> <li>9 References Current scientific literature is recommended separately for the individual experiments. The following beserve as a general reference: <ul> <li>Kramme, Medizintechnik - Kapitel Biomedizinische Optik (Biophotonik), Springer</li> <li>Gerd Keiser, Biophotonics: Concepts to Applications, Springer</li> </ul> </li> </ul>	3 F N	Recommended prerequisites for participation Module Basics of Optics for Biomedical Engineering					
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<ul> <li>6 Grading Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</li> <li>7 Usability of the module MSc etit, WI-etit, MSc MEC, MSc Physics, MSc Chemistry, MSc Biomolecular Engineering</li> <li>8 Grade bonus compliant to §25 (2)</li> <li>9 References Current scientific literature is recommended separately for the individual experiments. The following be serve as a general reference: • Kramme, Medizintechnik - Kapitel Biomedizinische Optik (Biophotonik), Springer</li> <li>• Gerd Keiser, Biophotonics: Concepts to Applications, Springer</li> </ul>	5 P P	Prerequisite Passing the f	e for the award of cr	redit points ation			
<ul> <li>7 Usability of the module MSc etit, WI-etit, MSc MEC, MSc Physics, MSc Chemistry, MSc Biomolecular Engineering</li> <li>8 Grade bonus compliant to §25 (2)</li> <li>9 References Current scientific literature is recommended separately for the individual experiments. The following be serve as a general reference: <ul> <li>Kramme, Medizintechnik - Kapitel Biomedizinische Optik (Biophotonik), Springer</li> <li>Gerd Keiser, Biophotonics: Concepts to Applications, Springer</li> </ul> </li> </ul>	6 C	G <b>rading</b> Module exar • Modul	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 100 %)	
<ul> <li>8 Grade bonus compliant to §25 (2)</li> <li>9 References <ul> <li>Current scientific literature is recommended separately for the individual experiments. The following be serve as a general reference: <ul> <li>Kramme, Medizintechnik - Kapitel Biomedizinische Optik (Biophotonik), Springer</li> <li>Gerd Keiser, Biophotonics: Concepts to Applications, Springer</li> </ul> </li> </ul></li></ul>	7 U N	<b>Usability of</b> MSc etit, WI	<b>the module</b> -etit, MSc MEC, MSc	: Physics, MSc Che	emistry, MSc Biomo	olecular Engineering	
<ul> <li>9 References</li> <li>Current scientific literature is recommended separately for the individual experiments. The following be serve as a general reference:         <ul> <li>Kramme, Medizintechnik - Kapitel Biomedizinische Optik (Biophotonik), Springer</li> <li>Gerd Keiser, Biophotonics: Concepts to Applications, Springer</li> </ul> </li> </ul>	8 0	Grade bonu	s compliant to §25	(2)			
<ul> <li>Lorenzo Pavesi, Philippe M. Fauchet, Biophotonics, Springer</li> <li>Jürgen Popp, Valery V. Tuchin, Arthur Chiou, Stefan H. Heinemann, Handbook of Biophotonics, W.</li> </ul>	9 F C S	<ul> <li>Grade bonus compliant to §25 (2)</li> <li>References <ul> <li>Current scientific literature is recommended separately for the individual experiments. The following books can serve as a general reference: <ul> <li>Kramme, Medizintechnik - Kapitel Biomedizinische Optik (Biophotonik), Springer</li> <li>Gerd Keiser, Biophotonics: Concepts to Applications, Springer</li> <li>Lorenzo Pavesi, Philippe M. Fauchet, Biophotonics, Springer</li> <li>Jürgen Popp, Valery V. Tuchin, Arthur Chiou, Stefan H. Heinemann, Handbook of Biophotonics, Wiley-VCH</li> </ul> </li> </ul></li></ul>					

<b>Course nr.</b> 18-fr-2020-pj	<b>Course name</b> Project Seminar Biophotonics		
<b>Instructor</b> Prof. Dr. habil. Te	orsten Frosch	<b>Type</b> Project seminar	SWS 4

<b>Mo</b> F117	dule name	iral Networks and Ex	olutionary Algorit	hms				
<b>Mo</b>	<b>dule nr.</b> ad-2020	Credit points	Workload 120 h	Self-study 75 h	Module d	luration	Module cyc	cle
Lar Ger	nguage rman		120 11	Module owner Prof. DrIng. Jürg	gen Adamy	7		
1	<b>Teaching co</b> Fuzzy system nition, diagn identification rule generat genetic prog	ontent ns: basics, rule base nosis; Neural networ n, control, interpolati ion; Evolutionary alg gramming and its app	d fuzzy logic, desi ks: basics, multila on and approxima orithms: optimiza plications	gn methods, decis yer perceptrons, ra tion, Neuro-fuzzy: tion problems, evol	ion making adial basis optimizatio utionary st	g, fuzzy co functions, on of fuzzy crategies a	ntrol, pattern pattern reco systems, data nd their appli	n recog- gnition, a driven cations,
2	<ul> <li>Learning objectives</li> <li>After attending the module, a student is capable of: <ul> <li>recalling the elements and set-up of standardized fuzzy-logic, neural networks and evolutionary algorithms,</li> <li>discussing the pros and cons of certain set- ups of systems from computational intelligence for solving a given problem,</li> <li>recognizing situations in which tools taken from computational intelligence can be applied for problem solving,</li> <li>creating programs from algorithms taught in the lecture, and</li> <li>extending the learned standard procedures in order to solve new problems.</li> </ul> </li> </ul>							
3	Recommended prerequisites for participation							
4	Form of exa Module exa • Modul	<b>amination</b> m: e exam (Technical ez	xamination, Exam	ination, Duration:	90 Min., D	efault RS)		
5	<b>Prerequisit</b> Passing the	e <b>for the award of c</b> final module examin	<b>redit points</b> ation					
6	Grading Module exan • Modul	m: e exam (Technical ex	xamination, Exam	ination, Weighting	: 100 %)			
7	Usability of BSc iST, MS	<sup>c</sup> <b>the module</b> c ETiT, MSc MEC, M	Sc WI-ETiT, MSc i	CE, MSc EPE, MSc	CE, MSc Ii	nformatik		
8	Grade bonu	is compliant to §25	(2)					
9	9 References Adamy: Fuzzy Logik, Neuronale Netze und Evolutionäre Algorithmen, Shaker Verlag (available for purchase at the FG office)							
Co	urses							
	<b>Course nr.</b> 18-ad-2020-	vl Fuzzy Logic, N	Jeuronal Networks	s and Evolutionary	Algorithms	S		1
	Instructor Prof. DrIng	. Jürgen Adamy				<b>Type</b> Lecture		<b>SWS</b> 2

<b>Course nr.</b> 18-ad-2020-ue	<b>Course name</b> Fuzzy Logic, Neuronal Networks and Evolutionary Algorithm	s	
<b>Instructor</b> Prof. DrIng. Jür	gen Adamy	<b>Type</b> Practice	<b>SWS</b> 1

Mo Pro	<b>dule name</b> ject Seminar	Systems of Biomedic	al Engineering					
<b>Mo</b> 18-	<b>dule nr.</b> ha-2030	Credit points 8 CP	Workload 240 h	Self-study 180 h	Module du 1 Term	iration	Module cyc Every Seme	<b>:le</b> ester
Lar Ger	nguage man/English			<b>Module owner</b> Prof. DrIng. Chi	ristoph Hoog	Antink		
1	<b>Teaching co</b> Within this systems of b software, e.g	ntent nodule, students wo iomedical engineer g. for automated dia	ork independently ing. The focus is o gnosis or therapy.	in small project te on the developmer	eams on indi <sup>,</sup> nt of systems	vidual ta consisti	sks from the ng of hardwa	field of are and
2	2 Learning objectives After completing the module, students will be able to independently abstract the technical requirements for a system in the area of biomedical engineering (e.g. for measuring and evaluating or simulating a physiological process). They can independently derive sub-projects from these requirements and create time schedules. They have successfully developed, optimized and tested a system comprising e.g. hardware and software. Graduates are enabled to apply methodological competencies, such as teamwork, in their everyday professional life.							
3	Recomment Interest in w	led prerequisites for orking independent	o <b>r participation</b> ly on hardware ar	d software				
4	<ul> <li>Form of examination Module exam: <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> <li>Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.</li> </ul></li></ul>							
5	<b>Prerequisite</b> Passing the	e for the award of c	e <b>redit points</b> ation					
6	Grading Module exan • Modul	n: e exam (Study achie	evement, Oral/wri	tten examination, V	Weighting: 1	00 %)		
7	Usability of MSc MedTee	<b>the module</b> c, BSc/MSc iST						
8	Grade bonu	s compliant to §25	(2)					
9	9 References Leonhardt, S., & Walter, M. (Eds.). (2016). Medizintechnische Systeme: Physiologische Grundlagen, Gerätetech- nik und automatisierte Therapieführung. Springer-Verlag.							
Coi	urses							
	<b>Course nr.</b> 18-ha-2030-	pj Project Semin	ar Systems of Bior	nedical Engineerin	g			
	InstructorTypeSWSProf. DrIng. Christoph Hoog AntinkProject seminar4							

Mo Evo	dule name	tems - From Biology	to Technology					
Mo	dule nr.	Credit points	Workload	Self-study	Module o	duration	Module cy	cle
18-	ad-2050	3 CP	90 h	60 h	1 Term		Summer te	rm
Ger	i <b>guage</b> man			Prof. DrIng. Jürg	gen Adamy	ý		
1	<b>Teaching co</b> theory of bio algorithms, rithms, mult algorithms,	ontent ological evolution, in applications, DNA co i-objective optimizati developmental proce	troduction to gen omputing, artificia ion, meta models, esses, self-adaptati	etics, population g al life, theory of evo co-evolution, genet	enetics, po olutionary ic coding, :	opulation g algorithm representa	growth, evolu s, optimizatio tions of evolu	itionary on algo- itionary
2	Learning ol After attend	<b>jectives</b> ing the module, a stu	ident is capable of	f:				
	<ol> <li>understanding the basic principles of evolutionary biology on a systems level,</li> <li>transferring of this knowledge to the technical domain (evolutionary algorithms),</li> <li>applying evolutionary algorithms to hard optimization problems,</li> <li>gaining insight into the potentials and challenges of interdisciplinary research (natural and engineer- ing/computer science).</li> </ol>							
3	Recomment Introductory	<b>ded prerequisites fo</b> courses mathematic	or participation cs. Basic computer	skills.				
4	<ul> <li>Form of examination</li> <li>Module exam:</li> <li>Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)</li> </ul>							
5	Prerequisite Passing the	e <b>for the award of c</b> final module examina	<b>redit points</b> ation					
6	Grading Module exa • Modul	n: e exam (Technical ex	xamination, Oral e	examination, Weigh	nting: 100	%)		
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> ISc MEC, MSc iST, M	ISc WI-ETiT, MSc	iCE, MSc EPE, MSc	c CE, MSc I	Informatik	, Biotechnik	
8	Grade bonu	s compliant to §25	(2)					
9	References							
	<ul> <li>D.J. Futuyama: Evolutionary Biology. W. Henning, Genetik, Springer Verlag</li> <li>D.B. Fogel: Evolutionary Computation, IEEE Press</li> <li>I. Rechenberg: Evolutionsstrategie '94</li> <li>HP. Schwefel: Evolution and Optimum Seeking</li> </ul>							
Coι	ırses							
	<b>Course nr.</b> 18-ad-2050-	vl Evolutionary S	Systems - From Bio	ology to Technology	<i>y</i>			
	Instructor Prof. Dr. rer.	nat. Bernhard Send	hoff			<b>Type</b> Lecture		sws

Mo	dule name					
Mo	nputational M dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
18-	kp-2100	4 CP	120 h	90 h	1 Term	Every Semester
Lar	nguage		·	Module owner		
Eng	glish			Prof. Dr. techn. H	leinz Köppl	
1	Teaching of The Interna- tion in the of USA since 2 competition of computa from all bac Seminar par biochemists of the proje The seminar synthetic bi	ontent tional Genetically Eng lomain of synthetic bi 2004. In the past yea a. This seminar provid tional modeling of bi ekground, but in parti cticipants that are inter for the 2017 IGEM pr ct. cr will cover basic mode ology research results	gineered Machine ology, initiated an ars teams from TU des training for st iomolecular circui cular from electric crested to become roject of TU Darms eling approaches b s and past IGEM p	(IGEM) competition d hosted by the Ma J Darmstadt partic udents and prospec- ts. The seminar ai cal engineering, con IGEM team member stadt and be respon- ut will focus on disc rojects in the doma	a is a yearly internation ssachusetts Institute ipated and were very ctive IGEM team men ms at computational mputer science, phys rs could later team u sible for the computational cussing and presentin ain of computational	onal student competi- of Technology (MIT), y successfully in the mbers in the domain lly inclined students ics and mathematics. p with biologists and ational modeling part ag recent high-impact modeling.
2	<ul> <li>Learning objectives</li> <li>Students that successfully passed that seminar should be able to perform practical modeling of biomolecular circuits that are based on transcriptional and translational control mechanism of gene expression as used in synthetic biology. This relies on the understanding of the following topics: <ul> <li>Differential equation models of biomolecular processes</li> <li>Markov chain models of biomolecular processes</li> <li>Use of computational tools for the composition of genetic parts into circuits</li> <li>Calibration methods of computational models from experimental measurement</li> <li>Use of bioinformatics and database tools to select well-characterized genetic parts</li> </ul> </li> </ul>					
3	Recommen	ded prerequisites fo	or participation			
4	Form of exa Module exa • Modu Report and/ the lecture.	amination m: le exam (Study achie ⁄or Presentation and/	vement, Oral/writ or Colloquium. Th	tten examination, I le type of examinat	Default RS) ion will be announce	d in the beginning of
5	<b>Prerequisit</b> Passing the	e for the award of c final module examina	<b>redit points</b> ation			
6	Grading Module exa • Modu	m: le exam (Study achie	vement, Oral/wri	tten examination, V	Veighting: 100 %)	
7	<b>Usability o</b> BSc etit, MS	f <b>the module</b> Sc etit				
8	Grade bon	is compliant to §25	(2)			
9	References					
Co	urses					

Course nr. 18-kp-2100-se	<b>Course name</b> Computational Modeling for the IGEM Competition		
Instructor Prof. Dr. techn. H	leinz Köppl	<b>Type</b> Seminar	<b>SWS</b> 2

Mo	dulo nomo						
Sig	nal Detection	and Parameter Estim	nation				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
18-: Lar	zo-2050	8 CP	240 h	180 h 1 Term Summer term			
Eng	glish			Prof. DrIng. Abc	lelhak Zoubir		
1	<ul> <li>many common engineering operations under a variety of names. In this course, the theory behind detection and estimation will be presented, allowing a better understanding of how (and why) to design "good" detection and estimation schemes.</li> <li>These lectures will cover: <ul> <li>Fundamentals of Detection and Estimation Theory</li> <li>Hypothesis Testing: <ul> <li>Bayesian/Ideal Observer/Neyman-Pearson Tests</li> <li>Receiver Operating Characteristics</li> <li>Uniformly Most Powerful Tests</li> <li>Matched Filter</li> </ul> </li> <li>Estimation Theory: <ul> <li>Types of Estimators</li> <li>Sufficiency and the Fisher-Neyman/Factorisation Criterion</li> <li>Unbiasedness and minimum variance</li> <li>Fisher Information and the CRB</li> <li>Asymptotic properties of the MLE</li> </ul> </li> </ul></li></ul>						
2	Learning of After succes can design h In addition, adequately p	<b>ojectives</b> sful completion of th hypothesis tests and e students will be able present the methods	e module, studen estimators for exis to review existing and results from o	ts know the basics sting problems and g work on detectior existing publication	of detection and esti implement them in 1 and estimation inde and discuss them s	mation theory. They Matlab on their own. ependently. They can scientifically.	
3	<b>Recommen</b> DSP, genera	<b>ded prerequisites fo</b> l interest in signal pro	<b>r participation</b> ocessing				
4	Form of exa Module exa • Modul Report and/ the lecture.	mination n: e exam (Study achiev or Presentation and/o	vement, Oral/writ or Colloquium. Th	tten examination, I le type of examinat	Default RS) ion will be announce	d in the beginning of	
5	Prerequisite Passing the f	e for the award of cr final module examina	r <b>edit points</b> ation				
6	<ul> <li>Grading Module exam:</li> <li>Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</li> </ul>						
7	Usability of MSc ETiT,M	<b>the module</b> Sc iST, MSc iCE, Wi-I	ETiT				
8	Grade bonu	s compliant to §25	(2)				

9	References					
	<ul> <li>Lecture slid</li> <li>Jerry D. Gi Press, 1996</li> <li>S. Kassam.</li> <li>S. Kay. Fun 1993.</li> <li>S. Kay. Fun</li> <li>E. L. Lehm.</li> <li>E. L. Lehm.</li> <li>Leon-Garci 1994.</li> <li>P. Peebles.</li> <li>H. Vincent 1994.</li> <li>Louis L. Sc Education I</li> <li>Harry L. Va 2003.</li> <li>A. M. Zoub May 2004.</li> </ul>	les bson and James L. Melsa. Introduction to Nonparametric Der 5. Signal Detection in Non-Gaussian Noise. Springer Verlag, 198 damentals of Statistical Signal Processing: Estimation Theory. I annentals of Statistical Signal Processing: Detection Theory. I ann. Testing Statistical Hypotheses. Springer Verlag, 2nd editi ann and George Casella. Theory of Point Estimation. Springer a. Probability and Random Processes for Electrical Engineerin Probability, Random Variables, and Random Signal Principles. Poor. An Introduction to Signal Detection and Estimation. Spr harf. Statistical Signal Processing: Detection, Estimation, and POD, 2002. In Trees. Detection, Estimation, and Modulation Theory, volun ir and D. R. Iskander. Bootstrap Techniques for Signal Processi	tection with Application 8. Prentice Hall, Prentice Hall, 1998. on, 1997. Verlag, 2nd edition, 199 g. Addison Wesley, 2nd McGraw-Hill, 3rd edition inger Verlag, 2nd edition I Time Series Analysis. F ne I,II,III,IV. John Wiley ng. Cambridge Universit	s. IEEE 99. edition, 1, 1993. 1, Pearson & Sons, y Press,		
CO	urses	Course nome				
	18-zo-2050-se	Signal Detection and Parameter Estimation		1		
	InstructorTypeSWSProf. DrIng. Abdelhak ZoubirSeminar4					

Mo	dule name		tion in modicine			
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
20-	00-0677	3 CP	90 h	60 h 1 Term Every 2. Semester		
Lar Ger	<b>nguage</b> rman			Module owner Prof. Dr. Georgios	s Sakas	
1	Teaching co - Participant initial scient - Deeper and - Critical disc - Preparation - Giving a ta - Interactive Learning ab simulation,	ontent is independently fam ific papers (usually F d/or wider library res cussion of the provid n of a presentation (w lk in front of a heter discussion after the pout methods related navigation, tracking	iliarize themselve English-language t search originating ed topic vritten text and sl ogenous (mixed p presentation l to planning and and others.	s with a chosen ser exts) from the initially p ides) about the top rior knowledge) au l navigation are: s	ninar topic by workin provided papers ic dience egmentation, registr	ng with the provided
2	Learning objectivesSuccessful participation in the course enables students to become acquainted with an unfamilar topic by working with scientific papers. They recognize the essential aspects of the examined works and are able to concisely present them to an audience with mixed prior knowledge on the subject. They apply a number of presentation techniques in the process. The students are able to actively guide and participate in a scientific discussion on the presented topic.Recommended prerequisites for participation					
3	Recommended prerequisites for participation Bachelors: >=4th semester Masters: >=1st semester					
4	Form of exa Course relat • [20-00	amination ed exam: )-0677-se] (Study ac	hievement, Oral/v	vritten examination	n, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0677-se] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %)	)
7	<ul> <li><sup>7</sup> [20-00-0677-se] (study achievement, Oral/ written examination, weighting: 100 %)</li> <li><sup>7</sup> Usability of the module         <ul> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> <li>B.Sc. Computational Engineering</li> <li>M.Sc. Computational Engineering</li> <li>M.Sc. Wirtschaftsinformatik</li> <li>B.Sc. Psychologie in IT</li> <li>Joint B.A. Informatik</li> <li>B.Sc. Sportwissenschaft und Informatik</li> <li>M.Sc. Sportwissenschaft und Informatik</li> <li>Can be used in other degree programs.</li> </ul> </li> </ul>					
8	Grade bonu	is compliant to §25	(2)			

9	<b>References</b> Will be given in s	References Will be given in seminar.					
Co	Courses						
	Course nr.Course name20-00-0677-seComputer-aided planning and navigation in medicine						
	Instructor Prof. Dr. Georgio	s Sakas	<b>Type</b> Seminar	SWS 2			
Mc Me	Module name Medical Image Processing						
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Mo 20-	odule nr. -00-0379	Credit points 3 CP	Workload 90 h	Self-study 60 h	Module duration	Module cycle Every 2. Semester	
Lan	nguage rman			Module owner Prof. Dr. Bernt Sc	chiele		
1	<b>Teaching co</b> The lecture data (CT, NI techniques t	ontent consists of two parts MR, PET, SPECT, Ultr hat are typically app	. The first half of asound) work. Th lied to medical im	the lecture describ he second half of th ages.	es how devices that e lecture covers vario	yield medical image ous image processing	
2	2 Learning objectives After successfully completing the course, students have an overview over the mechanisms used in and the abilities of modern medical image processing techniques. They are able to solve basic to medium level problems in medical image processing.						
3	Recommended prerequisites for participation Basics within Mathematics are highly recommended. Participation in lecture "Bildverarbeitung".						
4	Form of examinationCourse related exam:• [20-00-0379-vl] (Technical examination, Oral/written examination, Default RS)						
5	Prerequisite for the award of credit points Pass exam (100%)						
6	Grading Course relat • [20-00	ed exam: )-0379-vl] (Technical	examination, Ora	al/written examina	tion, Weighting: 100	9%)	
7	7       Usability of the module         B.Sc. Informatik         M.Sc. Informatik         B.Sc. Computational Engineering         M.Sc. Computational Engineering         M.Sc. Wirtschaftsinformatik         B.Sc. Psychologie in IT         Joint B.A. Informatik         B.Sc. Sportwissenschaft und Informatik         M.Sc. Sportwissenschaft und Informatik						
8	Can be used Grade bonu	in other degree prog s compliant to §25	grams. (2)				
9	References						
	References1) Heinz Handels: Medizinische Bildverarbeitung2) 2) Gonzalez/Woods: Digital Image Processing (last edition)3) 3) Bernd Jähne: Digitale Bildverarbeitung. 6. überarbeitete und erweiterte Auflage. Springer, Berlin u. a.2005, ISBN 3-540-24999-04) Kristian Bredies, Dirk Lorenz: Mathematische Bildverarbeitung. Einführung in Grundlagen und moderne Theorie. Vieweg+Teubner, Wiesbaden 2011, ISBN 978-3-8348-1037-3						

<b>Course nr.</b> 20-00-0379-vl	<b>Course name</b> Medical Image Processing		
Instructor		<b>Type</b> Lecture	SWS 2

Mo Ana	<b>Module name</b> Analysis and Synthesis of Human Movements I						
<b>Mo</b> 03-	<b>dule nr.</b> 04-0580	<b>Credit points</b> 5 CP	Workload 150 h	Self-study 120 h	Module duration 1 Term	Module cyc Every 2. Set	c <b>le</b> mester
Lar Ger	<b>iguage</b> man/English			<b>Module owner</b> Prof. Dr. phil. An	dré Seyfarth		
1	Teaching co	ntent		<u>.</u>			
2	Learning objectives						
3	Recommended prerequisites for participation						
4	Form of examinationCourse related exam:• [03-41-0580-se] (Study achievement, Optional, Default RS)						
5	<b>Prerequisite</b> Passing the f	e for the award of c	r <b>edit points</b> ation				
6	Grading Course relate • [03-41	ed exam: -0580-se] (Study acl	hievement, Optior	nal, Weighting: 1)			
7	Usability of	the module					
8	Grade bonu	s compliant to §25	(2)				
9	9 References						
Cot	ırses						
	<b>Course nr.</b> 03-41-0580-	se <b>Course name</b> Einführung in	die biomechanisc	he Bewegungserfas	ssung und -analyse		
	Instructor				<b>Type</b> Seminar		SWS 2

Mo	<b>Nodule name</b> Deep Generative Models							
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module of	luration	Module cyc	cle mester
Lar	nguage		100 11	Module owner Prof. DrIng. Mic	chael Gösel	e		
1	<b>Teaching co</b> Generative M Adversarial 1	<b>ntent</b> Models, Implicit and networks, Numerical	Explicit Models, I Optimization for	Maximum Likelihoo Generative models	od, Variatio	onal AutoF ons in med	ncoders, Ger lical Imaging	ierative
2	<ul> <li>Learning objectives         After students have attended the module, they can         Explain the structure and operation of Deep Generative Models (DGM)         Critically scrutinize scientific publications on the topic of DGMs and thus assess them professionally         independently construct / implement basic DTMs in a high-level programming language designed for this purpose         Transfer the implementation and application of DTMs to different applications     </li> </ul>							
3	Recommended prerequisites for participation         - Python Programming         - Linear Algebra         - Image Processing/Computer Vision I         - Statistical Machine Learning							
4	<ul> <li>Form of examination Course related exam:</li> <li>• [20-00-1035-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul>							
5	Prerequisite Pass exam (2	e for the award of c 100%)	redit points					
6	Grading Course relat • [20-00	ed exam: )-1035-iv] (Technica	l examination, Ora	al/written examina	ition, Weigl	nting: 100	%)	
7	Usability of B,Sc, Inform M.Sc. Inform May be used	<b>the module</b> atik natik l in other degree pro	grams.					
8	<ul> <li>8 Grade bonus compliant to §25 (2)</li> <li>In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2) der 5.</li> <li>Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.</li> </ul>							
9	<b>9 References</b> No textbooks as such. Online materials will be made available during the course.							
Cot	ırses							
	<b>Course nr.</b> 20-00-1035-	iv Deep Generat	ive Models					
	Instructor Prof. DrIng	. Michael Gösele				<b>Type</b> Integrate	d course	SWS 4

Mo Bas	dule name ics of Biophor	tonics				
<b>Mo</b> 18-	<b>dule nr.</b> fr-2010	Credit points 4 CP	Workload 120 h	Self-study 75 h	Module duration 1 Term	Module cycle Summer term
Lar Ger	<b>nguage</b> rman/English	1	I	<b>Module owner</b> Prof. Dr. habil. To	orsten Frosch	1
1	1 Teaching content Review of the fundamentals of optics, laser technology, light-matter interaction, and spectroscopic systems, cov- ering medical applications such as photodynamic therapy and optical heart rate measurement etc.; spectroscopy and imaging with linear optical processes: IR absorption, Raman spectroscopy, with applications e.g. in breath analysis, drug quality control, as well as detection of biomarkers; laser microscopy, e.g. wide-field microscopy, Raman microscopy and chemical imaging, fluorescence microscopy, with applications e.g. in neurostimulation research; spectroscopy and imaging with nonlinear optical processes: fundamentals of nonlinear optics, multi- photon fluorescence, e.g., with application for in vivo imaging of the brain, coherent nonlinear optical processes such as SHG and CARS, multimodal imaging, e.g. with potential application in intra-operative tumor imaging.					
2	<ul> <li>Learning objectives</li> <li>Students get to know established and state of the art biophotonic systems in medical technology and understand the underlying concepts. They are familiar with linear and nonlinear optical processes of light-matter interaction and understand the principles of spectroscopy and microscopy based on them. With the help of the gained knowledge, the students will be able to evaluate and compare common biophotonic methods and instruments. Furthermore, they will be able to recommend appropriate techniques and methods for a particular application.</li> </ul>					
3	Recommen Physics for H	<b>ded prerequisites fo</b> Electrical Engineering	or participation g and Mathematic	s I (Electrical Engir	eering)	
4	Form of exa Module exa • Modul	<b>amination</b> m: le exam (Technical ex	xamination, Exam	ination, Duration:	90 Min., Default RS)	
5	Prerequisite Passing the	e for the award of c final module examina	<b>redit points</b> ation			
6	Grading Module exa • Modul	m: le exam (Technical ex	xamination, Exam	ination, Weighting	: 100 %)	
7	Usability of MSc (WI-) e	t <b>he module</b> tit, MSc MEC, MSc N	/ledTec, BSc/MSc	iST		
8	Grade bonu	is compliant to §25	(2)			
9	<ul> <li>References</li> <li>Kramme, Medizintechnik - Chapter Biomedizinische Optik (Biophotonik), Springer</li> <li>Gerd Keiser, Biophotonics: Concepts to Applications, Springer</li> <li>Lorenzo Pavesi, Philippe M. Fauchet, Biophotonics, Springer</li> <li>Jürgen Popp, Valery V. Tuchin, Arthur Chiou, Stefan H. Heinemann, Handbook of Biophotonics, Wiley-VCH</li> </ul>					
CO	urses					

<b>Course nr.</b> 18-fr-2010-vl	Course name Basics of Biophotonics		
<b>Instructor</b> Prof. Dr. habil. T	'orsten Frosch	<b>Type</b> Lecture	<b>SWS</b> 2
<b>Course nr.</b> 18-fr-2010-ue	Course name Basics of Biophotonics		·
<b>Instructor</b> Prof. Dr. habil. T	`orsten Frosch	<b>Type</b> Practice	<b>SWS</b> 1

Mo Art	<b>dule name</b> ificial Intellige	ence in Medicine				
<b>Mo</b>	<b>dule nr.</b> ha-2020	Credit points	Workload	Self-study	Module duration	Module cycle Winter term
Lar Ger	nguage man			Module owner Prof. DrIng. Chr	istoph Hoog Antink	
1	Teaching co	ontent				
	<ul> <li>Introd</li> <li>Data a</li> <li>Featur</li> <li>Statist</li> <li>Classif <ul> <li>L</li> <li>S</li> <li>D</li> <li>N</li> </ul> </li> <li>Overfit</li> <li>Influer</li> <li>Evalua</li> <li>"Expla</li> <li>Regula</li> </ul>	uction, terms and de equisition and prepro- e extraction and visu- ical fundamentals fication methods inear Regression, Log upport Vector Machin Decision Trees, Rando Neural Networks tting and underfitting face of unbalanced da attion of algorithms inable AI" atory Requirements	limitations ocessing alization methods gistic Regression nes om Forest, XGBoos g with medical dat ita sets	s t ta		
2	2 Learning objectives Students have a basic understanding of the terminology of Artificial Intelligence, especially in the medical context. They have learned how features can be extracted from medical data and visualized. The students have an overview of current procedures and know how they work. They are familiar with current application examples from various subfields of medical technology, e.g. signal processing, image processing, spectroscopy gene sequencing, etc. Students understand the dangers of underfitting, overfitting, and imbalanced (e.g. related to gender ratio) data sets in a medical context. They are aware of the social and ethical responsibility of their future professional activities in relation to Fair AI. Students have an advanced understanding of algorithm evaluation, are familiar with the concept of "Explainable AI" and know the basic regulatory requirements for					cially in the medical alized. The students in current application ressing, spectroscopy, palanced (e.g. related esponsibility of their anding of algorithm ory requirements for echnology problems.
3	<b>Recommen</b> 18-zo-1030	<b>ded prerequisites fo</b> Fundamentals of Sig	or participation nal Processing			
4	Form of exa Module exam • Modul The examin than 21 stud	amination m: e exam (Technical ex ation takes place in f lents register, the exa	kamination, Oral/ form of a written amination will be	written examinatio exam (duration: 9 an oral examinatio	on, Duration: 90 Min. 0 minutes). If one ca n (duration: 20 min.	., Default RS) an estimate that less ).
5	Prerequisite Passing the	e for the award of c final module examina	<b>redit points</b> ation			
6	<ul> <li>6 Grading Module exam:</li> <li>• Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>					)
7	Usability of MSc MedTee	<b>the module</b> c, BSc/MSc iST, MSc	MEC			
8	Grade bonu	is compliant to §25	(2)			

By participating in online tests, a bonus can be acquired for the exam. The following key applies "points achieved at the end of the semester" -> "grade improvement": 60% -> 0.1; 65% -> 0.2; 70% -> 0.3; 75% -> 0.4; >=80% -> 0.5. The bonus is converted into raw points, i.e. a bonus of 0.5 corresponds to half the points of a whole grade step (e.g. 3.0 to 2.0). Exam Bmust be passed without a bonus to receive the bonus. The total score is the points achieved + bonus points and is rounded."

## 9 References

- Friedman, Jerome, Trevor Hastie, and Robert Tibshirani. The elements of statistical learning. Vol. 1. No. 10. New York: Springer series in statistics, 2001.
- Bishop, Christopher M. Pattern recognition and machine learning. Springer, 2006.

## Courses

CO	urses			
	<b>Course nr.</b> 18-ha-2020-vl	<b>Course name</b> Artificial Intelligence in Medicine		
	<b>Instructor</b> Prof. DrIng. Ch	ristoph Hoog Antink	<b>Type</b> Lecture	<b>SWS</b> 2
	<b>Course nr.</b> 18-ha-2020-ue	<b>Course name</b> Artificial Intelligence in Medicine		
	<b>Instructor</b> Prof. DrIng. Ch	ristoph Hoog Antink	<b>Type</b> Practice	<b>SWS</b> 1
	<b>Course nr.</b> 18-ha-2020-pr	<b>Course name</b> Artificial Intelligence in Medicine		
	Instructor Prof. DrIng. Ch	ristoph Hoog Antink	<b>Type</b> Internship	<b>SWS</b> 1

Mo Bio	<b>dule name</b> informatics I					
<b>Mo</b> 18-	<b>dule nr.</b> kp-1020	Credit points 3 CP	Workload 90 h	Self-study 60 h	Module duration 1 Term	Module cycle Winter term
Lar Ger	n <b>guage</b> rman/English	1		<b>Module owner</b> Prof. Dr. techn. H	leinz Köppl	
1	German/English       Prof. Dr. techn. Heinz Koppi         1       Teaching content         • Biomolecular foundations of high-throughput measurement techniques (Microarrays, RNA-Seq, genome sequencing, proteinarrays, mass-spectrometry, flow-cytometry, mass-cytometry, genomics, proteomics, metabolomics)         • Foundations of statistics and machine learning (decision theory, regression, classification and clustering)         • Exact substring search, dynamic programming, algorithms for sequence comparison (PAM, BLAST, BLAST2, etc), alignment of multiple sequences (ClustalW, DAlign, etc)         • Important databases in bioinformatics and their use in medicine and biology (GenBank, Gene Expression Omnibus, Rfam, UniProt, Pfam, KEGG, BRENDA, Pathway Commons)         • Analysis of interaction networks (modularity, graph partitioning, spanning trees, differential network analysis, network motifs, STRING database, PathBLAST)         • Introduction to structural biology, structure prediction for RNA and proteins, Protein Data Bank (PDB)					
2	2 Learning objectives After successful completion students are aware of frequently used high-throughput methods in molecular biology and are familiar with the resulting data format. They know the most important bioinformatics databases and acquired the necessary background to understand standard bioinformatics algorithms and to implement them from scratch in R or Matlab. Students are familiar with the basics of structural analysis and with structure prediction. With respect to communication skills, students learned to exchange informatio, ideas, problems and solutions related to bioinformatics with experts and with lay persons.					
3	"General Co	mputer Science I"	or participation			
4	Form of exa Module exa • Modul	<b>amination</b> m: e exam (Technical ez	xamination, Exam	ination, Duration:	90 Min., Default RS)	
5	<b>Prerequisit</b> Passing of M	e for the award of c Iodule final exam	redit points			
6	<ul> <li>Grading Module exam:</li> <li>Module exam (Technical examination, Examination, Weighting: 100 %)</li> </ul>					
7	Usability of BSc Biomed	the module				
8	Grade bonu	is compliant to §25	(2)			
9	References					
Co	urses					

<b>Course nr.</b> 18-kp-1020-vl	Course name Bioinformatics I		
<b>Instructor</b> Prof. Dr. techn. H	Heinz Köppl	<b>Type</b> Lecture	<b>SWS</b> 2

# 2.5 Optional Subjects AIS-CSR: Control Systems and Robotics

Mo Fou	dule name Indations of F	Robotics				
<b>Mo</b> 20-	<b>dule nr.</b> 00-0735	Credit points	Workload 300 h	Self-study 210 h	Module duration	Module cycle Every 2. Semester
Lar Ger	nguage rman			Module owner Prof. Dr. rer. nat.	Oskar von Strvk	
1	1 Teaching content This course covers spatial representations and transformations, manipulator kinematics, vehicle kinematics, velocity kinematics, Jacobian matrix, robot dynamcis, robot sensors and actuators, robot control, path planning, localization and navigation of mobile robots, robot autonomy and robot development. Theoretical and practical assignments as well as programming tasks serve for deepening of the understanding of the course topics.					
2	Learning objectives         After successful participation, students possess the basic technical knowledge and methodological skills necessary for fundamental investigations and engineering developments in robotics in the fields of modeling, kinematics, dynamics, control, path planning, navigation, perception and autonomy of robots.					
3	<b>Recommended prerequisites for participation</b> Recommended: basic mathematical knowledge and skills in linear algebra, multi-variable analysis and funda- mentals of ordinary differential equations					
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>• [20-00-0735-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul>					
5	<b>Prerequisit</b> Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ted exam: 0-0735-iv] (Technica	l examination, Ora	al/written examina	tion, Weighting: 100	%)
7	<ul> <li><sup>7</sup> Usability of the module         B.Sc. Informatik         M.Sc. Informatik         B.Sc. Computational Engineering         M.Sc. Computational Engineering         M.Sc. Wirtschaftsinformatik         B.Sc. Psychologie in IT         Joint B.A. Informatik         B.Sc. Sportwissenschaft und Informatik         M.Sc. Sportwissenschaft und Informatik     </li> </ul>					
0	Can be used	l in other degree prog	grams.			
ð	In dieser Vo Novelle der um bis zu 1	orlesung findet eine A APB und den vom FB : .0 führen kann.	(2) nrechnung von vo 20 am 30.3.2017 b	orlesungsbegleitend eschlossenen Anrec	len Leistungen statt, chnungsregeln zu eine	die lt. 25 (2) der 5. er Notenverbesserung
9	References					

Co	urses			
	<b>Course nr.</b> 20-00-0735-iv	<b>Course name</b> Foundations of Robotics		
	Instructor Prof. Dr. rer. nat.	. Oskar von Stryk Type	ted course	<b>SWS</b> 6

Mo Svs	<b>dule name</b> tem Dynamics	and Automatic Con	trol Systems II					
Mo	dule nr.	Credit points	Workload	Self-study	Module d	uration	Module cyc	cle
Lar Ger	nguage rman	/ Cr	210 II	Module owner     Summer term       Prof. DrIng. Jürgen Adamy				
1	<ol> <li>Teaching content Main topics covered are:         <ol> <li>Root locus method (construction and application),</li> <li>State space representation of linear systems (representation, time solution, controllability, observability, observer- based controller design)</li> </ol> </li> </ol>							
2	<ul> <li>2 Learning objectives After attending the module, a student is capable of: <ol> <li>constructing and evaluating the root locus of given systems</li> <li>describing the concept and importance of the state space for linear systems</li> <li>defining controllability and observability for linear systems and being able to test given systems with respect to these properties stating controller design methods using the state space, and applying them to given systems applying the method of linearization to non-linear systems with respect to a given operating point </li> </ol></li></ul>							
3	Recommended prerequisites for participation System Dynamics and Control Systems I							
4	Form of exam Module exam • Module	mination n: e exam (Technical e:	xamination, Exam	ination, Duration:	180 Min., D	Default RS	))	
5	<b>Prerequisite</b> Passing the fi	for the award of c nal module examin	<b>redit points</b> ation					
6	Grading Module exam • Module	n: e exam (Technical e	xamination, Exam	ination, Weighting	: 100 %)			
7	<b>Usability of</b> BSc ETiT, MS	<b>the module</b> Sc MEC, MSc iST, M	Sc WI-ETiT, MSc i	CE, MSc EPE, MSc	CE, MSc In	formatik		
8	Grade bonus	s compliant to §25	(2)					
9 Cot	References Adamy: Syste urses Course pr.	emdynamik und Re	gelungstechnik II,	Shaker Verlag (ava	ilable for pu	urchase at	t the FG office	e)
	18-ad-1010-v	VI System Dynan	nics and Automati	c Control Systems	I	Type		SMC
	Prof. DrIng.	Jürgen Adamy				Lecture		3

<b>Course nr.</b> 18-ad-1010-ue	<b>Course name</b> System Dynamics and Automatic Control Systems II		
<b>Instructor</b> Prof. DrIng. Jür	gen Adamy	<b>Type</b> Practice	<b>SWS</b> 2

Mo Lab	<b>Module name</b> Laboratory Matlab/Simulink I						
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle
18-	fi-1030	3 CP	90 h	45 h	1 Term	Every Seme	ester
Lar Ger	i <b>guage</b> man			Module owner Prof. DrIng. Rolf Findeisen			
1	In this lab tutorial, an introduction to the software tool MatLab/Simulink will be given. The lab is split into two parts. First the fundamentals of programming in Matlab are introduced and their application to different problems is trained. In addition, an introduction to the Control System Toolbox will be given. In the second part, the knowledge gained in the first part is applied to solve a control engineering specific problem with the software tools.						
2	<b>Learning objectives</b> Fundamentals in the handling of Matlab/Simulink and the application to control engineering tasks.						
3	Recommended prerequisites for participationThe lab should be attended in parallel or after the lecture "System Dynamics and Control Systems I"						
4	<ul><li>Form of examination</li><li>Module exam:</li><li>Module exam (Study achievement, Oral/written examination, Default RS)</li></ul>						
5	<b>Prerequisit</b> Passing the	e <b>for the award of c</b> final module examination	<b>redit points</b> ation				
6	Grading Module exa • Modul	m: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 100 %)		
7	Usability of BSc ETiT; B	t <b>he module</b> Sc MEC					
8	Grade bonu In case of E-	<b>is compliant to §25</b> Learning: Possibility	(2) to improve the gr	ade up to 1,0			
9	References						
	<ul> <li>Lecture notes for the lab tutorial can be obtained at the secretariat</li> <li>Lunze; Regelungstechnik I</li> <li>Dorp; Bishop: Moderne Regelungssysteme</li> <li>Moler: Numerical Computing with MATLAB</li> </ul>						
Coι	ırses						
	<b>Course nr.</b> 18-fi-1030-p	or Laboratory Ma	atlab/Simulink I				
	Instructor M.Sc. Alexa	nder Steinke, Prof. D	rIng. Rolf Findei	sen	<b>Type</b> Internshi	ip	SWS 3

Mo Lab	Module name Laboratory Control Engineering L							
<b>Mo</b> 18-	<b>dule nr.</b> fi-1020	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module of 1 Term	duration	Module cyc Summer ter	c <b>le</b> rm
Lar Ger	nguage man			Module owner Prof. DrIng. Rolf Findeisen				
1	<b>Teaching co</b> Using approp systems. The they provide data-driven	ontent priate test benches th e priority hereby lies e. Additionally, some modelling) are prese	e students apply co in the application further topics of t ented by practical	ontroller design me of the design meth he domain of cont Experiments.	thods taug ods and th rol systems	ht in the ba ne evaluatio s (e.g. auto	asic lecture of on of the para omation engin	control ameters neering,
2	Learning of After comple for different experiments	<b>pjectives</b> tion of this module the dynamic systems p and to bring them i	he students will be resented in the m nto operation at tl	able to practically a odule "System dyr ne lap setup.	apply the m namics and	nodelling and l control sy	nd design tecl ystems I" to 1	hniques real lab
3	Recomment System Dyna	ded prerequisites for amics and Control Sy	or participation stems I					
4	<ul> <li>Form of examination Module exam:</li> <li>Module exam (Study achievement, Oral/written examination, p/np RS) Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture</li> </ul>							
5	Prerequisite Passing the f	e <b>for the award of c</b> final module examin	<b>redit points</b> ation					
6	Grading Module exar • Modul	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting:	100 %)		
7	<b>Usability of</b> BSc ETiT	the module						
8	Grade bonu	s compliant to §25	(2)					
9	<b>References</b> Lab handout	s will be given to stu	ıdents.					
Co	urses							
	<b>Course nr.</b> 18-ko-1020-	pr Laboratory Co	ntrol Engineering	I				
	InstructorTypeSWSProf. DrIng. Ulrich KonigorskiInternship4					SWS 4		

Mo	dule name					
Inte	egrated Robo	tics Project 1	1			1
Mo	dule nr. $00,0324$	Credit points	Workload	Self-study	Module duration	Module cycle
Lar	00-0324	0 CP	160 11	Module owner	1 101111	Every 2. Semester
Ger	rman/English			Prof. Dr. rer. nat.	Oskar von Stryk	
1	Teaching co - guided ind as far as pos - becoming a - developme - application - document presentation	ontent ependent work on a c ssible, as member of a acquainted with the ent of a solution appro- a and evaluation base ation of task, appro- n	concrete task from a team of develope relevant state of re pach and its imple d on robot experin ach, implementat	development and a ers esearch and techno mentation nents or simulation ion and results in	application of modern logy 1s a final report and c	robotic systems and, onduction of a final
2	<b>Learning of</b> Through su methods of r evaluation.	<b>bjectives</b> ccessful participation modern robotic syster They train presentati	n students acquir ns as well as in-dep ion skills and, as fa	e deepened knowl oth skills for develoj ar as possible, team	edge in selected are oment, implementation work.	eas, subsystems and on, and experimental
3	Recommended prerequisites for participation         - basic knowledge within Robotics as given in lecture "Grundlagen der Robotik"         - programming skills depending on task					
4	<ul> <li>Form of examination Course related exam:</li> <li>• [20-00-0324-pr] (Study achievement, Oral/written examination, Default RS)</li> </ul>					
5	<b>Prerequisit</b> Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ted exam: D-0324-pr] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %	)
7	Usability of the module         B.Sc. Informatik         M.Sc. Informatik         B.Sc. Computational Engineering         M.Sc. Computational Engineering         M.Sc. Wirtschaftsinformatik         B.Sc. Psychologie in IT         Joint B.A. Informatik         B.Sc. Sportwissenschaft und Informatik         M.Sc. Sportwissenschaft und Informatik         May be used in other degree programs.					
8	Grade bonu	is compliant to §25	(2)			
9	<b>References</b> Will be give	n in lecture.				
Co	urses					

	<b>Course nr.</b> 20-00-0324-pr	<b>Course name</b> Integrated Robotics Project (Part 1)		
	Instructor		<b>Type</b> Internship	SWS 4

Mo	dule name					
Mo	egrated Robot dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
20-	00-0357	6 CP	180 h	120 h	1 Term	Every 2. Semester
Lan Ger	<b>nguage</b> man/English			Module owner Prof. Dr. rer. nat.	Oskar von Stryk	
1	Teaching co - guided ind as far as pos - becoming a - developme - application - documenta presentation	ontent ependent work on a c ssible, as member of a acquainted with the r nt of a solution appro- and evaluation base ation of task, appro-	concrete task from a team of develope relevant state of re pach and its imple d on robot experin ach, implementat	development and a ers esearch and techno ementation ments or simulation ion and results in	application of modern logy ns a final report and c	onduction of a final
2	Learning ol Through su methods of r evaluation.	<b>bjectives</b> ccessful participation modern robotic syster They train presentati	n students acquir ns as well as in-dej ion skills and, as f	e deepened knowl oth skills for develop ar as possible, team	edge in selected are pment, implementation work.	eas, subsystems and on, and experimental
3	Recommended prerequisites for participation- basic knowledge within Robotics as given in lecture "Grundlagen der Robotik"- programming skills depending on task- Participation in "Integriertes Robotik-Project 1"					
4	<ul> <li>Form of examination Course related exam:</li> <li>• [20-00-0357-pr] (Study achievement, Oral/written examination, Default RS)</li> </ul>					
5	<b>Prerequisit</b> Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0357-pr] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %	)
7	Usability of the module         B.Sc. Informatik         M.Sc. Informatik         B.Sc. Computational Engineering         M.Sc. Computational Engineering         M.Sc. Wirtschaftsinformatik         B.Sc. Psychologie in IT         Joint B.A. Informatik         B.Sc. Sportwissenschaft und Informatik         M.Sc. Sportwissenschaft und Informatik         M.Sc. Sportwissenschaft und Informatik					
8	Grade bonu	is compliant to §25	(2)			
9	<b>References</b> Will be give	n in course.				
<b>Co</b> ι	urses					

	<b>Course nr.</b> 20-00-0357-pr	<b>Course name</b> Integrated Project (Part 2)		
	Instructor		<b>Type</b> Internship	SWS 4

Mo	dule name	ol Engineering II						
Mo	dule nr.	Credit points	Workload	Self-study	Module o	duration	Module cyc	cle
Lan Ger	nguage man	5.01	100 11	Module owner Prof. DrIng. Jürg	gen Adamy	y	Winter term	
1	<b>Teaching co</b> During the l Non-linear c of an overhe	ontent aboratory course the ontrol of a gyroscope ad crane system, Pro	e following exper e, Nonlinear multiv ogrammable logic	iments will be conv variable control of a control of a stirring	ducted: Co an aircraft, g process	oupling co Servo con	ntrol of a hel trol systems,	licopter, Control
2	<ul> <li>2 Learning objectives After attending this module, a student is capable of: <ol> <li>recalling the basics of the conducted experiments,</li> </ol> </li> </ul>							
	<ol> <li>organize and comprehend background information for experiments,</li> <li>assemble experimental set-ups based on manuals,</li> <li>judge the relevance of experimental results by comparing them with theoretically predicted outcomes,</li> <li>present the results of the experiments</li> </ol>							
3	3 Recommended prerequisites for participation System Dynamics and Control Systems II, the attendance of the additional lecture "System Dynamics and Control Systems III" is recommended							
4	Form of exa Module exar • Modul Report (inclu and/or Collo the beginnin	mination n: e exam (Study achie iding submission of p oquium (testate), but ig of the lecture.	vement, Oral/writ programming code never more than	tten examination, I ) and/or Presentati two out of it. The t	Default RS on and/or type of exa	) Oral exam mination v	ination (25 n will be annou	ninutes) nced in
5	Prerequisite Passing the f	e for the award of c	<b>redit points</b> ation					
6	Grading Module exar • Modul	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Veighting:	100 %)		
7	Usability of MSc ETiT, M	<b>the module</b> ISc MEC, MSc iST, M	ISc Wi-ETiT, Biote	chnik				
8	Grade bonu	s compliant to §25	(2)					
9	References Adamy: Inst	ruction manuals for	the experiments (	available during the	e kick-off n	neeting)		
	<b>Course nr.</b> 18-ad-2060-	pr Laboratory Co	ntrol Engineering	II				
	Instructor Prof. DrIng	. Jürgen Adamy, M.S	c. Nikolas Hohma	ınn		<b>Type</b> Internshi	р	SWS 4

Mo Coi	Iodule name ontrol of Drives						
<b>Mo</b>	dule nr.	<b>Credit points</b>	Workload	Self-study 90 h	Module duration	Module cycle	
Lar Eng	<b>iguage</b> glish	5.01	130 11	Module owner Prof. DrIng. Ger	Module owner       Prof. DrIng. Gerd Griepentrog		
1	<ul> <li>Teaching content         Control structures for drives; Design of controllers for drives; VSIs for drives; Space Vectors as basis of modelling AC-machines; Reference frames for description of AC-machines; Control oriented block diagram for DC-drive; Structure and design of the controllers;         Control oriented block diagram for Permanent Magnet Synchronous Machine (PMSM); Control oriented block diagram for Induction machine (IM)         Torque control for AC-machines using linear or switching controllers. Field Oriented Control and Direct Torque Control for PMSM and IM. Models and observers for rotor flux of IM         Speed control, including oscillatory load. Resolver and Encoder. Problem of Motion control     </li> </ul>						
2	Learning of Upon succes 1. develo in field 2. design 3. Under: 4. Develo and to as non 5. Design the co 6. Under: in this 7. Derive referen 8. Design	pjectives sful completion of the p the control-oriented weakening range. the control loops for stand and apply space op the dynamic equat simplify these equati -linear control-orient a the control loops act ntrol loops and the control loops and the estand the deduction of lecture, e.g. for the of the models and the nee and to apprise the the control loops for	e module, studen d block diagrams r 1.) concerning th e vectors and mas ions of the permations by help of sui- ted block diagram cording to 4.) esp ontrol parameters of equations given doubly fed induction observers for the e benefits and dra r the super-impos	ts will be able to: for the DC-machine he structure and th ter their application nent exited synchro table rotating refere becially the field-ori in the literature for ion machine. rotor flux for the twbacks of the diffe ed speed controls of	e operating in base sp e control parameters n in different rotating phous machine and th ence frames and repre- tented control concer or machine types, wh induction machine in even for mechanically	beed range as well as a, g frames of reference. he induction machine esent these equations ning the structure of ich are not discussed in different frames of y oscillating loads.	
3	<b>Recommen</b> BSc ETiT or	<b>ded prerequisites fo</b> equivalent, especiall	<b>or participation</b> y Control Theory	and Electrical Mac	hines / Drives		
4	Form of exa Module exa • Modul	<b>mination</b> n: e exam (Technical ex	kamination, Exam	ination, Duration:	90 Min., Default RS)		
5	Prerequisite Passing the	e for the award of c	<b>redit points</b> ation				
6	<ul> <li>6 Grading Module exam:</li> <li>• Module exam (Technical examination, Examination, Weighting: 100 %)</li> </ul>						
7	7 Usability of the module MSc ETiT, MSc EPE, MSc MEC, Wi-ETiT						
8	Grade bonu	is compliant to §25	(2)				

## 9 References

Lecture notes, instructions for exercises are available in Moodle for download. Literature:

- Mohan, Ned: "Electric Drives and Machines"
- De Doncker, Rik; et. al.: "Advanced Electrical Drives"
- Schröder, Dierk: "Elektrische Antriebe Regelung von Antriebssystemen"
- Leonhard, W.: "Control of Electrical Drives"

# Courses

CO	Lourses							
	<b>Course nr.</b> 18-gt-2020-vl							
	<b>Instructor</b> Prof. DrIng. Ger	<b>Type</b> Lecture	<b>SWS</b> 2					
	Course nr.Course name18-gt-2020-ueControl of Drives							
	Instructor M.Sc. Ivan Kliasheu, Prof. DrIng. Gerd Griepentrog		<b>Type</b> Practice	<b>SWS</b> 2				

Mo Lab	<b>dule name</b> oratory Matla	b/Simulink II					
Мо	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle
18-	fi-2100	6 CP	180 h	120 h	1 Term	Every Seme	ester
Lar	nguage			Module owner			
Ger	rman			Prof. DrIng. Rol	f Findeisen		
1	<b>Teaching co</b> The lab is sp tool Simulin the second p problems as	ntent lit into the two parts k are introduced and part, the knowledge well as simulation to	s Simulink and Cor l their application gained in the first asks.	ntrol Engineering II to problems from c part is applied to a	. First the fundamen lifferent fields of app utonomously solve so	tals of the sim lication is trai everal control	nulation ined. In l design
2	2 Learning objectives The students will be able to work with the tool MatLab/Simulink on their own and can solve tasks from the areas of control engineering and numericial simulation. The students will know the different design methods of the control system toolbox and the fundamental concepts of the simulation tool Simulink. They can practically apply the knowledge gathered in the lectures "System Dynamics and Control Systems I and II" and "Modelling and Simulation".						
3	Recommended prerequisites for participationThe lab should be attended in parallel or after the lectures "System Dynamics and Control Systems II" and"Modelling and Simulation"						
4	<ul> <li>Form of examination         Module exam:         <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> <li>Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture</li> </ul> </li> </ul>						
5	<b>Prerequisite</b> Passing the f	e for the award of c inal module examin	<b>redit points</b> ation				
6	Grading Module exan • Modul	n: e exam (Study achie	evement, Oral/wri	tten examination, V	Weighting: 100 %)		
7	Usability of MSc etit, MS	<b>the module</b> Sc MEC					
8	Grade bonu	s compliant to §25	(2)				
9	9 References Lecture notes for the lab tutorial can be obtained at the secretariat						
Coi	urses	Γ					
	Course nr.	Course name	at ab (Cincelling) - II				
	18-п-2100-р	Laboratory Ma	auad/ Simulink II				01470
	Instructor Prof. DrIng. Rolf Findeisen				I <b>ype</b> Internshi	D	5WS 4

Mo Mu	dule name	Bobust Control					
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle
Lar	nguage	0 CP	180 11	Module owner			
Ger	man Ta a shi sa a sa			Prof. DrIng. Rol	r Findeisen		
1	<ul> <li>Basics (MIMO systems, SVD, system norms)</li> <li>Controller design for multivariable systems</li> <li>H2 and H8 Control design in the frequency domain</li> <li>Robust Control (uncertainty description, robustness analysis, robust controller design)</li> </ul>						
2	Learning objectives The students are able to formulate, analyse, and design controllers for multivariable systems. They are able to express control tasks as H2 and H8 optimization problems, to represent uncertainities of a system in a suitable form and to design a controller which ensures robust stability and robust performance.						
3	Recommended prerequisites for participation System Dynamics and Automatic Control Systems I and II						
4	<ul> <li>Form of examination</li> <li>Module exam: <ul> <li>Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)</li> <li>The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 25 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be appropriate the bacimping of the locture.</li> </ul></li></ul>						
5	<b>Prerequisite</b> Passing the f	e <b>for the award of c</b> inal module examin	<b>redit points</b> ation				
6	Grading Module exar • Module	n: e exam (Technical e	xamination, Oral/	written examinatio	n, Weighting: 100 %	<b>)</b> )	
7	Usability of	the module					
8	Grade bonu	s compliant to §25	(2)				
9	References						
	<ul> <li>S. Skogestad, I. Postlethwaite, Multivariable Feedback Control,2. Auflage, 2005, Wiley</li> <li>K. Zhou, Essentials of Robust Control, 1998, Prentice-Hall</li> <li>O. Föllinger, Regelungstechnik, 11. Auflage, 2013, VDE Verlag</li> </ul>						
Co	urses						
	<b>Course nr.</b> 18-fi-2070-v	Course name Multivariable	and Robust Contro	ol			
	InstructorTypeSWSDr. Ing. Eric LenzLecture3						

<b>Course nr.</b> 18-fi-2070-ue	<b>Course name</b> Multivariable and Robust Control		
Instructor Dr. Ing. Eric Lenz	Z	<b>Type</b> Practice	<b>SWS</b> 1

Mo Mo	dule name deling, Simul	ation, and Optimizat	tion				
<b>Mo</b> 18-	<b>dule nr.</b> fi-2030	Credit points 7 CP	Workload 210 h	Self-study 135 h	Module duration	Module cy Winter terr	<b>cle</b> n
Laı Gei	<b>nguage</b> rman/English			<b>Module owner</b> Prof. DrIng. Rol	f Findeisen		
1	<b>Teaching c</b> Physics-base reduction, n modeling, n	ontent ed modeling, modelir umerical integration nachine learning sup	ng of distributed pa methods, static and ported modeling.	arameter systems, 1 1 dynamic optimiz <i>a</i>	model simplificatio ttion, parameter op	n, linearization timization, data	ı, model a-driven
2	Learning objectives The students are familiar with different modeling approaches for dynamical systems and can apply those to various fields of applications. They acquire the ability to simulate the dynamical behavior of the modeled systems. They can select and use suitable integration methods. They can perform a model reduction and decompose dynamical systems. They acquire the fundamental knowledge of static and dynamic optimization of systems. The obtain a perspective on data-driven and machine learning supported modeling.						
3	Recommended prerequisites for participation Basic concepts of control theory. Fundamentals of linear algebra.						
4	<ul> <li>Form of examination</li> <li>Module exam: <ul> <li>Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS)</li> <li>The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 25 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be announced in the beginning of the lecture</li> </ul></li></ul>						
5	<b>Prerequisit</b> Passing the	e for the award of c final module examin	r <b>edit points</b> ation				
6	Grading Module exa • Modu	m: le exam (Technical e:	xamination, Oral/	written examinatio	n, Weighting: 100	%)	
7	Usability of	f the module					
8	Grade bon	is compliant to §25	(2)				
9	<ul> <li>9 References</li> <li>P.E. Wellstead. Introduction to Physical Systems Modeling. Academic Press.</li> <li>L. Grüne, O. Junge. Gewöhnliche Differentialgleichungen. Springer Spektrum.</li> <li>G.F. Franklin, J.D. Powell and A. Emnami-Naeini. Feedback Control of Dynamical Systems, Addison-Wesley.</li> <li>C.a. Athanasios. Interpolation Methods for Model Reduction. SIAM.</li> </ul>						
0	Course nr.	Course name	1				
	18-fi-2030-v	A Modeling, Sin	nulation, and Opti	mization	1		
	<b>Instructor</b> Dr. Ing. Eric	c Lenz, Prof. DrIng.	Rolf Findeisen		<b>Type</b> Lecture	2	<b>SWS</b> 3

<b>Course nr.</b> 18-fi-2030-ue	<b>Course name</b> Modeling, Simulation, and Optimization		
Instructor Dr. Ing. Eric Lenz	z, Prof. DrIng. Rolf Findeisen	<b>Type</b> Practice	<b>SWS</b> 2

Mo Svs	dule name	s and Automatic Cor	trol Systems III					
<b>Mo</b>	dule nr. ad-2010	Credit points 4 CP	Workload 120 h	Self-study 75 h	<b>Module o</b> 1 Term	duration	Module cyc Winter tern	<b>cle</b>
Lar	nguage		120 11	Module owner Prof. DrIng. Jür	gen Adamy	V		
1	<ul> <li>Teaching content Topics covered are:</li> <li>1. basic properties of non-linear systems,</li> <li>2. limit cycles and stability criteria,</li> <li>3. non-linear control of linear systems,</li> <li>4. non-linear control of non-linear systems,</li> <li>5. observer design for non-linear systems</li> </ul>							
2	<ul> <li>Learning objectives After attending the module, a student is capable of: <ol> <li>explaining the fundamental differences between linear and non-linear systems,</li> <li>testing non-linear systems for limit cycles,</li> <li>stating different definitions of stability and testing the stability of equilibria, <li>recalling the pros and cons of non-linear controllers for linear systems,</li> <li>recalling and applying different techniques for controller design for non-linear systems,</li> <li>designing observers for non-linear systems</li> </li></ol> </li> </ul>							
3	Recommen	ded prerequisites fo	or participation					
4	Form of exa Module exa • Modul	<b>mination</b> n: e exam (Technical e	xamination, Exam	ination, Duration:	180 Min., I	Default RS	3)	
5	<b>Prerequisite</b> Passing the	e for the award of c	<b>redit points</b> ation					
6	Grading Module exan • Modul	n: e exam (Technical e	xamination, Exam	ination, Weighting	: 100 %)			
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> ISc MEC, MSc iST, N	ISc WI-ETiT, MSc	iCE, MSc EPE, MSc	c CE, MSc I	Informatik	:	
8	Grade bonu	s compliant to §25	(2)					
9	9 References Adamy: Systemdynamik und Regelungstechnik III (available for purchase at the FG office)							
Cot	Irses	Course nome						
	18-ad-2010-	vl System Dynam	nics and Automati	c Control Systems I	II			
	<b>Instructor</b> Prof. DrIng	. Jürgen Adamy, M.S	Sc. Karsten Kreutz			<b>Type</b> Lecture		<b>SWS</b> 2

<b>Course nr.</b> 18-ad-2010-ue	<b>Course name</b> System Dynamics and Automatic Control Systems III		
<b>Instructor</b> Prof. DrIng. Jür	gen Adamy, M.Sc. Karsten Kreutz	<b>Type</b> Practice	<b>SWS</b> 1

Mo Pro	Module name Project Course Control Engineering							
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module o	luration	Module cyc	cle
Lan Ger	nguage man	0 Gr	240 11	Module owner Prof. DrIng. Rol	f Findeisen		Summer ter	
1	<ul> <li>Teaching content         Teams of 2 - 4 students work on different control engineering projects under the guidance of a project coordinator from the institute. The projects mainly cover the following subject areas:         <ul> <li>Modelling, analysis and design of multivariable control systems</li> <li>Modelling, analysis and design of distributed parameter systems</li> <li>Robust control design</li> <li>System analysis, supervision and fault diagnosis</li> <li>Modelling and identification</li> </ul> </li> <li>Application areas are machine tools, production lines, test benches, process control, automobiles.</li> </ul>							
2	2 Learning objectives After completing of this module the students will be familiar with the individual steps of investigating a control engineering project. This includes in particular the compilation of a system specification as well as critical discussions and systematic selection of appropriate control engineering solutions and their real technical implementation. Doing so the students learn the practical application of control engineering methods taught in the module "System Dynamics and Control Systems I" to real world problems. Additionally, in this module the students are supposed to improve their professional skills. These skills include e.g. teamwork, presentation techniques and systematic information retrieval.							
3	Recommend Lecture "Sys	<b>led prerequisites fo</b> tem Dynamics and C	or participation Control Systems I"					
4	Form of exa Module exar • Modul Report and/	<b>mination</b> n: e exam (Study achie or Presentation. The	vement, Oral/writ type of examinat	tten examination, I ion will be announ	Default RS) ced in the	) beginning	of the lecture	2.
5	<b>Prerequisite</b> Passing the f	e for the award of c	<b>redit points</b> ation					
6	Grading Module exar • Module	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting:	100 %)		
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> ISc MEC						
8	Grade bonu	s compliant to §25	(2)					
9	9 References Handouts will be distributed at start of the project (e.g. Hints for writing a project documentation, etc.)							
	Course nr.	Course name	Control Engineer	ing				
	Instructor Prof. DrIng	. Rolf Findeisen				<b>Type</b> Project se	eminar	SWS 4

Mo Pro	Module name Project Seminar Bobotics and Computational Intelligence						
<b>Mo</b>	dule nr.	Credit points	Workload 240 h	Self-study	Module duration	Module cycle	
Lar	iguage	0.01	21011	Module owner Drof. Dr. Ing. Jürgen Adamy			
1	Teaching co The followin Industrial r 1. Types 2. Geome 3. Dynan 4. Contro Mobile robo	ontent ag topics are taught i obots and applications etry and kinematics nic model ol of industrial robots ots	n the lecture:		gen ruaniy		
	<ol> <li>Types and applications</li> <li>Sensors</li> <li>Environmental maps and map building</li> <li>Trajectory planning</li> <li>Group projects are arranged in parallel to the lectures in order to apply the taught material in practical exercises.</li> </ol>						
2	<ul> <li>2 Learning objectives</li> <li>Upon successful completion of the module, students are capable of: <ol> <li>recalling the basic elements of industrial robots,</li> <li>recalling the dynamic equations of industrial robots and be able to apply them to describe the dynamics of a given robot,</li> <li>stating model problems and solutions to standard problems in mobile robotics,</li> <li>planing a small project,</li> <li>organizing the work load in a project team,</li> <li>searching for additional background information on a given project,</li> <li>creating ideas on how to solve problems arising in the project,</li> <li>writing an scientific report about the outcome of the project</li> <li>presenting the results of the project.</li> </ol> </li> </ul>						
3	Recommen	ded prerequisites fo	or participation				
4	Form of exa Module exa • Modul Report and/	<b>amination</b> m: e exam (Study achie for Presentation. The	vement, Oral/writ type of examinat	tten examination, I ion will be announ	Default RS) ced in the beginning	of the lecture.	
5	Prerequisite Passing the	e for the award of c	redit points ation				
6	Grading Module exan • Modul	m: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 100 %)		
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> ISc MEC, MSc iST, M	ISc WI-ETiT, MSc	iCE, MSc EPE, MSc	c CE, MSc Informatik	ζ	
8	Grade bonus compliant to §25 (2)						

9	References							
	Adamy: Lecture	notes (available for purchase at the FG office)						
Coi	Courses							
	Course nr.	Course name						
	18-ad-2070-pj Project Seminar Robotics and Computational Intelligence							
	Instructor Type S							
	Prof. DrIng. Jüı	gen Adamy	Project seminar	4				

<b>Mo</b> Pra	Module name Practical Training with Drives							
Mo	dule nr.	Credit points	Workload	Self-study	Module o	duration	Module cyc	cle
Lar		5 CP	150 II	Module owner				
Ger	man/English			Prof. DrIng. Yve	s Burkhard	lt		
1	Teaching co The purpose An introduct drives to wo fed AC drive respective co	ntent of this laboratory is ion in measurement ck and investigating of s. The laboratory ex- purses (ETiT or MEC)	gaining extented problems concerr drive systems unde speriments are in- ).	knowledge about ra ning drives is given er laboratory condi dividually coordina	ealization a . The conte tions. Spec ated with t	and behavi ents of the ial attention the previou	our of drive s laboratory is on is paid to i us knowledge	systems. setting nverter- e of the
2	Learning of The student	<b>jectives</b> s get the ability of m	easurement for el	ectrical motors, ger	nerators an	d transfor	mers.	
3	Recomment Bachelor of	<b>led prerequisites fo</b> Science in Electrical 1	or participation Engineering, Powe	er Engineering or s	imilar			
4	<ul> <li>Form of examination         Module exam:         <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> <li>Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture</li> </ul> </li> </ul>							
5	<b>Prerequisite</b> Passing the f	e <b>for the award of c</b> rinal module examination	<b>redit points</b> ation					
6	Grading Module exan • Modul	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting:	100 %)		
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> Sc MEC, MSc WI-ET	ΪT					
8	Grade bonu	s compliant to §25	(2)					
9	<ul> <li>9 References Textbook with lab instructions <ul> <li>W. Nürnberg: Die Prüfung elektrischer Maschinen, Springer, 2000</li> <li>P. Brosch: Moderne Stromrichterantriebe, Kamprath-Reihe, Vogel-Verlag, 1998</li> <li>Textbook - A. Binder: Motor Development for Electrical Drive Systems</li> <li>Textbook - G. Griepentrog: Control of Drives</li> </ul></li></ul>							
Coι	ırses							
	<b>Course nr.</b> 18-bt-2100-j	or Course name Practical Train	ing with Drives					
	InstructorTypeSWSProf. DrIng. Yves Burkhardt3							

<b>Course nr.</b> 18-bt-2090-tt	<b>Course name</b> Laboratory Briefing		
Instructor Prof. DrIng. Yve	es Burkhardt	<b>Type</b> Tutorial	<b>SWS</b> 0

Mo Sys	Module name System Dynamics and Automatic Control Systems I							
<b>Mo</b> 18-	<b>dule nr.</b> fi-1010	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module duration	Module cycle Winter term		
Lar Gei	<b>iguage</b> man			<b>Module owner</b> Prof. DrIng. Roli	f Findeisen	1		
1	<b>Teaching co</b> Description dynamic sys structure op	ontent and classification of tems; Frequency res timization	dynamic system ponse; Linear tim	s; Linearization ar e-invariant closed-	ound an equilibriun loop systems; Contro	n point; Stability of oller design; Control		
2	Learning of Students wi dynamic beh invariant sys	<b>ojectives</b> Il know how to desc aviour in time and fr stems.	ribe and classify o equency domain.	lifferent dynamic s The students will b	systems. They will be e able to design contr	e able to analyse the collers for linear time		
3	Recommended prerequisites for participation							
4	<ul> <li>Form of examination Module exam:</li> <li>Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)</li> </ul>							
5	Prerequisite for the award of credit points Passing the final module examination							
6	<ul> <li>6 Grading Module exam:</li> <li>• Module exam (Technical examination, Examination, Weighting: 100 %)</li> </ul>							
7	Usability of	the module						
8	Grade bonu	s compliant to §25	(2)					
9	References							
	<ul> <li>Skript Konigorski: "Systemdynamik und Regelungstechnik I", Aufgabensammlung zur Vorlesung, Lunze: "Regelungstechnik 1: Systemtheoretische Grundlagen, Analyse und Entwurf einschleifiger Regelungen",</li> <li>Föllinger: "Regelungstechnik: Einführung in die Methoden und ihre Anwendungen",</li> <li>Unbehauen: "Regelungstechnik I:Klassische Verfahren zur Analyse und Synthese linearer kontinuierlicher Regelsysteme, Fuzzy-Regelsysteme", Föllinger: "Laplace-, Fourier- und z-Transformation",</li> <li>Jörgl: "Repetitorium Regelungstechnik",</li> <li>Merz, Jaschke: "Grundkurs der Regelungstechnik: Einführung in die praktischen und theoretischen Methoden",</li> <li>Horn, Dourdoumas: "Rechnergestützter Entwurf zeitkontinuierlicher und zeitdiskreter Regelkreise",</li> <li>Schneider: "Regelungstechnik für Maschinenbauer",</li> <li>Weinmann: "Regelungen. Analyse und technischer Entwurf: Band 1: Systemtechnik linearer und linearisierter Regelungen auf anwendungsnaher Grundlage"</li> </ul>							
Co	urses							
<b>Course nr.</b> 18-fi-1010-vl	<b>Course name</b> System Dynamics and Automatic Control Systems I							
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<b>Instructor</b> M.Sc. Florian We	eigand, Prof. DrIng. Rolf Findeisen	<b>Type</b> Lecture	<b>SWS</b> 3					
Course nr. 18-fi-1010-tt	<b>Course name</b> System Dynamics and Automatic Control Systems I- Auditori	um Exercise						
<b>Instructor</b> Prof. DrIng. Rol	lf Findeisen	TypeSWTutorial1						

Mo	dule name											
Me	asuring Techr	nique				1						
<b>Mo</b>	<b>dule nr.</b> kn-1011	Credit points	Workload	Self-study	Module duration	Module cycle						
Lar	nguage	0.01	100 11	Module owner								
Ger	rman			Prof. Dr. Mario K	upnik							
1	<ul> <li>Teaching content         The module includes theoretical discussion and practical application of the measuring chain in detail on example the electrical variables (current, voltage, impedance, power) and selected non-electrical variables (frequency, time, force, pressure and acceleration).     </li> <li>In the lecture the following chapter will be thematically treated measuring signals and measuring equipment (oscilloscope, laboratory testing equipment), static measurement error and disturbance variables (especially temperature), basic measurement circuits, AD conversion principles and filtering, measurement method non-electrical variables and the statistics of measurements (distributions, statist safe tests).     The topics of the lecture are discussed in the exercise of the module. Examples are analyzed and their application in measurement scenarios are practiced.     The practicum of the module consists of five experiments which are time closely matched in time to the lecture:     <ul> <li>Measuring of signals in the time range with digital storage oscilloscope, error of measurement (aliasing / subsampling, leackage) and window functions</li> <li>Measuring of mechanical dimensions with suitable primary sensors, sensor electronics / amplifier circuits</li> <li>computer-based measuring</li> <li>Importing of sensor signals, whose processing and the resulting automated control of a process using a programmable logic controller (PLC)</li> </ul></li></ul>											
2	2 Learning objectives The students know the structure of the measuring chain and the specific properties of the corresponding elements. They know the structure of electronic measuring instruments and basic measuring circuits for electrical and selected non-electrical variables and can apply them. They know the basics of capturing, processing, transferring and storage of measurement data and can describe error sources and quantifying their influences. In the practicum, the students deepen the basis of the measurements with the oscilloscope, the understanding of the relationship between time and frequency range. Methodically they are able to document and evaluate the data during laboratory measuring											
3	Recommen Basics of ET	<b>ded prerequisites fo</b> iT I-III, Math I-III, Ele	or participation ectronic									
4	Form of examination         Module exam:         • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)         Course related exam:         • [18-kn-1011-pr] (Study achievement, Optional, Default RS)											
5	<b>Prerequisit</b> Passing the	e for the award of c final module examin	<b>redit points</b> ation									
6	<ul> <li>Grading Module exam:         <ul> <li>Module exam (Technical examination, Examination, Weighting: 4)</li> <li>Course related exam:                 <ul> <li>[18-kn-1011-pr] (Study achievement, Optional, Weighting: 2)</li> </ul> </li> </ul> </li> </ul>											
7	Usability of	the module				Usability of the module						

	BSc ETiT, BSc Wi-ETiT, BSc MEC				
8	Grade bonus co	mpliant to §25 (2)			
9	References				
	<ul> <li>Slide set of lecture</li> <li>Textbook and exercise book Lerch: "Elektrische Messtechnik", Springer</li> <li>Exercise documents</li> <li>Practical experiment manuals</li> </ul>				
Co	urses				
	Course nr.Course name18-kn-1011-vlMeasuring Technique				
	<b>Instructor</b> Prof. Dr. Mario K	upnik	<b>Type</b> Lecture	<b>SWS</b> 2	
	<b>Course nr.</b> 18-kn-1011-ue	<b>Course name</b> Measuring Technique			
	<b>Instructor</b> Prof. Dr. Mario K	upnik	<b>Type</b> Practice	<b>SWS</b> 1	
	<b>Course nr.</b> 18-kn-1011-pr	<b>Course name</b> Measuring Technique Lab			
	<b>Instructor</b> Prof. Dr. Mario K	upnik	<b>Type</b> Internship	SWS 2	

<b>Mo</b> Ele	<b>dule name</b> ctromechanica	al Systems I						
<b>Mo</b>	dule nr.	Credit points	Workload	Self-study	Module o	duration	Module cyc	cle
Lar	iguage	5 Cr	130 II	Module owner Prof. Dr. Mario K	upnik			
1	Teaching co Structure an transducers	n <b>tent</b> Id design methods c petween mechanical	of elektromechani and acoustical net	cal systems, mech	anical, aco devices of	ustical an electrome	d thermal ne chanical trans	tworks, sducers.
2	2 Learning objectives The module provides the following competencies upon successful completion: Comprehension, description, cal- culation and application of the most relevant electromechanical transducers, comprising electrostatic transducer (e.g. microphone and accelerometer), piezoelectric transducers (e.g micro motors, micro sensors), electrody- namic transducer (loudspeaker, shaker), piezomagnetic transducer (e.g. ultrasonic source). Design of complex electromechanical systems like sensors and actuators and their applications by applying the discrete element network method.							
3	Recommende Electrical En	led prerequisites for gineering and Inform	or participation nation Technology	7 I				
4	Form of exa Module exar • Modul	<b>mination</b> n: e exam (Technical ex	xamination, Exam	ination, Duration:	120 Min., 1	Default RS	5)	
5	<b>Prerequisite</b> Passing the f	e for the award of c	<b>redit points</b> ation					
6	Grading Module exar • Module	n: e exam (Technical ex	xamination, Exam	ination, Weighting	: 100 %)			
7	Usability of BSc ETiT, BS	<b>the module</b> Sc WI-ETïT, MSc MEG	C					
8	Grade bonu	s compliant to §25	(2)					
9	References Book: Electro chanical Sys	omechanical Systems tems I, Workbook	s in Microtechnic u	ınd Mechatronic, Sj	pringer 201	12, Script f	for lecture Ele	ectrome-
Co	ırses							
	<b>Course nr.</b> 18-kn-1050-	vl Electromechar	nical Systems I					
	Instructor M.Sc. Omar	Dali, Prof. Dr. techn.	Dr.h.c. Andreas Bi	nder, Prof. Dr. Mari	o Kupnik	<b>Type</b> Lecture		SWS 2
	<b>Course nr.</b> 18-kn-1050-	Course name ue Electromechar	nical Systems I					
	<b>Instructor</b> M.Sc. Omar	Dali, Prof. Dr. techn.	Dr.h.c. Andreas Bi	nder, Prof. Dr. Mari	o Kupnik	<b>Type</b> Practice		SWS 2

Mo Intr	dule name	ectrodynamics					
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle
Lar Ger	nguage man	0.01	100 11	Module owner     Prof. DrIng. Herbert De Gersem			1111
1	1 <b>Teaching content</b> Vector calculus, orthogonal coordinate systems, Maxwell's equations, interface and boundary conditions, layered media, electrostatics, scalar potential, Coulomb integral, separation of variables, method of image charges, magnetostatics, vector potential, Biot-Savart law, stationary current fields, fields in matter, energy flow, skin effect, plane waves, polarization, TEM waves, reflection and multi-layer problems, multi conductor transmission lines (capacitance, inductance, and conductance matrix), velocity definitions, basics of rectangular waveguides.						
2	2 Learning objectives Students will be familiar with Maxwell's equations in integral and differential form for static and dynamic field problems. They will have a mental picture of wave phenomena in free space. They are able to recognice and interpret wave effects in the different areas of electrical engineering. They are able to derive the wave effects from Maxwell's equations and have a good understanding of the necessary mathematical tools.						
3	<b>Recommended prerequisites for participation</b> Lecture notes. Further literature recommendations are given in the course.						
4	<ul> <li>Form of examination</li> <li>Module exam:</li> <li>Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)</li> </ul>						
5	<b>Prerequisite</b> Passing the fit	for the award of c	<b>redit points</b> ation				
6	Grading Module exam • Module	: exam (Technical e:	xamination, Exam	ination, Weighting	: 100 %)		
7	<b>Usability of t</b> BSc ETiT, BSc	<b>he module</b> c Wi-ETiT					
8	Grade bonus Improvement	compliant to §25 by up to 0.4 due to	(2) bonus points wh	ich can be acquired	l by means of e-learn	ing online te	sts.
9	References Lecture notes	. Further literature	recommendations	s are given in the c	ourse.		
Coi	ırses						
	<b>Course nr.</b> 18-dg-1010-v	Course name1Introduction to	o Electrodynamics				
	Instructor Prof. DrIng.	Herbert De Gersem	ι		<b>Type</b> Lecture		SWS 2
	<b>Course nr.</b> 18-dg-1010-u	Course name Introduction to	o Electrodynamics				
	Instructor     Type       Prof. Dr. Ing. Herbert De Gersem     Practice					SWS 2	

	<b>Course nr.</b> 18-dg-1010-tt	<b>Course name</b> Introduction to Electrodynamics		
	Instructor Prof. DrIng. Her	bert De Gersem	<b>Type</b> Tutorial	<b>SWS</b> 1

Mo	dule name	nginooring					
Mo	dule nr	Credit points	Workload	Solf_study	Module duration	Module ov	clo
18-	bi-2050	3 CP	90 h	60 h	1 Term	Summer te	rm
Lar Ger	<b>iguage</b> man			Module owner Prof. DrIng. Yve	s Burkhardt		
1	1 <b>Teaching content</b> From the comprehensive and interdisciplinary domain of the railway technology (vehicle technology, signal and safety technology, construction engineering and railway operating technology) the module picks out the domain of the automotive engineering with the emphasis of the mechanical part. It offers an interrelated introduction into selected chapters of the rail vehicle engineering with special emphasis in the railway-specific technical solutions and procedures. Theoretical basics as well as essential components of the rail vehicle are taught in depth.						
2	<b>Learning objectives</b> After completing the module, students will have developed an understanding of the mechanical and mechanical engineering principles of modern rail vehicles.						
3	Recommended prerequisites for participation Bachelor in Electrical Engineering, Mechatronics or Mechanical Engineering						
4	<ul> <li>Form of examination Module exam:</li> <li>Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)</li> </ul>						
5	<b>Prerequisite</b> Passing the f	for the award of c nal module examination	<b>redit points</b> ation				
6	<b>Grading</b> Module exan • Module	ı: e exam (Technical ex	xamination, Exam	ination, Weighting	: 100 %)		
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> Sc MEC, MSc EPE, 1	MSc WI-ETiT				
8	Grade bonus	s compliant to §25	(2)				
9	<ul> <li>9 References</li> <li>References/Textbooks: <ul> <li>Detailed textbook; Filipovic, Z: Elektrische Bahnen. Springer, Berlin, Heidelberg, 1995.</li> <li>Obermayer, H.J.: Internationaler Schnellverkehr. Franckh-Kosmos, Stuttgart, 1994.</li> </ul> </li> </ul>						
Coι	ırses						
	<b>Course nr.</b> 18-bi-2050-v	Course nameIRailway Vehic	le Engineering				
	InstructorTypeSWSDrIng. Michael KaratasLecture2					<b>SWS</b> 2	

<b>Mo</b> Dat	<b>dule name</b> a-driven Mod	elling of Dynamic Sy	stems			
<b>Mo</b> 18-1	<b>dule nr.</b> fi-2090	Credit points 4 CP	Workload 120 h	Self-study 75 h	Module duration 1 Term	Module cycle Winter term
Lar Ger	<b>iguage</b> man	1		Module owner Prof. DrIng. Rol	f Findeisen	1
1	Teaching co	ontent				
	<ul> <li>Important topics of signal processing and stochastics</li> <li>Disturbance and excitation signals</li> <li>Identification of linear systems <ul> <li>Non-parametric identification (Frequency response estimation)</li> <li>Parametric identification (Characteristic values, Output error and equation error minimization, Subspace method, Kalman filter)</li> <li>Recursive methods</li> </ul> </li> <li>Closed loop identification</li> <li>Basics of data-driven modelling of non-linear systems</li> </ul>					
2	<ul> <li>2 Learning objectives         The students are taught the fundamental methods of data-driven modelling (identification).         Based on assumptions on the system and constraints imposed by the measurements, the students are able to select, parametrize and apply appropriate methods to generate non-parametric and parametric models from the measurement data.     </li> </ul>					
3	Recomment Basics in the	<b>ded prerequisites fo</b> e field of control engi	or participation neering (e.g. lectu	ıre System Dynami	cs and Automatic Co	ntrol Systems I)
4	Form of exa Module exa • Modul The examina 25 students will be anno	amination m: e exam (Technical ex ation takes place in fo register, the examina ounced in the beginni	amination, Oral/ rm of a written ex tion will be an ora ng of the lecture.	written examinatio am (duration: 90 n ıl examination (dur	n, Default RS) ninutes). If one can es ration: 25 min.). The	stimate that less than type of examination
5	Prerequisite Passing the	e for the award of c final module examination	redit points ation			
6	Grading Module exa • Modul	m: e exam (Technical e:	amination, Oral/	written examinatio	n, Weighting: 100 %	)
7	Usability of MSc etit, MS	<b>the module</b> Sc MEC				
8	Grade bonu	is compliant to §25	(2)			
9 Coi	<ul> <li>References</li> <li>Pintelon, R.; Schoukens, J.: System Identification: A Frequency Domain Approach. IEEE Press, New York, 2001.</li> <li>Ljung, L.: System Identification: Theory for the user. Prentice Hall information and systems sciences series. Prentice Hall PTR, Upper Saddle River NJ, 2. edition, 1999.</li> </ul>					

	<b>Course nr.</b> 18-fi-2090-vl	<b>Course name</b> Data-driven Modelling of Dynamic Systems		
	<b>Instructor</b> Dr. Ing. Eric Len	Z	<b>Type</b> Lecture	<b>SWS</b> 2
	<b>Course nr.</b> 18-fi-2090-ue	<b>Course name</b> Data-driven Modelling of Dynamic Systems		
	<b>Instructor</b> Dr. Ing. Eric Len	Z	<b>Type</b> Practice	<b>SWS</b> 1

Мо	dule name					
Nev Mo	w Technologie dule pr	es of Electrical Energy	Workload	Actuators	Module duration	Module cycle
18-	bi-2040	4 CP	120 h	75 h	1 Term	Summer term
Lar Ger	<b>iguage</b> man∕English			Module owner Prof. DrIng. Yve	s Burkhardt	
1	<ul> <li>Teaching content Goal: The application of new technologies, i.e. super conduction, magnetic levitation techniques and magneto-hydrodynamic converter principles, are introduced to the students. The physical operation mode in principle, implemented prototypes and the current state of the development are described in detail. Content: Application of the superconductors for electrical energy converters: <ul> <li>rotating electrical machines (motors and generators),</li> <li>solenoid coils for the fusion research,</li> <li>locomotive- and railway transformers,</li> <li>magnetic bearings.</li> </ul> Active magnetic bearings ("magnetic levitation"): <ul> <li>basics of the magnetic levitation technique,</li> <li>magnetic bearings for high speed drives in kW to MW range,</li> <li>application for high-speed trains with linear drives.</li> </ul> Magneto-hydrodynamic energy conversion: <ul> <li>physical principle,</li> <li>state of the art and perspectives.</li> </ul> Fusion research: <ul> <li>magnetic field arrangements for contactless plasma inclusion,</li> <li>state of the current research.</li> </ul> </li> </ul>					
2	Learning of After compl systems as v	<b>bjectives</b> letion of the module s vell as magnetic levit	students have bas ation, magnetohy	ic knowledge of ag drodynamics and f	oplication of superco usion technology.	nductivity in energy
3	Recommen Physics, Ele	ded prerequisites fo ctrical Machines and	<b>or participation</b> Drives, Electrical	Power Engineering		
4	Form of exa Module exa • Modu	amination m: le exam (Technical ex	xamination, Exam	ination, Duration:	60 Min., Default RS)	
5	<b>Prerequisit</b> Passing the	e for the award of c	redit points			
6	Grading Module exa • Modu	m: le exam (Technical ex	xamination, Exam	ination, Weighting	: 100 %)	
7	Usability of MSc EPE, M	f <b>the module</b> ISc ETiT, MSc MEC, N	ASc WI-ETiT			
8	Grade bonu	is compliant to §25	(2)			
9	References					

Detailed textbook

- Komarek, P.: Hochstromanwendungen der Supraleitung, Teubner, Stuttgart, 1995
- Buckel, W.: Supraleitung, VHS-Wiley, Weinheim, 1994
  Schweitzer, G.; Traxler, A.; Bleuler, H.: Magnetlager, Springer, Berlin, 1993
  Schmidt, E.: Unkonventionelle Energiewandler, Elitera, 1975

## Courses

- 00	u13C3					
	Course nr.	Course name	Course name			
	18-bi-2040-vl	18-bi-2040-vl New Technologies of Electrical Energy Converters and Actuate				
	Instructor		Туре	SWS		
	Prof. DrIng. Yve	Lecture	2			
	Course nr.	Course name				
	18-bi-2040-ue	New Technologies of Electrical Energy Converters and Actua	tors			
	Instructor		Туре	SWS		
	Prof. DrIng. Yve	Practice	1			

Mo Des	dule name	cal Machines and Act	cuators with Nume	erical Field Calcula	tion			
<b>Mo</b> 18-	<b>dule nr.</b> bi-2110	Credit points 5 CP	Workload 150 h	Self-study 120 h	Module of 1 Term	luration	Module cyc Summer ter	c <b>le</b> rm
Lar Ger	<b>nguage</b> rman/English			<b>Module owner</b> Prof. DrIng. Yve	es Burkhard	lt		
1	<b>Teaching co</b> Introduction FEM, 2D ele applications Calculation	ontent to Finite Element M ectromagnetic Desig such as squirrel-cag of temperature distri	lethod (FEM), Bas n of transformers e machines (Exam bution within pow	ic examples of elec , AC machines, po ple: Wind generat er devices	ctromagnet ermanent 1 or); Coolin	ic devices magnet de ng systems	designed in 2 vices; eddy and thermal	2D with current design:
2	Learning of Upon comple package to b	<b>ojectives</b> etion of the module, pasic field problems.	students will have	a good knowledge	in applyin	g FEMAG a	and ANSYS s	oftware
3	Recommended prerequisites for participation Strongly recommended is the attendance of lecture and active co-operation in the tutorial "Energy Converters - CAD and System Dynamics"							
4	<ul> <li>Form of examination         Module exam:         <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> <li>Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of             the lecture</li> </ul> </li> </ul>							
5	Prerequisite Passing the	e <b>for the award of c</b> final module examin	<b>redit points</b> ation					
6	Grading Module exan • Modul	n: e exam (Study achie	vement, Oral/writ	ten examination, V	Weighting:	100 %)		
7	<b>Usability of</b> MSc EPE, M	<b>the module</b> Sc ETiT, MSc MEC						
8	Grade bonu	s compliant to §25	(2)					
9	References Detailed tex expert-Verla	tbook; User manual 1 g, 5. Aufl., 2000	FEMAG and ANSY	S. Müller, C. Groth:	: FEM für P	Praktiker - I	Band 1: Grun	ıdlagen,
Co	urses							
	<b>Course nr.</b> 18-bi-2110-s	Se Design of Elec	trical Machines an	d Actuators with N	Numerical H	Field Calcu	lation	
	<b>Instructor</b> DrIng. Bog	dan Funieru				<b>Type</b> Seminar		SWS 2

Mo	dule name	chatronic Systems I	aboratory				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle
18- Lar	nguage	5 CP	150 h	Module owner	1 Ierm	Summer te	rm
Ger	rman			Prof. DrIng. Yve	s Burkhardt		
1	Teaching co Safety instru • Report • Individ semest • The gr	ntent ctions; Practical exp preparation (one fo lual review of the st er ading consists of the	eriments about el r each group) for udents' knowledg e evaluation of the	ectrical drive system each experiment e (individual perfo group performance	ms and mechatronic rmance) during and, e and the individual j	actuators: /or at the ene performance.	d of the
2	Learning ob On completion using the act	<b>jectives</b> on of the module stud ors and measuring t	dents will have tra hem.	ined the use of mee	chanical actors and ac	equired knowl	ledge in
3	Recommend Lecture "Elel	Recommended prerequisites for participation Lecture "Elektrische Maschinen und Antriebe" and "Maschinenelemente und Mechatronik 1"					
4	<ul> <li>Form of examination</li> <li>Module exam: <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> </ul> </li> <li>The examination has the form of a Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.</li> </ul>						
5	<b>Prerequisite</b> Passing the f	e <b>for the award of c</b> inal module examin	<b>redit points</b> ation				
6	Grading Module exar • Module	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 100 %)		
7	Usability of BSc MEC	the module					
8	Grade bonu	s compliant to §25	(2)				
9	<b>References</b> Detailed text	book with description	on for the perform	ance of the lab tes	ts		
Cot	urses						
	<b>Course nr.</b> 18-bt-1030- <sub>I</sub>	or Actuators for 1	Mechatronic Syste	ms Laboratory			
	Instructor Prof. DrIng	Yves Burkhardt			<b>Type</b> Internshi	p	<b>SWS</b> 3
	<b>Course nr.</b> 18-bt-2090-t	t Laboratory Br	iefing				
	Instructor Prof. DrIng	Yves Burkhardt			<b>Type</b> Tutorial		<b>SWS</b> 0

Mo	Module name							
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle	
18-	bi-2120	5 CP	150 h	120 h	1 Term	Summer te	rm	
Lar Ger	<b>iguage</b> man			Module owner Prof. DrIng. Yves Burkhardt				
1	Teaching co Content of t systems, car Content of t	ntent he lecture part: Mo dynamic, energy sto he seminary work:	ono- and hybrid di orage; simulation of car	rive concepts, moto with electric drive	r technology, DC an train, presentation	d AC machine	s, drive ork	
2	<b>Learning objectives</b> After completing the module, students have acquired knowledge of the basic design procedures for electric drives in hybrid and electric cars.							
3	<b>Recommended prerequisites for participation</b> Bachelor in Electrical Engineering or Mechatronics, "Electrical Drives and Machines" and "Power electronics"							
4	Form of examination         Module exam:         • Module exam (Study achievement, Oral/written examination, Default RS)         Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of the lecture.							
5	<b>Prerequisite</b> Passing the f	e <b>for the award of c</b> inal module examina	<b>redit points</b> ation					
6	Grading Module exar • Module	n: e exam (Study achie	vement, Oral/writ	tten examination, V	Weighting: 100 %)			
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> Sc MEC, MSc EPE, N	MSc WI-ETiT					
8	Grade bonu	s compliant to §25	(2)					
9	References         • Textbook         • Binder, A.: Electric machines and drives         • Mitschke, M.: Dynamik der Kraftfahrzeuge, Springer Verlag Berlin							
Coι	ırses							
	<b>Course nr.</b> 18-bi-2120-s	e Planning and	application of elec	trical drives (Drive	s for electric vehicle	s)		
	18-bi-2120-se       Planning and application of electrical drives (Drives for electric vehicles)         Instructor       Type       SWS         Seminar       2							

Mo Pro	Module name Project Seminar Automatic Control Systems							
Мо	dule nr.	Credit points	Workload	Self-study	Module dura	tion Module c	ycle	
18-	ad-2080	8 CP	240 h	180 h	1 Term	Winter te	rm	
Ger	<b>iguage</b> man			Prof. DrIng. Jür	gen Adamy			
1	<b>Teaching co</b> In a small pr automation	o <b>ntent</b> roject group under t technology are work	he guidance of a s ed on.	cientific assistant,	individual proj	ects from a subje	ct area of	
2	Learning of	ojectives		<u>.</u>				
	Allel allellu	ing the module, a st	ident is capable of					
	<ol> <li>planing a small project,</li> <li>organizing the work within a project team</li> </ol>							
	<ol> <li>3. searching for scientific background information on a given project,</li> </ol>							
	4. creating ideas on how to solve problems arising in the project,							
	<ol> <li>6. giving a talk on the results of the project.</li> </ol>							
3	Recomment	led prerequisites fo	or participation					
4	Form of exa Module exa • Modul Report and/	<b>mination</b> n: e exam (Study achie or Presentation. The	vement, Oral/writ	tten examination, I ion will be announ	Default RS) ced in the begi	nning of the lectu	re.	
5	Prerequisite Passing the	e for the award of c	<b>redit points</b> ation					
6	Grading							
	Module exar • Modul	n: e exam (Study achie	vement Oral/wri	tten examination A	Neighting: 100	%)		
		(_ tauj utilit	,,	, -		-1		
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> ISc MEC, MSc iST, N	ISc WI-ETiT, MSc	iCE, MSc EPE, MSc	c CE, MSc Infor	matik		
8	Grade bonu	s compliant to §25	(2)					
9	9 References Training course material							
Co	urses							
	<b>Course nr.</b> 18-ad-2080-	pj Project Semin	ar Automatic Cont	rol Systems				
	<b>Instructor</b> Prof. DrIng	. Jürgen Adamy		<b>.</b> -	<b>Tyr</b> Pro	<b>e</b> ject seminar	<b>SWS</b> 4	

Mo	dule name							
Pro Mo	ject Course Pi dule nr.	Credit points	Workload	Self-study	Module d	luration	Module cv	cle
18-	fi-2110	8 CP	240 h	180 h	1 Term	urution	Winter tern	n
Lan Ger	i <b>guage</b> man			Module owner Prof. DrIng. Rol	f Findeisen			
1	<ul> <li>Teaching content</li> <li>Teams of 2-4 students work on different mechatronic projects under the guidance of a project coordinator from the institute. The projects mainly cover the following subject areas:         <ul> <li>Modeling, analysis, and design of mechatronic systems</li> <li>Robust control design</li> <li>System analysis, supervision and fault diagnosis</li> <li>Modeling and identification</li> </ul> </li> <li>Application areas are mechatronic actuators, machine tools, production lines, test benches, automobiles, quadro-copters.</li> </ul>							
2	2 Learning objectives After completing the project, the students will be familiar with the individual steps of investigating a mechatronic project. This includes in particular the compilation of a system specification as well as critical discussions and systematic selection of appropriate mechatronic solutions and their real technical implementation. Doing so, the students learn the practical application of mechatronic methods taught in the lectures to real world problems. Additionally, in this project course, the students are supposed to improve their professional skills. These skills include e.g. teamwork, presentation techniques and systematic information retrieval.							
3	Recommended prerequisites for participation Lectures "System Dynamics and Automatic Control Systems I", "System Dynamics and Automatic Control Systems II"							
4	Form of exa Module exa • Modul Report and/	<b>mination</b> n: e exam (Study achie or Presentation. The	vement, Oral/writ type of examinat	tten examination, I ion will be announ	Default RS) ced in the l	oeginning	of the lecture	e.
5	<b>Prerequisit</b> Passing the	e for the award of c	<b>redit points</b> ation					
6	Grading Module exa • Modul	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Veighting:	100 %)		
7	Usability of MSc etit, MS	t <b>he module</b> Sc MEC, MSc iST						
8	Grade bonu	s compliant to §25	(2)					
9	<b>References</b> Handouts w	ill be distributed at s	tart of the project	(e.g. hints for writ	ing project	documen	tation, etc.)	
<b>Co</b> ι	ırses	1						
	<b>Course nr.</b> 18-fi-2110-p	j Course name p Project Course	Practical Applica	tion of Mechatroni	CS			
	Instructor Prof. DrIng	. Rolf Findeisen, M.S	Sc. Julian Zeiß			<b>Type</b> Project se	eminar	SWS 4

Mo Tin	<b>dule name</b> ne domain met	hods for electromag	gnetic field simula	tion			
<b>Mo</b>	dule nr.	Credit points	Workload	Self-study	Module duration	Module cyc	cle
Lor	ug-2020	5.61	<b>JO II</b>	Modulo ouror	1 ICIIII	whiter term	.1
Ger	rman/English			Prof. DrIng. Her	bert De Gersem		
1	<b>Teaching co</b> Finite Differe domain. Hig computing. I	ntent ence, Finite Volume h order Discontinue Particle based simul	and Finite Elemer ous Galerkin meth ations for beams a	tt Methods for the s ods. Stability and nd plasmas.	solution of Maxwell e convergence analysis	equations in t s. High perfo	he time rmance
2	Learning ob Students lerr Furthermore codes for cor	<b>jectives</b> the theoretical bas the lecture mediate mmon problems of F	is of advanced sim es practical skills fo Electrical Engineer	ulation techniques or the implementat ing	for time dependent e ion, analysis and app	lectromagneti lication of sim	ic fields. 1ulation
3	Recommend Maxwell's eq	ed prerequisites for uations, infinitesim	or participation al calculus, vector	calculus. Basics of	differential equation	s and linear a	ılgebra
4	<ul> <li>Form of examination</li> <li>Module exam:</li> <li>Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)</li> </ul>						
5	<b>Prerequisite</b> Passing the f	for the award of on a module examin	e <b>redit points</b> ation				
6	Grading Module exan • Module	n: e exam (Technical e	xamination, Oral e	examination, Weigl	nting: 100 %)		
7	<b>Usability of</b> MSc ETiT	the module					
8	Grade bonu	s compliant to §25	(2)				
9	<b>References</b> Lecture slide	s, matlab scripts, va	rious literature so	urces			
Cot	urses	· · · ·					
	<b>Course nr.</b> 18-dg-2020-	Course name 71 Time domain	methods for electr	omagnetic field sir	nulation		
	InstructorTypeSWSPrivatdozent Dr. rer. nat. Erion GjonajLecture2						

Mo Ma	<b>dule name</b> chine Learnin	g and Deep Learning	g for Automation S	Systems			
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
18- Lar	ad-2100	3 CP	90 h	60 h Module owner	1 Term	Summer term	
Ger	man			Prof. DrIng. Jürgen Adamy			
1	Teaching co	ontent					
	<ul> <li>Concepts of machine learning</li> <li>Linear methods</li> <li>Support vector machines</li> <li>Trees and ensembles</li> <li>Training and assessment</li> <li>Unsupervised learning</li> <li>Neural networks and deep learning</li> <li>Convolutional neuronal networks (CNNs)</li> <li>CNN applications</li> <li>Recurrent neural networks (RNNs)</li> </ul>						
2	2 Learning objectives Upon completion of the module, students will have a broad and practical view on the field of machine learning. First, the most relevant algorithm classes of supervised and unsupervised learning are discussed. After that, the course addresses deep neural networks, which enable many of today's applications in image and signal processing. The fundamental characteristics of all algorithms are compiled and demonstrated by programming examples. Students will be able to assess the methods and apply them to practical tasks.						
3	Recomment Fundamenta Preferred: L	<b>ded prerequisites fo</b> al knowledge in linea ecture "Fuzzy logic, :	or participation ar algebra and stat neural networks a	istics nd evolutionary alş	gorithms"		
4	Form of exa Module exa • Modul The examina 7 students r will be anno	amination m: le exam (Technical ex ation takes place in fo egister, the examinat ounced in the beginn	kamination, Oral/ orm of a written ex ion will be an ora ing of the lecture.	written examinatio am (duration: 90 n l examination (dur	on, Duration: 90 Min. ninutes). If one can es ation: 30 min.). The	, Default RS) stimate that less than type of examination	
5	Prerequisit Passing the	e for the award of c final module examination	<b>redit points</b> ation				
6	Grading Module exa • Modul	m: le exam (Technical e:	xamination, Oral/ <sup>,</sup>	written examinatio	on, Weighting: 100 %	)	
7	Usability of	the module					
8	Grade bonu	is compliant to §25	(2)				
9	References						

- T. Hastie et al.: The Elements of Statistical Learning. 2. Aufl., Springer, 2008
- I. Goodfellow et al.: Deep Learning. MIT Press, 2016
- A. Géron: Hands-On Machine Learning with Scikit-Learn, Keras and TensorFlow. 2. Aufl., O'Reilly, 2019

## Courses

<b>Course nr.</b> 18-ad-2100-vl	<b>Course name</b> Machine Learning and Deep Learning for Automation System	15					
Instructor DrIng. Michael	Vogt	<b>Type</b> Lecture	<b>SWS</b> 2				

Mo Rot	<b>dule name</b> oot Learning:	Integrated Project -	Part 1				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle
20-	00-0753	6 CP	180 h	120 h	1 Term	Every 2. Se	mester
Eng	iguage glish			Prof. Dr. rer. nat.	Oskar von Stryk		
1	<b>Teaching co</b> In "Robot Learnin interests, on their project	ontent arning: Integrated P ng with assistance of which they will purs , try out the algorith	Project, Part 1", stu their advisor. The sue in-depth litera ums of interest and	dents will pose a co students will select ture studies. Using i implement a prote	urrent research probl a robot learning topi these results, they w otype in simulation.	em in the do c to fit their r ill develop a j	main of esearch plan for
2	<b>Learning ol</b> Upon succes in the doma	<b>ojectives</b> sful completion of the in of robot learning a	is course, students and test first resea	will be able to inde rch ideas in simula	pendently develop sn tion.	nall research j	projects
3	Recomment Previous or	ded prerequisites for concurrent participation	or participation tion in the lecture	"Robot Learning".			
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>• [20-00-0753-pj] (Study achievement, Oral/written examination, Default RS)</li> </ul>						
5	Prerequisite for the award of credit points Pass exam (100%)						
6	<ul> <li>6 Grading Course related exam:</li> <li>• [20-00-0753-pj] (Study achievement, Oral/written examination, Weighting: 100 %)</li> </ul>						
7	Usability of B.Sc. Inform M.Sc. Inform B.Sc. Comp M.Sc. Comp M.Sc. Wirtse B.Sc. Psycho Joint B.A. In B.Sc. Sportv M.Sc. Sportv	the module natik natik utational Engineerin utational Engineerin chaftsinformatik ologie in IT formatik vissenschaft und Info wissenschaft und Info	g ormatik formatik				
8	Grade bonu	is compliant to §25	(2)				
	Deferre						
9	Keferences						
Co	urses						
	<b>Course nr.</b> 20-00-0753-	pj Robot Learnin	g: Integrated Proj	ect - Part 1			
	Instructor Prof. Dr. rer.	nat. Oskar von Strv	k		<b>Type</b> Project		SWS 4

Mo	dule name						
Roł	oot Learning:	Integrated Project -	Part 2			1	
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cyc	cle mostor
Lar	00-0734	0 CP	100 11	Module owner	1 101111	Every 2. Se	mester
Eng	glish			Prof. Dr. rer. nat.	Oskar von Stryk		
1	<b>Teaching co</b> In "Robot Le from Part 1 written and	ontent earning: Integrated I and apply it to a real potentially submitte	Project, Part 2", stu robot. A scientific d to a national or	idents will complet article on the resea international scien	e their approach to t arch problem, methoo tific venue.	he research p ls and results	oroblem will be
2	<b>Learning ol</b> Upon succes in the doma	<b>bjectives</b> sful completion of th in of robot learning	is course, students and test first resea	will be able to inde rrch ideas in simula	pendently develop sn tion.	nall research	projects
3	3 Recommended prerequisites for participation Previous or concurrent participation in the lecture "Robot Learning".						
4	<ul> <li>Form of examination Course related exam:         <ul> <li>[20-00-0754-pj] (Study achievement, Oral/written examination, Default RS)</li> </ul> </li> </ul>						
5	5 Prerequisite for the award of credit points Pass exam (100%)						
6	<ul> <li>6 Grading Course related exam:</li> <li>• [20-00-0754-pj] (Study achievement, Oral/written examination, Weighting: 100 %)</li> </ul>						
7	<ul> <li>7 Usability of the module</li> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> <li>B.Sc. Computational Engineering</li> <li>M.Sc. Computational Engineering</li> <li>M.Sc. Wirtschaftsinformatik</li> <li>B.Sc. Psychologie in IT</li> <li>Joint B.A. Informatik</li> <li>B.Sc. Sportwissenschaft und Informatik</li> <li>M.Sc. Sportwissenschaft und Informatik</li> </ul>						
	Can be used	in other degree pro	grams.				
8	Grade bonu	is compliant to §25	(2)				
9	9 References						
	Course nr.	Course name	a Integrated Dra	oot Dort 9			
	Instructor Prof. Dr. rer.	nat. Oskar von Stry	k	ett - Palt 2	<b>Type</b> Project		SWS 4

Mo Cor	<b>dule name</b> nputational E	ngineering and Robo	otics				
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle	
Lar Ger	nguage rman			Module owner Prof. Dr. phil. nat	. Marc Fischlin		
1	<ul> <li>Teaching content         <ul> <li>Foundations of modelling and simulation</li> <li>Problem specification and system description for computational engineering</li> <li>Model generation for the example of mechanical systems</li> <li>Model analysis for the example of mechanical systems</li> <li>Implementations of simulations for the example of robots and other systems</li> <li>Interpretation and validation using measurement data</li> <li>Applications in simulation and control of robots as well as in physically based animation and computer games</li> </ul> </li> </ul>						
2	2 Learning objectives Upon successful completion of this class, students will be able to develop first models and simulations and can perform first simulation studies within robotics. They know the necessary key steps needed to construct simulations (problem specification, model generation, model analysis, implementation, and validation) and can use them to construct first simulations to meet the specification requirements.						
3	Recommended prerequisites for participation						
4	<ul> <li>Form of examination Course related exam:         <ul> <li>[20-00-0011-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul> </li> </ul>						
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points				
6	Grading Course relat • [20-00	ed exam: )-0011-iv] (Technical	l examination, Ora	al/written examina	tion, Weighting: 100	9%)	
7	Usability of the module         B.Sc. Informatik         B.Sc. Wirtschaftsinformatik         B.Sc. Computational Engineering         B.Sc. Psychologie in IT         Joint B.A. Informatik         B.Sc. Sportwissenschaft und Informatik         M.Sc. Sportwissenschaft und Informatik         B.Sc. Informationssystemtechnik         May be used in other degree programs						
8	Grade bonus compliant to §25 (2)         In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2) der 5.         Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.						
9	<b>References</b> F. Föllinger: P. Corke: Ro F.L. Severan	Einführung in die Z botics, Vision & Con ce: System Modeling	ustandsbeschreibu trol, Springer, 201 g and Simulation:	ing dynamischer S 1 An Introduction, J.	vsteme (Oldenbourg, Wiley & Sons, 2001	1982)	

Co	Courses								
	<b>Course nr.</b> 20-00-0011-iv	<b>Course name</b> Computational Engineering and Robotics							
	Instructor		<b>Type</b> Integrated course	SWS 3					

Mo Tec	<b>dule name</b> hnical Mecha	nics for Electrical En	gineering			
<b>Mo</b>	<b>dule nr.</b> 26-6400	Credit points	Workload	Self-study	Module duration	Module cycle
Lan Ger	nguage man		100 11	Module owner DrIng. Nicklas N	Iorrick	
1	Teaching co Statics: for adhesion an Mechanics o Kinematics: Kinetics: dyn angular mor	ontent ce, moment (torque) d friction. of elastic bodies: stres point and rigid body namic force and mom mentum conservatior	, free body diagr ss and deformation movement. ent equilibrium ec la laws, impact.	am, equilibrium eo n, tension, torsion, quations, energy an	quations, center of g bending. d work, linear oscilla	ravity, truss, beams, tors, momentum and
2	2 Learning objectives In this course the students will learn the basic concepts of technical mechanics. They should be able to analyze the statics of simple statically determinate planar systems, to carry out elementary elastomechanical calculations of statically determinate and statically indeterminate structures, to describe and analyze movements, and to solve planar motion problems, oscillation and shock phenomena with the laws of kinetics.					
3	Recommended prerequisites for participation					
4	<ul> <li>Form of examination</li> <li>Module exam:</li> <li>Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)</li> </ul>					
5	Prerequisit Passing the	e for the award of c final module examina	<b>redit points</b> ation			
6	Grading Module exa • Modul	m: le exam (Technical ex	xamination, Exam	ination, Weighting	: 100 %)	
7	Usability of	the module				
8	Grade bonu	is compliant to §25	(2)			
9	<b>References</b> Markert, No Exercises ar	orrick: Einführung in e embodied in the bc	die Technische M ook.	echanik, ISBN 978	-3-8440-3228-4	
	Further reading: Markert: Statik - Aufgaben, Übungs- und Prüfungsaufgaben mit Lösungen, ISBN 978-3-8440-3279-6 Markert: Elastomechanik - Aufgaben, Übungs- und Prüfungsaufgaben mit Lösungen, ISBN 978-3-8440-3280-2 Markert: Dynamik - Aufgaben, Übungs- und Prüfungsaufgaben mit Lösungen, ISBN 978-3-8440-2200-1 Gross, Hauger, Schröder, Wall: Technische Mechanik 1 - 3. Springer-Verlag Berlin (2012-2014). Hagedorn: Technische Mechanik, Band 1 - 3. Verlag Harri Deutsch Frankfurt.					
Ο Οι	ırses					

<b>Course nr.</b> 16-26-6400-vl	<b>Course name</b> Technical Mechanics for Electrical Engineering		
Instructor		<b>Type</b> Lecture	<b>SWS</b> 3
<b>Course nr.</b> 16-26-6400-ue	<b>Course name</b> Technical Mechanics for Electrical Engineering		
Instructor		<b>Type</b> Practice	SWS 2

Mo Rol	<b>dule name</b> oot Learning					
<b>Mo</b> 20-	<b>dule nr.</b> 00-0629	Credit points 6 CP	Workload 180 h	Self-study 120 h	<b>Module duration</b> 1 Term	Module cycle Every 2. Semester
Lar Eng	<b>1guage</b> glish	I	L	Module owner	L	
1	<ul> <li>Feaching content         <ul> <li>Foundations from robotics and machine learning for robot learning</li> <li>Learning of forward models</li> <li>Representation of a policy, hierarchical abstraction with movement primitives</li> <li>Imitation learning</li> <li>Optimal control with learned forward models</li> <li>Reinforcement learning and policy search</li> <li>Inverse reinforcement learning</li> </ul> </li> </ul>					
2	Learning objectives Upon successful completion of this course, students are able to understand the relevant foundations of machine learning and robotics. They will be able to use machine learning approaches to empower robots to learn new tasks. They will understand the foundations of optimal decision making and reinforcement learning and can apply reinforcement learning algorithms to let a robot learn from interaction with its environment. Students will understand the difference between Imitation Learning, Reinforcement Learning, Policy Search and Inverse Reinforcement Learning and can apply each of this approaches in the appropriate scenario.					
3	<b>Recommended prerequisites for participation</b> Good programming in Matlab Lecture Machine Learning 1 - Statistical Approaches is helpful but not mandatory.					
4	Form of exa Course relat • [20-00	<b>mination</b> ed exam: )-0629-vl] (Technica)	examination, Ora	al/written examina	tion, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0629-vl] (Technica	examination, Ora	al/written examina	tion, Weighting: 100	9%)
7	Usability of B.Sc. Inform M.Sc. Inform B.Sc. Comp M.Sc. Comp M.Sc. Wirtso B.Sc. Psycho Joint B.A. In B.Sc. Sportv M.Sc. Sportv M.Sc. Sportv	the module natik natik utational Engineering outational Engineerin chaftsinformatik ologie in IT formatik vissenschaft und Info wissenschaft und Info	g g ormatik ormatik			
8	Grade bonu	in other degree prog is compliant to §25	(2)			

	In dieser Vorlesu Novelle der APB u um bis zu 1.0 fü	ng findet eine Anrechnung von vorlesungsbegleitenden Leistu Ind den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsreg Irren kann.	ngen statt, die lt. 25 (2 geln zu einer Notenverbe	2) der 5. sserung		
9	References					
	Deisenroth, M. I	?; Neumann, G.; Peters, J. (2013). A Survey on Policy Search	for Robotics, Foundation	ons and		
	Trends in Roboti	CS				
	Kober, J; Bagnell	Kober, J; Bagnell, D.; Peters, J. (2013). Reinforcement Learning in Robotics: A Survey, International Journal of				
	Robotics Researc	Robotics Research				
	C.M. Bishop, Pat	tern Recognition and Machine Learning (2006),				
	R. Sutton, A. Bai	to. Reinforcement Learning - an Introduction				
	Nguyen-Tuong, I	D.; Peters, J. (2011). Model Learning in Robotics: a Survey				
Co	urses					
	Course nr.	Course name				
	20-00-0629-vl	Robot Learning				
	Instructor		Туре	SWS		
			Lecture	4		

Mo Phy	dule name sics and Tech	nology of Accelerato	ors			
<b>Mo</b> 05-	<b>dule nr.</b> 21-2514	Credit points 5 CP	Workload 150 h	Self-study 60 h	Module duration	Module cycle Every 2. Semester
Lar Gei	nguage rman		1	Module owner	I	
1	Teaching co	ntent		1		
2	Learning ob	jectives				
3	Recommend	led prerequisites fo	or participation			
4	Form of examinationModule exam:• Module exam (Study achievement, Study achievement, p/np RS)Course related exam:• [05-25-6302-pr] (Study achievement, Study achievement, p/np RS)					
5	Prerequisite for the award of credit points Passing the final module examination					
6	Grading Module exan • Module Course relate • [05-25	n: e exam (Study achie ed exam: -6302-pr] (Study ac	evement, Study ac	hievement, Weight achievement, Weiş	ing: 100 %) ghting: 0 %)	
7	Usability of	the module				
8	Grade bonu	s compliant to §25	(2)			
9	References					
Co	urses					
	<b>Course nr.</b> 18-bf-2010-v	Course name Accelerator Ph	nysics			
	<b>Instructor</b> Prof. Dr. Oliv	ver Boine-Frankenhe	eim		<b>Type</b> Lecture	<b>SWS</b> 2
	<b>Course nr.</b> 05-25-6302-	pr Vocational Lab	poratory: Introduc	tion to Accelerator	Physics	
	Instructor				<b>Type</b> Internshi	p SWS 2
	<b>Course nr.</b> 05-21-2502-	Course namekuIntroduction to	o Accelerator Phys	sics		
	Instructor				<b>Type</b> Course	SWS 2

Mo Opt	dule name	static and dynamic sy	/stems			
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
Lar Ger	nguage man	10 Cr	300 11	Module owner Prof. Dr. rer. nat.	Oskar von Stryk	Every 2. Semester
1	<ul> <li>optimization for static systems:</li> <li>unconstrained and constrained nonlinear optimization, optimality conditions</li> <li>numerical Newton type and SQP methods</li> <li>nonlinear least squares</li> <li>gradient free optimization methods</li> <li>practical aspects like problem formulation, approximation of derivatives, method specific parameters, assessment of a computed solution</li> <li>optimization for dynamic systems:</li> <li>parameter optimization and estimation problems</li> <li>optimal control problem</li> <li>maximum principle and optimality conditions</li> <li>numerical methods for computing optimal trajectories</li> <li>optimal feedback control</li> <li>linear quadratic regulator</li> <li>applications and case studies from engineering sciences and robotics</li> </ul>					
	theoretical methodolog	and practical assign	nments as well a	as programming t	asks for deepening	of knowledge and
2	Learning of Through suc techniques a optimization	bjectives ccessful participation s and computational mo n problems in engine	students acquire fu ethods of optimiza ering sciences.	indamental knowle ition for static and	edge and methodolog dynamic systems and	ical skills in concepts, their application for
3	Recommen grundlegend und Grundl	<b>ded prerequisites fo</b> le mathematische Ker agen gewöhnlicher D	or participation untnisse und Fähig ifferentialgleichur	keiten in Linearer A ngen	Algebra, Analysis meł	nrerer Veränderlicher
4	Form of exa Course relat • [20-00	amination ted exam: )-0186-iv] (Technical	examination, Ora	al/written examina	tion, Default RS)	
5	<b>Prerequisit</b> Pass exam (	e for the award of c 100%)	redit points			
6	Grading         Course related exam:         • [20-00-0186-iv] (Technical examination, Oral/written examination, Weighting: 100 %)					
7	Usability of	f the module				

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computatio M.Sc. Computati M.Sc. Wirtschaft B.Sc. Psychologie Joint B.A. Inform B.Sc. Sportwisse M.Sc. Sportwisse	onal Engineering onal Engineering sinformatik e in IT atik nschaft und Informatik nschaft und Informatik		
	May be used in o	ther degree programs.		
8	<b>Grade bonus con</b> In dieser Vorlesu Novelle der APB u um bis zu 1.0 füh	<b>npliant to §25 (2)</b> ng findet eine Anrechnung von vorlesungsbegleitenden Leistu nd den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsreg aren kann.	ngen statt, die lt. 25 (2 geln zu einer Notenverbe	) der 5. sserung
9	References - Script of Lectur - J. Nocedal, S.J. V - C.T. Kelley: Iter - L.M. Rios, N.V. implementations - A.E. Bryson, YO - J.T. Betts: Practic in Design and Co	e Wright: Numerical Optimization, Springer ative Methods for Optimization, SIAM Frontiers in Applied Ma Sahinidis: Derivative-free optimization: a review of algorithm , Journal of Global Optimization (2013) 56:1247-1293 C. Ho: Applied Optimal Control: Optimization, Estimation and cal Methods for Optimal Control and Estimation Using Nonlinea ntrol	thematics ns and comparison of so Control, CRC Press r Programming, SIAM Ad	oftware dvances
Coi	ırses			
	<b>Course nr.</b> 20-00-0186-iv	<b>Course name</b> Optimization of static and dynamic systems		
	Instructor		<b>Type</b> Integrated course	<b>SWS</b> 6

Mo Coi	Module name Computer Aided Design (CAD)						
<b>Mo</b> 16-	<b>dule nr.</b> 07-5020	Credit points 4 CP	Workload 120 h	Self-study 60 h	<b>Module duratio</b> 1 Term	n Module cy Summer te	<b>cle</b> rm
Lar Ger	<b>iguage</b> man	I	I	Module owner Prof. DrIng. Dip	l-WirtIng. Benjai	nin Schleich	
1	<b>Teaching co</b> Parametric 3 geometric el technical pro	ontent BD CAD systems, PD ements, features and oduct documentation	M systems, 3D ha l parametrics, asse ı, drawing standar	nd sketching, geon embly modeling, bi rds, product develo	netric models, des ll of materials, tole pment in teams.	ign of single par erances and surf	rts with face fits,
2	<ul> <li>Learning objectives</li> <li>On successful completion of this module, students should be able to: <ol> <li>Understand and apply parametric 3D CAD and PDM systems.</li> <li>Design parametric single parts and complex assemblies.</li> <li>Create engineering drawings for documentation.</li> <li>Manage generated product data using PDM processes.</li> <li>Work on and solve advanced tasks in virtual product development in teams.</li> </ol> </li> </ul>						
3	Recommend	ded prerequisites fo	or participation				
4	<ul> <li>Form of examination Module exam:</li> <li>Module exam (Technical examination, Special form, Default RS)</li> <li>Product modelling project (continuous assessment procedure: Reports on component modeling, assembly,</li> </ul>						
5	<b>Prerequisite</b> Passing the e	e for the award of c	redit points				
6	<b>Grading</b> Module exar • Module	n: e exam (Technical ex	xamination, Specia	al form, Weighting	: 100 %)		
7	<b>Usability of</b> Bachelor ME Bachelor WI Bachelor Me	<b>the module</b> 3 Pflicht -MB WP Projekte cchatronik					
8	Grade bonu	s compliant to §25	(2)				
9	<b>References</b> Lecture note on the websi	s can be purchased ir ite.	n the institute's sec	rretarial office. Exer	cises and backgro	und theory are a	vailable
Co	ırses						
	<b>Course nr.</b> 16-07-5020-	vl Course name	ed Design (CAD)				
	Instructor				<b>Type</b> Lectur	e	<b>SWS</b> 1
	<b>Course nr.</b> 16-07-5020-	ue Computer Aid	ed Design (CAD)				
	Instructor				<b>Type</b> Praction	e	<b>SWS</b> 1

<b>Course nr.</b> 16-07-5020-tt	<b>Course name</b> Computer Aided Design (CAD)		
Instructor		<b>Type</b> Tutorial	<b>SWS</b> 2

<b>Mo</b> Fur	<b>dule name</b> damentals of	Navigation I					
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle
Lar	i <b>guage</b> Ish	4 CP	120 11	<b>Module owner</b>	gen Bever	Summer te	1111
1	Teaching content Navigation principles, Earth models, Coordinate systems, Radio navigation, Basics and instruments (ADF, VOR, DME, ILS), dead reckoning, functional principles and error analysis, satellite navigation, Introduction into GPS, signal description and measurement principles, Dilution of Precision (DoP), Differential GPS, Augmentation systems (RAIM, GIC, WAAS, LAAS, EGNOS).						
2	<ul> <li>Learning objectives</li> <li>On successful completion of this module, students should be able to:</li> <li>1. Explain the physics associated with the navigation of the earth.</li> <li>2. Classify common coordinate systems and map projections.</li> <li>3. Judge the methods of radio, coupling, and satellite navigation with respect to performance and applications.</li> </ul>						
3	Recommended prerequisites for participation Recommanded: Control Engineering						
4	<ul> <li>Form of examination Module exam:</li> <li>Module exam (Technical examination, Oral examination, Duration: 20 Min., Default RS) Oral exam (in a group with 3 students) 60 min: 20 min per participiant</li> </ul>						
5	<b>Prerequisite for the award of credit points</b> Passing the examination						
6	<b>Grading</b> Module exan • Module	n: e exam (Technical ex	xamination, Oral e	examination, Weigl	nting: 100 %)		
7	Usability of WPB Master WPB Master WPB Master Master Mech	<b>the module</b> MB III (Wahlfächer AE III Nat_Ing-Bere PST III (Fächer aus atronik	aus Natur- und In ich Natur- und Ingeni	genieurwissenscha	ft) r Papiertechnik)		
8	Grade bonus	s compliant to §25	(2)				
9	References Course notes	available.					
Cot	ırses						
	<b>Course nr.</b> 16-23-5050-v	/l <b>Course name</b> /l Fundamentals	of Navigation I				
	Instructor				<b>Type</b> Lecture		SWS 2
	<b>Course nr.</b> 16-23-5050-1	Le <b>Course name</b> Fundamentals	of Navigation I				
	Instructor				<b>Type</b> Practice		<b>SWS</b> 1

Mo Tut	<b>dule name</b> orial Advance	l Cax Methods					
<b>Mo</b> 16-	<b>dule nr.</b> 07-5100	Credit points 4 CP	Workload 120 h	Self-study 60 h	Module duration 1 Term	Module cy Every Seme	<b>cle</b> ester
Lar Ger	n <b>guage</b> rman			Module owner Prof. DrIng. Dip	l-WirtIng. Benjam	in Schleich	
1	<b>Teaching co</b> Students gai course builds	n <b>tent</b> n knowledge of adv on the basic course	vanced CA Methoo 'Einführung in da	ds through the ana	alysis of recent indu tzte Konstruieren (C	ıstrial example AD)'.	es. This
2	2 Learning objectives The students will be familiar with advanced CA Methods. They are able to recognise, execute and plan the generic workflow of CA Processes. Furthermore they are able to transfer their theoretical knowledge into industrial practice.						
3	Recommended prerequisites for participation Einführung in das rechnergestützte Konstruieren (CAD) Virtuelle Produktentwicklung A, B, C						
4	<ul> <li>Form of examination Module exam:</li> <li>Module exam (Technical examination, Special form, Default RS)</li> </ul>						
5	<b>Prerequisite</b> Passing the f	for the award of c nal module examin	<b>redit points</b> ation				
6	Grading Module exan • Module	n: e exam (Technical e:	xamination, Speci	al form, Weighting	: 100 %)		
7	Usability of	the module					
8	Grade bonus	s compliant to §25	(2)				
9	References						
Coi	ırses						
	<b>Course nr.</b> 16-07-5100-1	t Tutorial Advan	nced CAx Method	3			
	Instructor				<b>Type</b> Tutoria	l	SWS

Mo Hai	<b>dule name</b> nds-On HCI					
<b>Mo</b> 20-	<b>dule nr.</b> 00-1116	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module duration	Module cycle Every 2. Semester
Lar Eng	<b>iguage</b> dish	I	I	<b>Module owner</b> Prof. Dr. Arjan Ku	ıijper	
1	You might have previously heard of or even tried out virtual/augmented reality, 3D printing, wearable or tangible user interfaces. The area of Human-Computer Interaction covers all these exciting topics and offers an opportunity to build new prototypes and try them out with people in the user studies. If you would like to better connect theory and practice in the area of Human-Computer Interaction (HCI), then the course of Hands-On Human-Computer Interaction (Hands-On HCI) is for you. The goal of the class is to walk you through the whole research cycle in HCI. It can play a great preparation role for your future bachelor/master thesis in HCI or lay a first brick in your academic path after finishing your studies.					
2	<ul> <li>Learning objectives After completing the module, students can </li> <li>differentiate between and apply three approaches to HCI research. distinguish three types of empirical research. effectively read a scientific publication. differentiate between types of HCI contributions. Formulate and define research questions, hypotheses and experimental variables. create a suitable study design based on the previously developed research questions. conduct a study using quantitative and qualitative methods to collect data. Analyze, evaluate and interpret quantitative data on the basis of statistical methods. Analyze and interpret qualitative data on the basis of grounded theory. Understand the peer review process and write reviews for a scientific publication. Understand and apply evaluation techniques with and without users. Write the knowledge gained as a scientific publication and present it to a specialist audience</li></ul>					
3	Recommend Recommend	ded prerequisites for led: Human-Comput	or participation er Interaction (TK	2)		
4	Form of exa Course relat • [20-00 The form of two of the for Written exan including ter	mination ed exam: )-1116-iv] (Technica the examination wil ollowing forms is pos n (duration 60 or 90 sts).	l examination, Ora l be announced at sible. or 120 minutes),	al/written examina the beginning of t oral exam (duration	tion, Default RS) he course. One or a n 15 or 30 minutes),	combination of max. homework (optional:
5	Prerequisite Pass exam (1	e for the award of c 100%)	redit points			
6	<ul> <li>Grading</li> <li>Course related exam:</li> <li>• [20-00-1116-iv] (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>					
7	Usability of B.Sc. Inform M.Sc. Inform May be used	<b>the module</b> natik natik l in other degree pro	grams.			
8	Grade bonu	is compliant to §25	(2)			

9	References					
Co	urses					
	<b>Course nr.</b> 20-00-1116-iv	Course name Hands-On HCI				
	<b>Instructor</b> Prof. Dr. Arjan K	uijper	<b>Type</b> Integrated course	SWS 4		
Mo Mo	<b>dule name</b> del Predictive	Control and Machin	e Learning			
-------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------	---------------------------------------	--------------------------------------	------------------------	----------------------
Module nr.         Credit points         Workload         Self-study         Module duration         Module cycle					Module cycle	
18-	fi-2040	4 CP	120 h	75 h	1 Term	Winter term
Lan Eng	<b>iguage</b> dish			Module owner Prof. Dr - Ing. Bolt	Findeisen	
1	1       Teaching content         Lecture:       Introduction and basics of optimal control, Linear Quadratic Regulator (LQR) in discrete and continuous time, basics of model predictive control (cost functions, constraints, receding horizon), nominal model predictive control for linear systems, robust and stochastic model predictive control, model predictive control of nonlinear systems, combination of machine learning and model predictive control. <i>Group work:</i> In a group project, the students will apply the learned. The group project evolves a review of state of the art for the selected task, the selection of suitable model predictive control approach, and the implementation using					
2	<ul> <li>2 Learning objectives         The students will understand the basics concepts of model predictive control. Furthermore, they are familiarized with machine learning approaches that can support model predictive controllers and possibly enhance the controller performance. This entails knowledge about theoretical questions such as stability in the nominal case, as well as extensions to the case of uncertain and disturbed systems. The students are enabled to design and implement model predictive controllers based on first principle/physical or data-based/machine learning based models. This entails the setup and design of the control structure as well as the tuning and identification of     </li> </ul>					
3	<b>Recommen</b> Basic concepted by the second sec	<b>ded prerequisites fo</b> ots of control theory. non and/or Matlab.	or participation Fundamentals of I	linear algebra, diffe	erential, and differen	ce equations. Knowl-
4	Form of examination         Module exam:         • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)         The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 25 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be an oral examination					
5	Prerequisite Passing the	e for the award of c final module examina	redit points ation			
6	<ul> <li>Grading Module exam:</li> <li>Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>					)
7	Usability of	the module				
8	<b>Grade bonu</b> Yes. Possibil	is compliant to §25 ity to improve the gr	(2) ade by a group we	ork/exercise.		
9	References					

- J. Rawlings, D. Mayne, and M. Diehl. Model predictive control: theory, computation, and design. Nob Hill Publishing.
- S. Rakovic, and W. Levine. Handbook of Model Predictive Control. Birkhäuser, 2018.

### Courses

00	Courses						
	<b>Course nr.</b> 18-fi-2040-vl	<b>Course name</b> Model Predictive Control and Machine Learning					
	Instructor Prof. DrIng. Rolf Findeisen		<b>Type</b> Lecture	<b>SWS</b> 2			
	<b>Course nr.</b> 18-fi-2040-ue	<b>Course name</b> Model Predictive Control and Machine Learning					
	Instructor Prof. DrIng. Rolf Findeisen		<b>Type</b> Practice	<b>SWS</b> 1			

## 2.6 Optional Subjects AIS-SS: Secure Systems

Mo IT S	<b>dule name</b> Security					
Module nr.Credit pointsWorkloadSelf-studyModule durationModule20-00-02196 CP180 h120 h1 TermEvery 2			Module cycle			
Language     Module owner       German     DrIng. Michael Kreutzer						
1	1 <b>Teaching content</b> Selected concepts of IT-Security (cryptography, security models, authentication, access control, security in networks; trusted computing, security engineering, privacy, web and browser security, information securit management. IT forensic, cloud computing)					control, security in information security
2	<ul> <li>2 Learning objectives         After successful participation in the course, students are versant in common mechanisms and protocols to increase security in modern it-systems. Students have broad knowledge of it-security, data protection and privacy on the Internet.     </li> <li>Students are familiar with modern information technology security concepts from the field of cryptography, identity management, web, browser and network security. Students are able to identify attack vectors in it-systems and develop countermeasures.     </li> </ul>					
3	Recomment Participation	<b>ded prerequisites fo</b> n of lecture Trusted S	or participation Systems			
4	Form of exa Course relat • [20-00	amination red exam: )-0219-iv] (Technica	l examination, Ora	al/written examina	tion, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0219-iv] (Technica	l examination, Ora	al/written examina	tion, Weighting: 100	9%)
7	Usability of the moduleB.Sc. InformatikM.Sc. InformatikM.Sc. WirtschaftsinformatikB.Sc. Psychologie in ITJoint B.A. InformatikB.Sc. Sportwissenschaft und Informatik					
	May be used	l in other degree pro	grams.			
8	In dieser Vo Novelle der A um bis zu 1	rlesung findet eine A APB und den vom FB .0 führen kann.	(2) .nrechnung von vo 20 am 30.3.2017 b	orlesungsbegleitend eschlossenen Anrec	len Leistungen statt, hnungsregeln zu eine	die lt. 25 (2) der 5. er Notenverbesserung
9	References					

- C. Eckert: IT-Sicherheit, 3. Auflage, Oldenbourg Verlag, 2004
- J. Buchmann, Einführung in die Kryptographie, 2.erw. Auflage, Springer Verlag, 2001
- E. D. Zwicky, S. Cooper, B. Chapman: Building Internet Firewalls, 2. Auflage, O'Reilly, 2000
- B. Schneier, Secrets & Lies: IT-Sicherheit in einer vernetzten Welt, dpunkt Verlag, 2000
- W. Rankl und W. Effing: Handbuch der Chipkarten, Carl Hanser Verlag, 1999
- S. Garfinkel und G. Spafford: Practical Unix & Internet Security, O'Reilly & Associates

#### Courses

00	u13C5			
	Course nr.	Course name		
	20-00-0219-iv	IT Security		
	Instructor		Туре	SWS
			Integrated course	4

Mo Phy	<b>dule name</b> vsical Layer Se	ecurity in Wireless Sy	rstems			
Module nr. Credit points Workload		Workload	Self-study	Module duration	Module cycle	
20- Lar Ger	00-0745 Iguage	6 CP	180 h	135 h Module owner Dr-Ing Michael	1 Term	Every 2. Semester
1	German       DrIng. Michael Kreutzer         1       Teaching content         Physical layer security techniques promise information theoretic security on the physical layer for wireless communication. This integrated course discusses the theory and practice of physical layer security. The underlying theory is introduced and the application of these fundamentals towards practical solutions is discussed. Attacks against (practical) physical layer security techniques are presented. Theoretical and practical exercises as well as the presentation of selected recent research results by seminar talks of students further deepen the understanding of the subject matter.         Course contents:       Properties of the physical layer         - Fundamentals of information theoretic security and delineation from cryptography         - Physical layer security techniques (such as cooperative jamming, orthogonal blinding, zero-forcing, interference alignment, key extraction)         - Practical aspects of physical layer security techniques         - Practical implementations of physical layer security techniques using software-defined radios         Sclorated current enumerations of physical layer security techniques using software-defined radios					
2	Learning ol After succes knowledge theoretic ba practical phy practical rea dently acqui comprehens	ojectives sfully attending the in the area of physic sics as well as theory ysical layer security t alization of physical are the current state of ible fashion.	course, students h al layer security. and practice of p techniques and de layer security tec of research on phy	have a basic theore They are able to d physical layer secur scribe their weakn hniques using soft rsical layer security	tical knowledge and lescribe the most imp rity techniques. They esses. Students have ware-defined radios. 7 and present the aqu	an in-deep practical portant information- v are able to analyze competencies in the . They can indepen- tired knowledge in a
3	Recomment Basics Mobi	<b>ded prerequisites fo</b> le Networking	or participation			
4	Form of exa Course relat • [20-00	n <b>mination</b> ed exam: )-0745-iv] (Technical	examination, Ora	l/written examina	tion, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	<ul> <li>Grading Course related exam:</li> <li>• [20-00-0745-iv] (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>					
7	Usability of	the module				

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik				
	Can be used in o	her degree programs.			
8	<b>Grade bonus compliant to §25 (2)</b> In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.				
9	References Selected literatur	e, will be given in lecture.			
Co	urses				
	Course nr.Course name20-00-0745-ivPhysical Layer Security in Wireless Systems				
InstructorTypeDrIng. Michael KreutzerIntegrated course			<b>SWS</b> 3		

Mo	dule name	zstems				
<b>Mo</b>	<b>dule nr.</b> 00-0583	Credit points	Workload	Self-study	Module duration	Module cycle
Lar Gei	nguage rman/English	0.01		Module owner Prof. DrIng. Ma	tthias Hollick	livery 2. bennester
1	German/English       Prof. DrIng. Matthias Hollick         1       Teaching content         The integrated course Secure Mobile Systems covers the topic area of security in wireless and mobile networks and communication systems. Fundamental topics will be enriched by current research.         Course contents:       - Security analysis and modelling of security threats in mobile and wireless systems         - Selected attacks and security mechanisms specific to mobile and wireless systems         - Security in wireless sensor networks         - Security in wireless mesh networks         - Threats against privacy and privacy-preserving mechanisms in mobile and wireless systems         - Security in cellular networks (GSM, UMTS, LTE)         - Selected research topisc in mobile and wireless systems					and mobile networks
2	<ul> <li>Learning objectives         After successfully attending the course, students have a specialized knowledge in the domain of security with emphasis on mobile, distributed, wireless communication networks. Students are able to apply and transfer the most important fundamentals from IT security, cryptography and traditional network security to the field of mobile systems.     </li> <li>Students obtain a thorough understanding of security mechanisms on the different network layers (application layer, transport layer, network layer, link layer, physical layer). As a result, they are able to thoroughly discuss the characteristics and principles in the area of mobile system security and exhibit detailed theoretical and</li> </ul>					
3	Recomment Grundlagen	<b>ded prerequisites fo</b> der Netzsicherheit u	<b>or participation</b> nd der Mobilen N	etze		
4	Form of exa Course relat • [20-00	nmination red exam: )-0583-vl] (Technica	examination, Ora	al/written examina	ition, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0583-vl] (Technica	examination, Ora	al/written examina	tion, Weighting: 100	)%)
7	Usability of B.Sc. Inform M.Sc. Inform M.Sc. Wirtso B.Sc. Psycho Joint B.A. In B.Sc. Sportv Can be used	the module natik natik chaftsinformatik ologie in IT formatik vissenschaft und Info in other degree prog	ormatik grams.			
8	Grade bonu	is compliant to §25	(2)			

	In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.					
9	References					
	Levente Buttyan	Jean-Pierre Hubaux: Security and Cooperation in Wireless N	letworks, Cambridge Un	iversity		
	Press, 2008, ISB	N: 978-0-521-87371-0 (book is available online for download)				
	Ausgewählte Buc	hkapitel und ausgewählte wissenschaftliche Veröffentlichunge	en.			
Cot	urses					
	Course nr.	Course name				
	20-00-0583-vl Secure Mobile Systems					
	Instructor Type SWS					
	Prof. DrIng. Matthias Hollick 2					

Mo Lab	dule name Exercise on S	Secure Mobile Netwo	orking			
Module nr.Credit pointsWorkloadSelf-studyModule durationModule cyc20-00-05526 CP180 h120 h1 TermEvery 2 Sec					Module cycle	
Lar	nguage	0 61	100 11	Module owner	Karston Waiha	Every 2. Semester
Ger	man/English			Prof. Dr. rer. nat.	Karsten weine	
1	The Lab Exercise on Secure Mobile Networking covers the applied software development as well as hardware- software development. Topic areas covered are communication networks, IT security, mobile networks and wireless communications as well as the combination of these. Goal is the solving of a given problem by implementation in software or hardware/software in a team.					
	<ul> <li>Course contents:</li> <li>Solving of a problem in the area of communication networks, IT security, mobile networks and wireless communications</li> <li>Survey on solution alternatives and discussion of pros and cons</li> <li>Conception of a software architecture or a combined hardware-software architecture</li> <li>Software/hardware design for the target platform</li> <li>Prototypical realization on the target platform</li> <li>Evaluation of the system with respect to performance aspects</li> <li>Documentation of the implemented solution</li> </ul>					tworks and wireless
2	2 Learning objectives After successfully attending the course, students have aquired the ability to solve problems in the area of secure mobile networking using software technology. The students have gained insight into the design/implementation of complex protocols or applications in one/multiple of the areas of communication networks, IT security, mobile netwokrs and wireless communications. They are able to implement the chosen protocols and application, and to test the functionality as well as to evaluate the performance. Students are able to document the developed software artefacts and to present the project progress and outcomes					
3	Recomment Successfull	<b>ded prerequisites fo</b> participation in an le	or participation cture of SEEMOO.			
4	Form of exa Course relat • [20-00	amination ed exam: )-0552-pr] (Study ac	hievement, Oral/v	vritten examination	n, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0552-pr] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %)	)
7	Usability of B.Sc. Inform M.Sc. Inform M.Sc. Wirtse B.Sc. Psycho Joint B.A. In B.Sc. Sportv	<b>the module</b> natik natik chaftsinformatik ologie in IT formatik vissenschaft und Info	ormatik			
8	Grade bonu	in other degree pro-	(2)			
0	Sidde Dolla	is compliant to 320	(-)			

9	References					
	will be given in	IdD.				
Co	urses					
	Course nr.	Course name				
	20-00-0552-pr	Secure Mobile Networking Lab				
	Instructor		Туре	SWS		
	Prof. DrIng. Ma	tthias Hollick	Internship	4		

Module name Project on Secure Mobile Networking							
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
20-	00-0553	9 CP	270 h	180 h	1 Term	Every 2. Semester	
Lar Ger	<b>nguage</b> rman/English			Module owner Prof. Dr. rer. nat.	Karsten Weihe		
1	Jerman/English       Prof. Dr. rer. nat. Karsten Weihe         1       Teaching content         The Project on Secure Mobile Networking covers the applied software development as well as hardware-software development. Topic areas covered are communication networks, IT security, mobile netwokrs and wireless communications as well as the combination of these. Goal is to independently carry out a development project in a team.         Course contents:       - Independent solving of a development project in the area of communication networks, IT security, mobile netwokrs and wireless communications         Project planning and project management       - Survey on solution alternatives and discussion of pros and cons         - Conception of a software architecture or a combined hardware-software architecture       - Software/hardware design for the target platform         - Prototypical realization on the target platform       - Evaluation of the system with respect to performance aspects         - Documentation of the implemented solution as well as extensive documentation of the project management						
2	Learning of After success of secure mo define, mana The student one/multiple They are abl evaluate the developed so	ojectives of the areas of common share and carrry out a shave gained insigned of the areas of common the to implement the performance. The of tware artefacts and	ourse, students hang software techn project. ht into the design nunication networl chosen protocols students are able l to present the pr	we aquired the abil nology. To this end n/implementation cs, IT security, mobil and application, a to document the oject progress and	lity to solve complex l, the students are al of complex protocol ile netwokrs and wire and to test the functi project planning an outcomes.	problems in the area ole to independently ls or applications in less communications. onality as well as to d management, the	
3	Recomment Successfull p	<b>ded prerequisites fo</b> participation of an le	or participation cture of SEEMOO.				
4	Form of examination         Course related exam:         • [20-00-0553-pp] (Study achievement, Oral/written examination, Default RS)						
5	Prerequisite for the award of credit points Pass exam (100%)						
6	<ul> <li>Grading Course related exam:</li> <li>[20-00-0553-pp] (Study achievement, Oral/written examination, Weighting: 100 %)</li> </ul>						
7	Usability of	the module					

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik					
	Can be used in or	ther degree programs.				
8	Grade bonus compliant to §25 (2)					
9	<b>References</b> Will be given in p	project.				
Co	urses					
	<b>Course nr.</b> 20-00-0553-pp	<b>Course name</b> Secure Mobile Networking Project				
	Instructor Prof. DrIng. Ma	tthias Hollick	<b>Type</b> Internship	<b>SWS</b> 6		

<b>Mo</b> Intr	dule name roduction to (	Cryptography					
<b>Mo</b> 20-	<b>dule nr.</b> 00-0085	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module duration	Module cycle Every 2. Semester	
Lar Gei	<b>nguage</b> rman			<b>Module owner</b> DrIng. Michael I	Kreutzer		
1	Teaching contentMathematical basic principles:• Calculations in congruence and residue class ringsBasic principles of encryption:• Symmetric vs. asymmetric cryptosystems• Block and stream ciphers, AES, DES• Cryptanalysis• Probability and perfect security• Public-key encryption• RSA, Diffie-Hellman, ElGamal• Factoring large numbers• Discrete logarithms• Cryptographic hash functions• Digital signatures• Identification						
2	Learning objectives         After successful completion of the module students         • understood the mathematical foundations of cryptography such as calculations in congruence and residue class rings, factoring large numbers, probability theory and perfect security         • understood the principles of public and secret key encryption and relevant schemes including their security and efficiency         • understood the principles of digital signatures and the relevant schemes including their security and efficiency						
3	Recomment Recomment • Linear • Funkt	<b>ded prerequisites fo</b> led: r Algebra for Comput ionale und Objektorie	or participation er Science entierte Programn	nierkonzepte			
4	Form of examination         Course related exam:         • [20-00-0085-iv] (Technical examination, Oral/written examination, Default RS)         The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.         White even (the size (0, - 0)) = 100, - is the base of the size (1, - i)) = 15, - 00, - is the base of the size (1, - i)).						
5	(optional: ir <b>Prerequisit</b>	ncluding tests). e for the award of c	redit points	-			
6	Pass exam ( Grading	(100%)					
-	Course rela • [20-0	<ul> <li>Grading</li> <li>Course related exam:</li> <li>• [20-00-0085-iv] (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>					

7	Usability of the	module				
	B. Sc. Informatik					
	M. Sc. Informatik					
	M. Sc. IT Sicherh	eit				
	M.Sc. IT Security	,				
	36 1 1.					
	May be used in o	ther degree programs.				
8	Grade bonus co	npliant to §25 (2)				
	In dieser Veranst	lltung findet eine Anrechnung von vorlesungsbegleitenden Leis	stungen statt, die lt. 25(2	2) der 6.		
	Novelle der Allge	meinen Prüfungsbestimmungen der TU Darmstadt und den v	vom Fachbereich Inform	atik am		
	14.07.2022 besch	llossenen Anrechnungsregeln zu einer Notenverbesserung um	bis zu 1.0 führen kann.			
9	References					
	<ul> <li>Johannes B</li> </ul>	uchmann: Einführung in die Kryptographie, 5. Auflage, Sprin	nger-Verlag, 2010, 278 p	o. ISBN:		
	978-3-642-	11185-3				
	<ul> <li>Johannes E</li> </ul>	uchmann: Cryptographic Protocols. Vorlesungsskript (u.a. U	Jndeniable, Fail-Stop un	d Blind		
	Signatures					
	<ul> <li>Neal Koblit</li> </ul>	z:A Course in Number Theory and Cryptography, Springer Ver	lag, 1994			
	• Alfred J. Me	enezes, Paul C. van Oorschot, Scot A. Vanstone: Handbook of A	pplied Cryptography, CR	C Press,		
	1997 (erhä	tlich als PDF)				
	Bruce Schn	eier: Applied Cryptography, John Wiley & Sons, Inc., 1994				
	• Douglas R.	Stinson: Cryptography - Theory and Practice, CRC Press, 199	5			
	<ul> <li>Gustavus J.</li> </ul>	Simmons: Contemporary Cryptology - The Science of Informa	ation Integrity, IEEE Pres	s, 1992		
Co	ırses					
	Course nr.	Course name				
	20-00-0085-iv	Introduction to Cryptography				
	Instructor		Туре	SWS		
			Integrated course	4		

Mo	dule name	1				
Mo	dule nr.	Credit points	es Workload	Self-study	Module duration	Module cycle
20-	00-1019	4 CP	120 h	90 h	1 Term	Every 2. Semester
Lar Ger	<b>nguage</b> rman/English			Module owner Prof. Dr. techn. S	tefan Katzenbeisser	
1	Teaching co	ontent		I		
	During the course of this seminar advanced theories and subjects from the field of "Science and Technology for Peace and Security" (PEASEC) will be developed. Based on the introduction and repetition of the princi-ples in scientific research, contemporary project topics which are related to PEASEC research will be offered by us and addressed by students applying scientific methods. During the semester scientific articles ("pa-pers") will be developed and presented. As usual in scientific work, students will constructively review each other's work in a peer-review process. Subsequently, the papers will be revised for the finalization and sub-mission. EXEMPLARY THEMATIC AREAS - Safety-critical human-computer interaction, social media and collaborative technologies in conflict and crisis situations, usable security and privacy - Information technology for peace and security, information warfare, manipulation of opinions, fake news, cyber war, cyber peace, dual-use in computer science, conscientious digitalization, computer science and society - Resilient IT-based (critical) infrastructures, particularly communication, agriculture, energy					
	- Resilient IT	based (critical) infra	structures, particures at ww	ılarly communicati w.peasec.de/lehre	on, agriculture, ener	gy
	PROCEDURE: - Technical introduction including the presentation and assignment of topics - Writing and submitting a short exposé - Methodological lecture - Short presentation of the own topic and constructive feedback - Submission of a first complete version of the paper - Assessment within a students' peer-review process - Final submission of the paper - Grading					
	A mandato second date and, if neces	ry introduction ("ki The assignment of to ssary, in the following	ck-off") is the f opics and formatio g week.	irst date, the ma on of groups will tal	ndatory methodolo ke place collaborative	gical lecture is the ely during the kickoff
2	Learning ol - Autonomou of computer - Further au - Preparation - Writing a s - Assessmen - Knowledge	<b>ojectives</b> Is familiarization with science conomous literature r a and presentation of cientific article t of scientific articles of the procedures of	a topic in the field research, interpret the topic to a het ("peer-review") w academic researc	l of peace, conflict a ation and classifica erogenous audience with constructive fea h and publication	and security research ation we and subsequent ex edback	from the per-spective pert discussion
3	Recommended prerequisites for participation         Principles in one of the subjects: Computer Science, IT-Security, Human-Computer-Interaction or Peace and Conflict Studies; basic knowledge in the topics of PEASEC					
4	Form of exa Course relat • [20-00	mination ed exam: )-1019-se] (Study acl	hievement, Oral/v	vritten examination	n, Default RS)	

5	Prerequisite for	the award of credit points					
	Pass exam (100%)						
6	Grading	Grading					
	• [20-00-101	am: 9-se] (Study achievement, Oral/written examination, Weight	ing: 100 %)				
	-		0				
7	Usability of the	module					
	B.Sc. Informatik						
	M.Sc. Informatik						
	May be used in c	ther degree programs.					
8	Grade bonus co	mpliant to §25 (2)					
9	References						
	Reuter, C. (2018	) Sicherheitskritische Mensch-Computer-Interaktion: Interal	ctive Technologien und	Soziale			
	Medien im Kriser	n- und Sicherheitsmanagement, 660 S., Wiesbaden: Springer V	Vieweg - im Druck				
	Altmann, J., Bern	hardt, U., Nixdorff, K., Ruhmann, I., & Wöhrle, D. (2016) Natur	wissenschaft - Rüstung -	Frieden			
	- Basiswissen für	die Friedensforschung (Vol. 49), Wiesbaden: Springer Vieweg	· ·				
	Flick, U. (2015)	introducing Research Methodology. Sage Publications Ltd					
	Further literature	e will be provided in the course dependent on the selected top	ic.				
Co	urses						
	Course nr.	Course name					
	20-00-1019-se	Crisis, Security and Peace Technologies					
	Instructor		Туре	SWS			
	Prof. Dr. techn. S	tefan Katzenbeisser	Seminar	2			

Mo	dulo nomo					
Info	ormation Tecl	nnology for Peace and	l Security			
Мо	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
20-	00-1026	6 CP	180 h	120 h	1 Term	Every 2. Semester
Lar	nguage			<b>Module owner</b>	tefan Katzenheisser	
1	Technological and scientific progress, especially the rapid development in information technology (IT), plays a crucial role regarding questions of peace and security. This course addresses the significance, potentials and challenges of IT for peace and security. For this purpose, the course offers an introduction to peace, conflict, and security research, thereby focusing on natural-science, technical and computer science perspectives. It thereby sheds light on cyber conflicts, war and peace, cyber arms control, cyber attribution and infra-structures as well as culture and interaction before an outlook is given. CONTENT: - Introduction to Natural-Science/Technical Peace Research and IT Perspectives of Peace, Conflict, and Secu-rity Research - Cyber War, Espionage, Defense, Darknets, Critical Infrastructures, Cultural Violence - Cyber Peace, Dual-Use, Confidence and Security Building Measures, Arms Control, Unmanned Systems, Verification, Attribution					
	<ul> <li>Verification, Attribution</li> <li>STRUCTURE: <ul> <li>Part I: Introduction und Foundations (Introduction and Overview, IT in Peace, Conflict and Security Research (Natural-Science/Technical Peace Research))</li> <li>Part II: Cyber War and Conflict (Information Warfare, Cyber Espionage and Cyber Defense, Darknets as Tools for Cyber Warfare)</li> <li>Part III: Cyber Peace (From Cyberwar to Cyberpeace, Dual-Use and Dilemmas of Cybersecurity, Confidence and Security Building Measures for Cyber Forces)</li> <li>Part IV: Cyber Arms Control (Arms Control and its Applicability to Cyberspace, Unmanned Systems: The Robotic Revolution, Verification in Cyberspace)</li> <li>Part V: Cyber Attribution and Infrastructures (Attribution of Cyber Attacks, Resilient Critical Infrastructures Security of Critical Information Infrastructures)</li> <li>Part VI: Social Interaction (Safety and Security, Cultural Violence, Social Media and ICT Usage in Conflict Areas)</li> <li>Part VII: Outlook (The Future of IT in Peace and Security)</li> </ul> </li> </ul>					nd Security Research se, Darknets as Tools urity, Confidence and anned Systems: The itical Infrastructures, CT Usage in Conflict
2	Learning of - Knowledge - Assessmen - Knowledge	bjectives e of basics of compute t of IT to promote or e in the design and de	er science for peac prevent peace and evelopment of IT f	e, conflict and secu d security for peace	ırity research	
3	Recommended prerequisites for participation Principles in one of the subjects: Computer Science, IT-Security, Human-Computer-Interaction or Peace and Conflict Studies					
4	Form of exa Course relat • [20-00	Form of examination Course related exam: • [20-00-1026-iv] (Technical examination, Oral/written examination, Default RS)				
5	<b>Prerequisit</b> Pass exam (	e for the award of c 100%)	redit points			

6	<ul> <li>Grading</li> <li>Course related exam:</li> <li>• [20-00-1026-iv] (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>						
7	Usability of the	module					
	B.Sc. Informatik						
	M.Sc. Informatik						
	May be used in c	ther degree programs.					
8	Grade bonus compliant to §25 (2)						
9	References						
Co	urses						
	Course nr.	Course name					
	20-00-1026-iv	Information Technology for Peace and Security					
	Instructor Type SWS						
	Prof. Dr. techn. S	tefan Katzenbeisser	Integrated course	4			

Mo Cor	<b>dule name</b>	itv				
Module nr. 20-00-0018Credit points 5 CPWorkload 150 hSelf-str				Self-study 105 h	Module duration	Module cycle Winter term
Lar Ger	nguage man			<b>Module owner</b> Prof. Dr. phil. nat	t. Marc Fischlin	
1	1       Teaching content         Part I: Cryptography       Background in mathematics for cryptography         • Security objectives: Confidentiality, Integrity, Authenticity         • Symmetric and asymmetric cryptography         • Hash functions and digital signatures         • Protocols for key distribution         Part II: IT-Security and Dependability         • Basic concepts of IT security         • Authentication         • Access control models and mechanisms         • Basic concepts of software security         • Dependable systems: error tolerance, redundancy, availability					
2	Learning objectives After successfully attending the course, students are familiar with the basic concepts, methods and models in the areas of cryptography and computer security. They understand the most important methods that allow to secure software and hardware systems against attackers and are able to apply this knowledge to concrete application scenarios					
3	Recommen	ded prerequisites fo	or participation			
4	Form of exa Course relat • [20-00 Written Exa	amination ed exam: )-0018-iv] (Technical m (90 min.)	examination, Ora	al/written examina	tion, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0018-iv] (Technical	examination, Ora	al/written examina	tion, Weighting: 100	)%)
7	Usability of the module B. Sc. Informatik B.Sc. Wirtschaftsinformatik Lehramt an Gymnasien - Fach Informatik May be used in other degree programs.					
8	<b>Grade bonu</b> In dieser Ver Novelle der 14.07.2022	is compliant to §25 ranstaltung findet ein Allgemeinen Prüfung beschlossenen Anrec	(2) e Anrechnung von gsbestimmungen hnungsregeln zu e	vorlesungsbegleite der TU Darmstadt einer Notenverbess	enden Leistungen stat und den vom Fachbe erung um bis zu 1.0	tt, die lt. 25(2) der 6. ereich Informatik am führen kann.
9	References					

	<ul> <li>M. Bishop, Computer Security: Art and Science, Addison Wesley, 2018</li> <li>P.C.van Oorschot: Computer Security and the Internet, Springer, 2021</li> <li>J. Katz, Y. Lindell: Introduction to Modern Cryptography, Chapman &amp; Hall, 2020</li> </ul>								
Co	urses								
	Course nr.	Course name							
	20-00-0018-iv	Computer Security							
	Instructor		Туре	SWS					
			Integrated course	3					

Mo For	<b>dule name</b> mal Methods	for Information Secu	rity			
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle
Lar Eng	<b>iguage</b> glish	901	270 11	Module owner Prof. DrIng. Hei	ko Mantel	Every 2. Semester
1	Teaching content         - formal modeling of security-critical systems in predicate logic         - theoretical foundations of access control and information-flow control         - formal modeling of security properties in predicate logic         - distinction between qualitative and quantitative security properties         - decidability and complexity results for security properties         - verification of security guarantees in distributed systems         - impact of stepwise composition and refinement on security guarantees         - formal languages for specifying security policies and their semantics         - certification of security-critical systems					
2	<b>Learning objectives</b> After successfully participating in this course, students know relevant formal security models and analysis techniques. They understand the fundamental differences between various classes of security properties and the interplay between stepwise software development and security guarantees. They are able to model systems and security requirements formally and to analyze security aspects rigorously based on formal specifications.					
3	<b>Recommen</b> Knowledge	<b>ded prerequisites fo</b> within Computer Scie	or participation ence and Mathem	atics according 1-4	semester of B.Sc. Co	omputer Science.
4	Form of exa Course relat • [20-00	amination red exam: D-0362-iv] (Technical	examination, Ora	al/written examina	tion, Default RS)	
5	Prerequisit Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0362-iv] (Technical	examination, Ora	al/written examina	tion, Weighting: 100	9%)
7	Usability of B.Sc. Inform M.Sc. Inform M.Sc. Wirts B.Sc. Psycho Joint B.A. In B.Sc. Sportw Can be used	<b>the module</b> natik natik chaftsinformatik ologie in IT nformatik wissenschaft und Info	ormatik grams.			
8	Grade bonı	is compliant to §25	(2)			
9	References					

- M. Bishop: Computer Security, Addison-Wesley
- J. Biskup: Security in Computing Systems, Springer-Verlag
- C. P. Pfleeger, S. L. Pfleeger: Security in Computing, Prentice Hall
   D. Denning: Cryptography and Data Security, Addison Wesley

Literature recommendations will be updatet regularly.

#### Courses

Course nr.	Course name		
20-00-0362-iv	Formal Methods for Information Security		
Instructor		Туре	SWS
		Integrated course	6

Mo Net	dule name	v				
Module nr. 20-00-0512Credit points 6 CPWorkloadSelf-study120 h120 h					Module duration	Module cycle Every 2. Semester
Lar Eng	Language English			<b>Module owner</b> DrIng. Michael I	Kreutzer	
1	English       DrIng. Michael Kreutzer         1       Teaching content         The integrated course Network Security covers the principles and practice of computer and telecommunication network security with particular emphasis on Internet security. After transferring the fundamentals of IT security and cryptography to the networking domain, we follow a top-down approach to network security. Starting with the application layer, the course provides a detailed discussion of network security principles and protocols. In addition to well known mechanisms, selected recent developments in the area of network security will be examined.         Course contents:       - Network security: introduction, motivation, and challenges         - Fundamentals: a reference model for network security, security standards for networks and the Internet, security threats, attacks, services, and mechanisms         - Cryptographic foundations for networking security: symmetric crypto and its use in networks, public-key crypto and its use in networks, support functions to implement network security         - Namplication layer security       - Transport layer security         - Network layer security       - Innk layer security         - Network layer security       - Innk layer security         - Network layer security       - Direvalls, intrusion detection systems         - Selected topics in network security       - Selected topics in network security					
2	Learning of After success cation netwo important fu are able to d thorough ur layer, netwo and principl field. Addit peer-to-peer of exercises,	ojectives sfully attending the c ork security with em indamentals from IT listinguish the most in inderstanding of security rk layer, link layer, ph es in the area of netwoionally, students are security, mobile netwoin the security of lite	ourse, students ha phasis on Interne security and cryp mportant basic teo rity mechanisms o hysical layer). As a work security and able to describe work security, etc.) rature, calculation	ve aquired an in-de t security. Student tography to the fie chniques for securir on the different net result, they are abl exhibit detailed th recent developme: . The exercise deep a swell as practica	ep knowledge in the s are able to apply a ld of communication ag communication ne twork layers (applicate to thoroughly discu- eoretical and practicate ints in the area of ne pens the theoretical for al implementation/ap	domain of communi- nd transfer the most a networks. Students etworks. They have a ation layer, transport as the characteristics cal knowledge in this etwork security (e.g. pundations by means oplication examples.
3	Recomment Knowledge i	ded prerequisites for in the area IT Securit	<b>r participation</b> y, Introduction to	Cryptography and	Communication Net	works
4	Form of exa Course relat • [20-00	mination ed exam: )-0512-iv] (Technical	examination, Ora	al/written examina	tion, Default RS)	
5	<b>Prerequisite</b> Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0512-iv] (Technical	examination, Ora	ıl/written examina	tion, Weighting: 100	%)
7	Usability of	the module				

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaft B.Sc. Psychologie Joint B.A. Inform B.Sc. Sportwisse	sinformatik e in IT atik nschaft und Informatik			
	Can be used in o	her degree programs.			
8	<b>Grade bonus compliant to §25 (2)</b> In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann				
9	<b>References</b> Charlie Kaufman, Radia Perlman, Mike Speciner: Network Security - Private Communication in a Public World, 2nd Edition, Prentice Hall, 2002, ISBN: 978-0-14-046019-6; additional texts may be announced				
Co	urses				
	<b>Course nr.</b> 20-00-0512-iv	Course name Network Security			
	Instructor DrIng. Michael	Kreutzer	<b>Type</b> Integrated course	SWS 4	

Mo Em	<b>dule name</b> bedded Syste	m Security				
<b>Mo</b> 20-	<b>dule nr.</b> 00-0581	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module duration 1 Term	Module cycle Every 2. Semester
Language GermanModule owner Prof. DrIng. Ahmad-Reza Sadeghi						
1       Teaching content Trusted Computing         - Authenticated Boot         - Binding and Sealing         - Integrity Measurement and Attestation         - Direct Anonymous Attestation         - Trusted Platform Modules (TPM/MTM)         - On-board Credentials         Mobile Security with focus on smartphones         - Selected Access Control and Permission Model Aspects         - Context-based Security Policies         - Selected Modern Attack Techniques         Hardware-based Cryptography         - Hardware-assisted Cryptographic Protocols						
2	<ul> <li>2 Learning objectives         During this lecture students acquire detailed knowledge of selected aspects in system security (based on hardware and software)     </li> </ul>					
3	Recomment Grundlagen	<b>ded prerequisites fo</b> der Kryptographie	or participation			
4	Form of exa Course relat • [20-00	<b>amination</b> ed exam: )-0581-iv] (Technica	l examination, Ora	al/written examina	tion, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0581-iv] (Technica	examination, Ora	al/written examina	tion, Weighting: 100	9%)
7	<ul> <li>7 Usability of the module</li> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> <li>M.Sc. Wirtschaftsinformatik</li> <li>B.Sc. Psychologie in IT</li> <li>Joint B.A. Informatik</li> <li>B.Sc. Sportwissenschaft und Informatik</li> <li>Can be used in other degree programs.</li> </ul>					
8	Grade bonu	is compliant to §25	(2)			
9	References					

	<ul> <li>Challener, David, VanDoorn, Leendert, Safford, David, Yoder, Kent, Catherman, Ryan ""A Practical Guide to Trusted Computing"", IBM Press, 2007</li> <li>Smith, Sean W. ""Trusted Computing Platforms: Design and Applications"", Springer Verlag, 2005</li> </ul>					
Co	Courses					
	Course nr.Course name20-00-0581-ivEmbedded System Security					
	Instructor Prof. DrIng. Ahmad-Reza Sadeghi		<b>Type</b> Integrated course	SWS 4		

<b>Mo</b>	Module name						
Put	Public Key Infrastructures						
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle	
20-	00-0063	6 CP	180 h	120 h	1 Term	Every 2. Semester	
Language German			<b>Module owner</b> DrIng. Michael I	Kreutzer			
1	Teaching co	ntent					

- 1. Security Goals
  - 1. Confidentiality
  - 2. Integrity
  - 3. Authenticity of Data
  - 4. Entity Authentication/Identification
  - 5. Non-repudiation
  - 6. Availability
  - 7. Other Goals
- 2. Public Key Cryptography
  - 1. Encryption (symmetric, assymetric, hybrid, cryptosystems, key exchange, performance, security, computational problems)
  - 2. Cryptographic Hash Functions
  - 3. Message Authentication Codes
  - 4. Digital Signatures (performance, standards)
- 3. Certificates
  - 1. X.509 Public Key Certificates (properties, content, extensions)
  - 2. PGP
  - 3. WAP Certificates
  - 4. Attribute Certificates
- 4. Trust Models
  - 1. Direct Trust (fingerprints, examples of)
  - 2. Web of Trust (key legitimacy, owner trust, trusted introducers)
  - 3. Use of PGP
  - 4. Hierarchical Trust (trusted list, common root, cross-certification, bridge)
- 5. Private Keys
  - 1. Software Personal Security Environments (PKCS#12, Java Keystore, application specific )
  - 2. Hardware Personal Security Environments (smart cards, hardware security modules, java cards)
  - 3. Private Key Life-cycle
- 6. Revocation
  - 1. Revocation (reaons for, requirements, criteria)
  - 2. Certificate Revocation Lists
  - 3. Delta Certificate Revocation Lists
  - 4. Other Certificate Revocation Lists (over-issued, indirect, redirect)
  - 5. OCSP
  - 6. Other Revocation Mechanisms (NOVOMODO)
- 7. Policies
  - 1. Certificate Life-cycle
  - 2. Certificate Policy and Certification Practice Statement
  - 3. Set of Provisions
- 8. Validity Models
  - 1. Shell Model
  - 2. Modified Shell Model
  - 3. Chain Model
- 9. Certification Path Validation
- 10. Trust Center
  - 1. Registration Authority (registration protocols, proof-of-possession, extended validation certificates)
  - 2. Certification Authority
  - 3. Certificate Management Authority
- 11. Certification Paths and Protocols
  - 1. Construction
  - 2. LDAP and other methods
  - 3 SCVP

2	<ul> <li>Learning objectives</li> <li>After completion of the module Public Key Infrastructures, the students are able to <ul> <li>understand the IT security goals and the cryptographic primitives to realize these goals.</li> <li>understand and explain the foundations of Public Key Infrastructures, in particular the different components (e.g., private keys, certificates, policies), actors (e.g., Trust centers, key owners) and processes (e.g., certificate request, certificate issuance, validation of certificates, revocation).</li> <li>understand, explain and apply the underlying theoretical models (e.g., trust models, validity models.</li> <li>use Public Key Infrastructures in practice (e.g., for Email signing and encryption, validation of the authenticity of web sites).</li> </ul> </li> </ul>
3	Recommended prerequisites for participation
4	<ul> <li>Form of examination Course related exam: <ul> <li>[20-00-0063-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul> The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests)</li></ul>
5	Prerequisite for the award of credit points Pass exam (100%)
6	<ul> <li>Grading</li> <li>Course related exam:</li> <li>• [20-00-0063-iv] (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>
7	Usability of the module B. Sc. Informatik M. Sc. Informatik M. Sc. IT Sicherheit May be used in other degree programs.
8	Grade bonus compliant to §25 (2)
9 Co	<ul> <li>References</li> <li>J. Buchmann, E. Karatsiolis, and A. Wiesmaier. ""Introduction to Public Key Infrastructures"", Springer-Verlag Berlin Heidelberg, 2013. ISBN: 978-3-642-40656-0 (Print) 978-3-642-40657-7 (Online)</li> <li>J. Buchmann, ""Einführung in die Kryptographie"", ISBN 3-540-41283-2</li> <li>C. Adams / S. Lloyd, ""Understanding Public-Key Infrastructure"", ISBN 1-57870-166-X</li> <li>Tom Austin, ""PKI / A Wiley Tech Brief"", ISBN 0-471-35380-9</li> <li>R. Housley / T. Polk, ""Planning for PKI"", ISBN 0-471-39702-4</li> <li>A. Nash / W. Duane / C. Joseph/ D. Brink, ""PKI Implementing and Managing E-Security"", ISBN 0-007-213123-3</li> <li>Henk C.A. van Tilborg, ""Encyclopedia of Cryptography and Security"", ISBN-13: 978-0387234731</li> </ul>

<b>Course nr.</b> 20-00-0063-iv	<b>Course name</b> Public Key Infrastructures		
Instructor		<b>Type</b> Integrated course	SWS 4

Mo	dule name	cal Infrastructures				
Mo 20-	<b>dule nr.</b> 00-0720	Credit points 3 CP	Workload 90 h	Self-study 60 h	Module duration	Module cycle Every 2. Semester
Lar Ger	Language German			Module owner DrIng. Michael	Kreutzer	
1	<b>Teaching c</b> Critical infra or impairm dramatic co	ontent astructures are organi ent would result in h onsequences (BMI, 20	sations or instituti ong-term supply s 09).	ons of major impor shortages, significa	tance to the state con ant disruption to pub	nmunity, their failure blic security or other
	The lecture focuses on different critical infrastructures and their security challenges. After an intro- duction into some basics, speakers from research institutions, companies, authorities or operators of critical infrastructures are lecturing on specific facets of the topic. A self-study of selected articles complements the lectures.					
	In the past years, speakers from the German Bundestag, the Federal Office of Civil Protection and Dis- aster Assistance (BBK), the Federal Office for Information Security (BSI), the German Federal Agency for Technical Relief (BBK), the Hessen Cyber Competence Center (Hessen 3C), Siemens AG, Deutsche Bahn, Deutsche Börse, German Air Traffic Control, as well as from universities and research institutions have given lectures					Protection and Dis- Federal Agency for AG, Deutsche Bahn, stitutions have given
2	<b>Learning objectives</b> After successfully attending the course, students are familiar with the most important IT security problems in critical infrastructures. They understand techniques that allow to secure critical infrastruces and are able to apply them in different sectors (such as the smart grid, the transportation or the telecommunications sectors).					
3	Recomment Computersy	ded prerequisites fo	or participation			
4	Form of exa Course rela • [20-0	<b>amination</b> ted exam: 0-0720-iv] (Technical	examination, Ora	al/written examina	tion, Default RS)	
5	<b>Prerequisit</b> Pass exam (	te for the award of c (100%)	redit points			
6	Grading Course rela • [20-0	ted exam: 0-0720-iv] (Technical	examination, Ora	al/written examina	tion, Weighting: 100	) %)
7	<ul> <li><sup>'</sup> Usability of the module         B.Sc. Informatik         M.Sc. Informatik         M.Sc. Wirtschaftsinformatik         B.Sc. Psychologie in IT         Joint B.A. Informatik         B.Sc. Sportwissenschaft und Informatik         Can be used in other degree programs.     </li> </ul>					
8	Grade bon	us compliant to §25	(2)			
9	References					

# Will be given in lecture.

Courses								
<b>Course nr.</b> 20-00-0720-iv	Course name Critical Infrastructure Protection							
<b>Instructor</b> DrIng. Michael	Type       Kreutzer     Integrated course	<b>SWS</b> 2						

Mo Ser	<b>dule name</b> ninar on Nety	working. Security. Mo	bility and Wirele	ss Communications		
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
Lar	nguage	5 Cr	90 11	Module owner	1 101111	Every 2. Semester
Gei	man/English			Prof. DrIng. Mat	tthias Hollick	
1	The Seminar on Networking, Security, Mobility, and Wireless Communications covers current research in the given topic areas. Under supervision of the tutors, the seminar imcludes studying, critically analyzing and discussing, summarizing, and presenting selected research articles. Deliverables are a short presentation, a final presentation, and a seminar paper.					
	<ul> <li>Course contents:</li> <li>Indepentent exploration of a topic in the area of networking, security, mobility, and wireless communications (typically in english)</li> <li>Own, enhanced literature study, gudided by tutor</li> <li>Interpretation and classification of the literature study, gudided by tutor</li> <li>Preparation of an introductory talk as well as a final talk including presentation slides, gudided by tutor</li> <li>Presentation of both talks for a heterogenous audience (experts/non-experts)</li> <li>Technical discussion after the talks</li> <li>Feedback to the speakers and the talks (including presentation skills) and technical content</li> </ul>					less communications udided by tutor ent
2	2 Learning objectives After successfully attending the course, students are able to work in a scientific manner under guidance. They know the fundamental techniques for scientific literature work and can apply them to a well-defined topic area. They have aquired intermediate knowledge on selected mechanisms, methodologies as well as applications for the investigated topic area. Students can present this aquired knowledge to a heterogeneous audience and explain the technical details of the investigated topic					nder guidance. They ell-defined topic area. ell as applications for neous audience and
3	Recomment Successfull	<b>ded prerequisites fo</b> participation in a lect	or participation ture of SEEMOO.			
4	Form of exa Course relat • [20-00	amination ed exam: )-0582-se] (Study ac	hievement, Oral/v	vritten examination	n, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	<ul> <li>Grading Course related exam:</li> <li>• [20-00-0582-se] (Study achievement, Oral/written examination, Weighting: 100 %)</li> </ul>				)	
7	Usability of B.Sc. Inform M.Sc. Inform M.Sc. Wirtso B.Sc. Psycho Joint B.A. In B.Sc. Sportw	<b>the module</b> natik natik chaftsinformatik ologie in IT nformatik wissenschaft und Info	ormatik			
Q	Can be used	in other degree prog	grams.			
ð	Grade Dont	is compliant to §25	(2)			

9	References					
	Depending on topic.					
Cot	ırses					
	Course nr.	Course name				
	20-00-0582-se Seminar on Networking, Security, Mobility, and Wireless Communications					
	Instructor Type SV			SWS		
	Prof. DrIng. Ma	tthias Hollick	Seminar	2		

Мо	dule name					
Sec	urity in Multi	media Systems and A	Applications	- 10 - 1		
<b>Mo</b>   20-	<b>dule nr.</b> 00-0093	Credit points	Workload 90 h	Self-study 60 h	Module duration	<b>Module cycle</b> Every 2 Semester
Lar		5.01	70 H	Module owner	1 Ieim	Livery 2. Demester
Ger	German			DrIng. Michael	Kreutzer	
1	<ul> <li>Teaching content         The students will gain an insight into the challenges of multimedia security and the established solution approaches. These include concepts such as media integrity, confidentiality and authenticity. The students already know the procedures used in digital watermarking, robust hashing, partial encryption, multimedia forensics and DRM. Choosing the appropriate solution from a full panoply of solution mechanisms they will be able to respond optimally to the multimedia security challenges depending on the respective requirements.         <ul> <li>Partial encoding procedures for video and audio to ensure confidentiality and authenticity</li> <li>Digital watermarks for images and audio - areas of application, methods and procedures</li> <li>Digital Rights Management and Copyright protection procedures</li> <li>Visual cryptography</li> <li>Besides discussing different algorithms, i.e. their possibilities, limitations and weaknesses, the commercial and societal aspects of protective measures will also be part of the lecture.</li> </ul> </li> </ul>					
2	<ul> <li>Learning objectives</li> <li>After successful completion of the module students got an overview of the challenges posed by multimedia security as well as known solutions. This includes concepts of digital watermarks, robust hashes, partial encryption, multimedia forensics, and DRM. The students are able to address challenges of multimedia security by applying appropriate solutions.</li> </ul>					
3	Recommend	ded prerequisites for led: Basic knowledge	<b>r participation</b> in Multimedia-Fo	ormats and IT Secu	rity.	
4	Form of exa Course relat • [20-00 The form of two of the for Written exa (optional: in	ed exam: )-0093-vl] (Technical the examination wil ollowing forms is pos m (duration 60 or cluding tests).	examination, Ora l be announced at sible. 90 or 120 minut	al/written examina the beginning of t tes), oral exam (d	tion, Default RS) he course. One or a luration 15 or 30 m	combination of max. hinutes), homework
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	<ul> <li>Grading Course related exam:</li> <li>[20-00-0093-vl] (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>					
7	Usability of B. Sc. Inform M. Sc. Inform M. Sc. IT Sid M.Sc. IT Sec May be used	<b>the module</b> natik matik cherheit curity l in other degree pro	grams.			
8	Grade bonu	is compliant to §25	(2)			

	In dieser Veranstaltung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25(2) der 6. Novelle der Allgemeinen Prüfungsbestimmungen der TU Darmstadt und den vom Fachbereich Informatik am 14.07.2022 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.						
9	References						
	<ul> <li>Steinmetz: Multimedia-Technologie. Grundlagen, Komponenten und Systeme, ISBN: 3540673326, Springer, Heidelberg, 2000</li> <li>Dittmann: Digitale Wasserzeichen, Springer Verlag, ISBN 3 - 540 - 66661 - 3, 2000</li> <li>Cox, Miller, Bloom: Digital Watermarking, Academic Press, San Diego, USA, ISBN 1-55860-714-5, 2002</li> <li>und spezifische Veröffentlichungen aus Tagungsbänden"</li> </ul>						
Co	urses						
	Course nr.Course name20-00-0093-vlSecurity in Multimedia Systems and Applications						
	Instructor		<b>Type</b> Integrated course	<b>SWS</b> 2			
Mo Saf	<b>dule name</b> ty of railway s	ignaling systems					
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<b>Mo</b> 20-	<b>dule nr.</b> 00-0461	Credit points 3 CP	Workload 90 h	Self-study 60 h	<b>Module durat</b> 1 Term	ion Module cy Every 2. Se	<b>cle</b> emester
Lar Ger	<b>iguage</b> man			<b>Module owner</b> DrIng. Michael Kreutzer			
1	Teaching co	ntent					
2	Learning ob	jectives					
3	Recommend	led prerequisites fo	or participation				
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>• [20-00-0461-se] (Study achievement, Oral/written examination, Default RS)</li> </ul>						
5	<b>Prerequisite</b> Pass exam (1	for the award of c 00%)	redit points				
6	Grading Course relate • [20-00	ed exam: -0461-se] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 10	)0 %)	
7	Usability of	the module					
8	Grade bonu	s compliant to §25	(2)				
9	References						
Cot	urses						
	<b>Course nr.</b> 20-00-0461-	Se Course name Sicherheitskor	zepte im Eisenbal	nnbetrieb			
	Instructor				<b>Typ</b> Sem	e inar	SWS 2

Mo Rea	<b>dule name</b> ll World Crypt	ography					
<b>Mo</b> 20-	<b>dule nr.</b> 00-0993	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module duration 1 Term	Module cy Every 2. Se	<b>cle</b> emester
Lar Ger	n <b>guage</b> rman			Module owner Prof. Dr. techn. S	tefan Katzenbeisser	·	
1	<b>Teaching co</b> Key derivation coin,).	ntent on, key exchange, s	secure communica	tion, credentials,	crypto currencies (T	LS, SSH, IPS	Sec, Bit-
2	2 Learning objectives After successful completion the participants understand the design choices and security guarantees of real-world cryptographic protocols, used in our daily lives. They learn to judge the significance and limitations of security models and security proofs for practical purposes.						
3	Recommend Einführung i	<b>led prerequisites fo</b> n die Kryptographie	or participation				
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>• [20-00-0993-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul>						
5	<b>Prerequisite</b> Pass exam (1	for the award of c	redit points				
6	Grading Course relate • [20-00	ed exam: -0993-iv] (Technical	l examination, Ora	ll/written examina	tion, Weighting: 100	9%)	
7	Usability of B.Sc. Inform M.Sc. Inform May be used	<b>the module</b> atik aatik in other degree pro	gams.				
8	Grade bonu	s compliant to §25	(2)				
9	References						
Cot	ırses						
	<b>Course nr.</b> 20-00-0993-	<b>Course name</b> iv Real World Cr	yptography				
	<b>Instructor</b> Prof. Dr. tech	ın. Stefan Katzenbei	isser		<b>Type</b> Integrate	d course	SWS 4

Mo Pra	dule name	System and IoT Secu	rity					
Mo 20-	<b>dule nr.</b> 00-0615	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module of 1 Term	duration	Module cyc Every 2. Se	<b>cle</b> mester
Lan Ger	n <b>guage</b> man			Module owner DrIng. Michael Kreutzer				
1	<b>Teaching co</b> In this pract specifically t - Design and - Design and - Modificatio - System prop	ntent ical course, the stud arget the open-sourc implementation of se implemenation of se ns of the Android Mi gramming in general	dents deal with d e Android OS and elected software a ecure user apps iddleware and Ker l	ifferent aspects of l comprise the follo attacks (ethical hac rnel to build securit	smartpho wing area king) ty architec	ne securit s: tures	y. The projec	ct tasks
2	Learning ob After success security med programmin	<b>jectives</b> sfully completing th chanisms in modern g in general.	is lab students w smartphone oper	ill have gained kno ating systems. Fut	owledge ar thermore t	nd hands- hey gain e	on expercien experience in	ce with system
3	Recommend - Basics oper - Knowledge	<b>led prerequisites fo</b> ating systems in C++ and Java	r participation					
4	<ul> <li>Form of examination Course related exam:</li> <li>• [20-00-0615-pr] (Study achievement, Oral/written examination, Default RS)</li> </ul>							
5	<b>Prerequisite</b> Pass exam (1	e for the award of cr	redit points					
6	Grading Course relate • [20-00	ed exam: -0615-pr] (Study acl	hievement, Oral/v	vritten examinatio	n, Weightii	ng: 100 %j	)	
7	Usability of the module B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik							
8	Grade bonu	s compliant to §25	(2)					
9	<b>References</b> Will be giver	ı in lab.						
Coι	ırses							
	<b>Course nr.</b> 20-00-0615-	pr Practical Lab o	on System and IoT	Security				
	Instructor					<b>Type</b> Internshi	p	SWS 4

Mo Cył	dule name persecurity Lal	)					
<b>Mo</b> 20-	<b>dule nr.</b> 00-1018	<b>Credit points</b> 6 CP	Workload 180 h	Self-study 120 h	Module duration 1 Term	Module cyc Every 2. Se	c <b>le</b> mester
Lar Eng	<b>1guage</b> glish			Module owner Prof. Dr. techn. S	tefan Katzenbeisser		
1	Teaching co In this lab w protocols, su discuss appli receive a spe	ntent e will learn the basi ch as BGP and DNS, cations security. We cific topic on which	c and advanced as , infrastructure mo will discuss and o they will work du	spects of network s odules, such as rou lemonstrate attack ring the semester,	security. We will revi ters, switches and fir is and defences. Each and on which they w	ew the found ewalls, and v of the stude ill be guided.	lational vill also nts will
2	<b>Learning ob</b> At the end o topics on wh	<b>jectives</b> f the course the stuc ich they will prepare	lents will acquire e projects. The gra	a good knowledge ade is based on the	in Network security, quality of the submi	and in partic tted project.	cular in
3	Recommend The students	led prerequisites for should have a backs	or participation ground in network	ing and in operatin	g systems - these are	prerequisite o	courses.
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>[20-00-1018-pr] (Study achievement, Oral/written examination, Default RS)</li> </ul>						
5	Prerequisite Pass exam (1	for the award of c .00%)	redit points				
6	Grading Course relate • [20-00	ed exam: -1018-pr] (Study ac	hievement, Oral/v	vritten examinatio	n, Weighting: 100 %	)	
7	Usability of B.Sc. Inform M.Sc. Inform May be used	<b>the module</b> atik aatik in other degree pro	grams.				
8	Grade bonu	s compliant to §25	(2)				
9	References						
Co	urses						
	<b>Course nr.</b> 20-00-1018-	pr Course name Cybersecurity	Lab				
	<b>Instructor</b> Prof. Dr. tech	D-00-1018-pr     Cybersecurity Lab       Instructor     Type       rof. Dr. techn. Stefan Katzenbeisser     4					

Mo	dule name	worked Systems Tr	ust Posilionco on	d Drivoqu			
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
20-	00-0969	3 CP	90 h	60 h	1 Term	Every 2. Semester	
Lar Eng	<b>iguage</b> slish			<b>Module owner</b> Prof. Dr. techn. S	tefan Katzenbeisser		
1	<ul> <li>Protection in Networked Systems: background, motivation, challenges</li> <li>Trust (Computational Trust): models and mechanisms</li> <li>Trust (Computational Trust): application in PKI, Cloud Computing, Reputation Systems, and Web Services</li> <li>Trust: regret management and device comfort</li> <li>Privacy: privacy definitions, models, data anonymity, communication anonymity</li> <li>Privacy &amp; Trust: privacy-preserving trust models, mechanisms, and application to IDM</li> <li>Security &amp; Economics</li> <li>Resilience: models, network intrusion detection systems, collaborative intrusion detection systems, honeypots</li> <li>Resilient networks</li> </ul>						
2	2 Learning objectives The integrated lecture Protection in Networked Systems ? Trust, Resilience, and Privacy covers the topics of computational trust, resilient and anonymous networks, and collaborative defense mechanisms. By attending this course, the students will be able to understand the problems and solutions in the context of networked systems. The course content will consider the concept of End-to-End systems emphasizing on users, devices, networks, and applications or services.						
3	<ul> <li>Recommended prerequisites for participation <ul> <li>Trust and Reputation for Service-Oriented Environments: Technologies For Building Business Intelligence And Consumer Confidence, Elizabeth Chang, Tharam Dillon, and Farookh K. Hussain, 374 pages, 2006. ISBN: 978-0-470-01547-6</li> <li>On anonymity in an electronic society: A survey of anonymous communication systems, Matthew Edman and Bülent Yener, ACM Computing Surveys, Vol. 42, Issue 1, 2009.</li> <li>Taxonomy and Survey of Collaborative Intrusion Detection, Emmanouil Vasilomanolakis, Shankar Karuppayah, Max Mühlhäuser, Mathias Fischer, ACM Computing Surveys, Vol. 47 Issue 4, 2015.</li> </ul> </li> </ul>						
4	Form of exa Course relat • [20-00	amination red exam: D-0969-iv] (Technical	examination, Ora	ıl/written examina	tion, Default RS)		
5	<b>Prerequisit</b> Pass exam (	e for the award of c 100%)	redit points				
6	Grading Course relat • [20-00	ed exam: )-0969-iv] (Technical	examination, Ora	ıl/written examina	tion, Weighting: 100	%)	
7	Usability of	the module					
8	Grade bonu	is compliant to §25	(2)				
9	References						
Cot	ırses						

<b>Course nr.</b> 20-00-0969-iv	<b>Course name</b> Protection in Networked Systems - Trust, Resilience, and Priv	/acy	
Instructor Prof. Dr. techn. S	stefan Katzenbeisser	<b>Type</b> Integrated course	<b>SWS</b> 2

Mo Lat	dule name Peace-, Secu	rity and Crisis Inforn	natics			
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
Lai Gei	nguage rman/English	0 CP	100 11	Module owner Prof. Dr. techn. S	tefan Katzenbeisser	Every 2. Semester
1	<b>Teaching co</b> The lab cour Technology specific area group and pr Examples fo	ontent rese offers developmen for Peace and Securi of development. Th rovide the students was r topics are available	nt projects relevan ty" (PEASEC). In nese topics are lin ith technical and so at www.peasec.do	t to the current res addition to a broac ked to the speciali cientific insight. Th e/lehre	earch of the research l overview, students v zations of the memb e topics will be worke	group "Science and will gain insight in a pers of the re-search d on in small groups.
2	<ul> <li>2 Learning objectives         Acquiring the qualification for solving a practical task in a team or by oneself and presenting the results, such as:         Resolution of an issue in the domain of peace, security and crisis informatics         Requirements engineering and empirical studies         Research of solution alternatives and assessment of their (dis)advantages         Design, prototypical implementation and maintenance of innovative applications         Evaluation of existing applications with regard to different assessment criteria         Documentation of the developed solution     </li> </ul>					
3	Recomment Foundations	<b>led prerequisites fo</b> of Computer Science	<b>r participation</b> e/Functional and	Object-oriented Pro	ogramming Concepts	
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>• [20-00-1020-pr] (Study achievement, Oral/written examination, Default RS)</li> </ul>					
5	Prerequisite Pass exam (1	e for the award of ca 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-1020-pr] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %)	
7	Usability of B.Sc. Inform M.Sc. Inform May be used	<b>the module</b> atik natik in other degree prog	grams.			
8	Grade bonu	s compliant to §25	(2)			
9 Co	References Reuter, C. (2 Medien im F Altmann, J., Frieden - Ba Further liter urses	2018) Sicherheitskri Arisen- und Sicherhei Bernhardt, U., Nixo siswissen für die Frie ature will be provide	tische Mensch-Co tsmanagement, 60 lorff, K., Ruhman densforschung (V d in the course de	mputer-Interaktion 60 S., Wiesbaden: n, I., & Wöhrle, D ol. 49), Wiesbaden ependent on the se	n: Interaktive Techno Springer Vieweg - im . (2016). Naturwisso .: Springer Vieweg. lected topic.	ologien und Soziale Druck enschaft - Rüstung -

<b>Course nr.</b> 20-00-1020-pr	<b>Course name</b> Lab Peace-, Security and Crisis Informatics		
Instructor Prof. Dr. techn. S	Stefan Katzenbeisser	<b>Type</b> Internship	SWS 4

Mo Sys	<b>Jodule name</b> System and IoT Security								
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle			
Lan	iguage	5 CP	90 11	Module owner	1 10111	Every 2. Semester			
Ger	man/English			Prof. DrIng. Ahr	nad-Reza Sadeghi				
1	In this seminar different security aspects of mobile devices (especially smartphone) will be analyzed and discussed. Students will process, summarize and evaluate a number of current scientific publications for a certain topic in form of an essay. Additionally, each student will present his work in front of the group at the end of the semester. Possible topics include: - Security models of current smartphone operating systems (e.g. Android, iOS, Windows Phone, MeeGo, Symbian, RIM) - Security analysis and comparison of current app store models - Usage of mobile devices in enterprises - Security extensions for Android								
	<ul> <li>- Osage of mobile devices in enterprises</li> <li>- Security extensions for Android</li> <li>- Kernel security</li> <li>- Application security (e.g. mobile malware and runtime attacks)</li> <li>- Privacy aspects in mobile devices</li> <li>- Security of mobile networks</li> </ul>								
2	<b>2 Learning objectives</b> This seminar covers several topics in the area of mobile security with the focus on smartphone security. Through this course students will gain detailed knowledge on the security and privacy aspects of mobile operating systems, devices, infrastructures and end-user applications. Moreover, they learn to examine current research in this area, to dive into a scientific topic and present their results in a short paper as well as an oral presentation.								
3	Recomment Grundlagen	<b>ded prerequisites fo</b> der Informatik	or participation						
4	Form of exa Course relat • [20-00	n <b>mination</b> ed exam: )-0652-se] (Study ac	hievement, Oral/v	vritten examination	ı, Default RS)				
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points						
6	Grading Course relat • [20-00	ed exam: )-0652-se] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %)	)			
7	Usability of the module B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik								
Q	Can be used	in other degree prog	grams.						
0	JI AUC DUILU	is compliant to \$25	(4)						

9	<b>References</b> Will be given in s	<b>References</b> Will be given in seminar.				
Co	Courses					
	<b>Course nr.</b> 20-00-0652-se	<b>Course name</b> System and IoT Security				
	Instructor Prof. DrIng. Ahmad-Reza Sadeghi		<b>Type</b> Seminar	SWS 2		

Mo Cry	<b>dule name</b> ptographic Pr	otocols						
<b>Mo</b>	<b>dule nr.</b> 00-1032	<b>Credit points</b>	Workload 180 h	Self-study 120 h	Module du	ration	Module cyc Every 2 Se	cle mester
Lar Eng	<b>iguage</b> glish	0.01	100 11	Module owner Prof. Dr. techn. S	tefan Katzen	beisser	livery 2. be	
1	<b>Teaching co</b> Cryptograph course cover mitments, S Retrieval, Se	ontent ic protocols allow pa s basic and advanced ecure Coin Flipping, ecure Multiparty Con	rties with potentia constructions for o Zero-Knowledge F nputation, and Ha	ally conflicting inter cryptographic proto Proofs, Mixnets, An- rdware-assisted Cr	rests to jointl cols and their onymous Cre yptographic	y perform r applicat dentials, Protocols	n certain tasl ions, includir Private Infor s.	ks. This ng Com- rmation
2	Learning of Students know and know th	<b>ojectives</b> ow basic and advance eir basic application	ed cryptographic p s.	rotocols, can assess	and compare	e their eff	ficiency and s	security,
3	Recomment Basic knowle "Computer S	<b>ded prerequisites fo</b> edge in applied crypt Security" or "Introduc	or participation ography is strong ction to Cryptogra	y recommended, e phy".	.g., by succes	sfully co	mpleting the	e course
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>• [20-00-1032-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul>							
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points					
6	Grading Course relat • [20-00	ed exam: )-1032-iv] (Technica	examination, Ora	al/written examina	ition, Weighti	ing: 100	%)	
7	Usability of B.Sc. Inform M.Sc. Inform M.Sc. IT Sic	<b>the module</b> natik natik herheit						
8	Grade bonu	is compliant to §25	(2)					
9	References							
Cot	urses							
	<b>Course nr.</b> 20-00-1032-	iv Cryptographic	Protocols					
	20-00-1032-WCryptographic ProtocolsInstructorTypeSWSProf. Dr. techn. Stefan KatzenbeisserIntegrated course4							

Mo Pro	dule name tection in Infr	astructures and Netv	works				
<b>Mo</b> 20-	<b>dule nr.</b> 00-1022	Credit points 3 CP	Workload 90 h	Self-study 60 h	Module duration	Module cyc Every 2. Se	<b>:le</b> mester
Lar Ger	<b>nguage</b> rman/English			Module owner Prof. Dr. techn. S	tefan Katzenbeisser		
1	<b>Teaching co</b> The Seminar chance to re - Trust - Privacy - Resilience in the doma	ontent r on Protection in Inf ad, analyze and sum in of infrastructures	rastructures and M marize current sc and networks.	Vetworks is a cycle ientific publication	of seminars where st s. The topics are rela	udents are gi ted to the are	ven the as of:
2	Learning objectivesStudents participating in the seminar will have the opportunity to learn and conduct research in the direction of these topics.Your task will be to understand state-of-the-art scientific publications in order to explain their contributions. Furthermore, you are expected to write a survey in relation to the topic assigned to you.						
3	Recommended prerequisites for participation Basic knowledge about it-security and distributed systems. Lectures: Computersystemsicherheit (CSS) Computer-Netzwerke und verteilte Systeme (CNuvS)						
4	Form of exa Course relat • [20-00	mination ed exam: )-1022-se] (Study ac	hievement, Oral/v	vritten examination	n, Default RS)		
5	Prerequisite Pass exam (2	e for the award of c 100%)	redit points				
6	Grading Course relat • [20-00	ed exam: )-1022-se] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %	)	
7	Usability of B.Sc. Inform M.Sc. Inform May be used	<b>the module</b> aatik natik l in other degree pro	gramss				
8	Grade bonu	s compliant to §25	(2)				
9	References						
Cou	urses						
	<b>Course nr.</b> 20-00-1022-	se Protection in I	nfrastructures and	l Networks			
	<b>Instructor</b> Prof. Dr. tecl	hn. Stefan Katzenbei	sser		<b>Type</b> Seminar		SWS 2

Mo Lab	<b>dule name</b> Blockchain						
<b>Mo</b>	<b>dule nr.</b> 00-1031	Credit points	Workload	Self-study	Module duration	Module cy	<b>cle</b>
Lar	iguage	0.01	100 11	Module owner	1 ICIM	Livery 2. De	linester
Ger	man/English			Prof. Dr. techn. S	tefan Katzenbeisse	r	
1	<ul> <li>The control content</li> <li>This course is aimed at students who have attended the lecture Cryptocurrencies and want to understand and examine some aspects of this topic in more detail. It provides a platform to check novel applications based on Blockchain technology for their feasibility and usefulness.</li> <li>Complex cryptographic systems and ideas from the lecture Cryptocurrencies should be understood in team work and implemented in a decentralized system. The students are asked to develop a project plan and outline, which should be implemented over the course of the semester.</li> <li>The students get first experiences with the implementation of a more complex development project.</li> </ul>						
2	<ul> <li>Learning objectives</li> <li>Participants of this course will learn about the technical and practical implications of distributed cryptographic systems. These include first hands-on experiences in the following areas:</li> <li>Development of smart contracts and distributed applications</li> <li>Communication of systems through decentral peer-to-peer networks</li> <li>Development of software using cryptographic building blocks</li> <li>Security and anonymity of users of cryptographic currencies</li> <li>Possible attacks on smart contracts and cryptocurrencies</li> </ul>						
3	<b>Recommended prerequisites for participation</b> This course is directed at students that finished the cryptocurrencies lecture with good marks and programming skills.						
4	Form of exa Course relate • [20-00	<b>mination</b> ed exam: -1031-pr] (Study ac	hievement, Oral/v	vritten examinatio	n, Default RS)		
5	Prerequisite Pass exam (2	e for the award of c	redit points				
6	Grading Course relate • [20-00	ed exam: -1031-pr] (Study ac	hievement, Oral/v	vritten examinatio	n, Weighting: 100	%)	
7	Usability of B.Sc. Inform M.Sc. Inform May be used	<b>the module</b> atik natik in other degree pro	grams.				
8	Grade bonu	s compliant to §25	(2)				
9	References						
Со	ırses						
	<b>Course nr.</b> 20-00-1031-	pr Lab Blockchai	n				
	<b>Instructor</b> Prof. Dr. tech	nn. Stefan Katzenbe	isser		<b>Type</b> Interns	hip	SWS 4

<b>Modu</b> Safety	Module name Safety-Critical Human-Computer-Interaction						
<b>Modu</b> 20-00	Module nr.Credit pointsWorkloadSelf-studyModule durationModule cycle20-00-10256 CP180 h120 h1 TermEvery 2. Semester						
<b>Langu</b> Germa	Language     Module owner       German     Prof. Dr. techn. Stefan Katzenbeisser						
1 T	1 Teaching content						

This course provides a sound and practice-oriented introduction and an overview of the foundations, meth-ods, and applications of human-computer-interaction (HCI) in the context of security, emergencies, crises, disasters, war, and peace. Addressing this, interactive, mobile, ubiquitous and cooperative technologies, as well as social media, are presented. Here, classical topics such as usable (IT) security, industry 4.0, civil pro-tection, medicine, and automotive, as well as augmented reality, crowdsourcing, shitstorm management, so-cial media analytics and cyberwar all find their place. Methodologically, the spectrum from usable safety to usable security engineering is covered from analysis through design to evaluation.

## CONTENT:

- Foundations and Methods (Usable Safety; Usable Security; Analysis, Design, Implementation, Evaluation; Law, Ethics and Culture)

- Safety-critical Interactive Systems (Business Information Systems, Crisis Management Systems, Medical Engineering, Warning Systems and Assistance Systems)

- Safety-critical	<b>Cooperative Systems</b>	(Social Media,	Cooperative Systems,	Voluntary	Participation,	Peace and
Security)						

STRUCTURE:

Part I: Introduction and Overview

Part II: Foundations and Methods

- Usable Safety (Usable Safety-Engineering of Safety-critical Interactive Systems, Usability-Engineering and User Experience of Safety-critical Systems, Quantitative Evaluation of Human-Computer-Interaction)

- Usable Security (Human Factors in Security, Tools for Usable (Cyber-)Security, Usable Solutions for Data Protection)

- Law, Ethics and Culture (Selected Legal Implications for Safety-critical IT, Ethical, Legal and Social Implica-tions (ELSI), International and Intercultural Aspects of Safety-critical Systems)

Part III: Safety-critical Interactive Systems

- Business Information Systems (Critical Infrastructures and Business Continuity Management, Safety-critical Human-Machine-Interaction in Industry 4.0, IT-Systems for Crisis Management: Requirements, Functionalities and Categories)

- Crisis Management and Medical Engineering (IT-Support of Standard and Exceptional Operations of Emer-gency Services, Safety-critical Human-Machine-Interaction in Medical Technology, Warnings of the Population in Disaster Situations)

- Warning Systems and Assistance Systems (Human Factors in the Development of Driver Assistance Systems, From Driver Information to Driver Assistance and Autonomous Driving)

Part IV: Safety-critical Cooperative Systems

- Social Media (Social Media in Emergency Situations, Crises and Catastrophes, Social Media Analytics for Companies and Authorities, Corporate Shitstorm Management: Confrontations in Social Media)

- Cooperative Systems for Mission Situations (Resilience through Cooperative Technologies, IT-based Pro-cess Support for Safety of Major Events, Situational Awareness in Augmented and Virtual Reality Simulation Games)
- Technology for Voluntary Participation (Humanitarian Aid and Concepts of Digital Aid, Involvement of Emergent Volunteers for the Mastery of Loss Events, Mobiles Crowdsourcing for the Integration of Volunteers)
- Peace and Security (Computer Science for Peace and Security, Social Media in Political Conflict Situations)

Part V: Outlook: The Future of Safety-critical Human-Computer-Interaction

Details for the current semester can be found at www.peasec.de/lehre

2 Learning objectives

	<ul> <li>Understanding of safety-critical HCI and the underlying disciplines HCI as well as crisis and security management</li> <li>Overview of selected basics and methods of safety-critical HCI (usable safety, usable security, analysis, design, implementation, evaluation, law, ethics, and culture)</li> <li>Orientation in application domains and fields</li> <li>Knowledge about safety-critical interactive systems (business information systems, crisis management sys-tems, medical engineering, warning and assistance systems)</li> <li>Knowledge about safety-critical cooperative systems (social media, cooperation systems, voluntary partici-pation, peace, and security)</li> </ul>				
3	<b>Recommended prerequisites for participation</b> Principles in one of the subjects: Computer Science, IT-Security, Human-Computer-Interaction or Peace and Conflict Studies				
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>[20-00-1025-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul>				
5	<b>Prerequisite for</b> Pass exam (100%	the award of credit points			
6	Grading Course related ex • [20-00-102	am: 5-iv] (Technical examination, Oral/written examination, Weig	shting: 100 %)		
7	Usability of the B.Sc. Informatik M.Sc. Informatik May be used in o	module ther degree programs.			
8	Grade bonus co	npliant to §25 (2)			
9	References				
Cot	urses				
	<b>Course nr.</b> 20-00-1025-iv	<b>Course name</b> Safety-Critical Human-Computer-Interaction			
	InstructorTypeSWSProf. Dr. techn. Stefan KatzenbeisserIntegrated course4				

Mo	dule name					
Inf	ormation Secu	Irity Management		- 10 - 1		
Mo	dule nr. 00-1123	Credit points	Workload 90 h	Self-study Module duration Module cycle		
La	nguage		, , , , , , , , , , , , , , , , , , ,	Module owner	1 101111	
German			Prof. Ph.D. Sebas	tian Faust		
1	Teaching co In the lecturestablished The followin Mature Capab Estable Inform Estable and IT Securit Key Pe Asset I Protect Qualit Risk a Vulner Busine Secure Secure Secure Manag Incide Audit Review	ontent ure, an exemplary, f in all processes of the ing topics are consider ity level assessment of ility Maturity Model ishment of a Cyber S- nation Security Gover ishment of an Inform Corundschutz ty Awareness within erformance Indicator Management, inform tion requirement and ative and quantitativ nalysis, treatment an rability Management ess Continuity Manages continuity Planni e IT operations, secure e development ng cloud services gement of service pro- nt Management: sect Management v of compliance and	fictitious organization. red, among others regarding informa Integration (CMM ecurity Strategy mance ation Security Mat the organization to measure inform ation networks an alyses and busines e risk managemen d monitoring proc (dealing with IT w gement (BCM) ng (BCP) ring operational pu- widers uring, detecting an governance	tion is used to de tion security of the II) Framework nagement System ( nation security d process analyses s impact analyses it cesses vulnerabilities in ov rocesses	emonstrate how info	ormation security is SO/IEC 27001:2013 ystems)
2	Learning ol The main ol focusing on • Knowl • Overv Grund • Identii • Knowl • System • Establ proces	bjectives bjective of this modu management rather edge, contents and s iew of common pro- schutz, NIST Cyberse fication and protectio edge of common risk natic assessment of in ishment of processes sses, incident manage	le is to learn how than technical or i tructures of an Inf cedures regarding ecurity Frameword on requirement an management pro nformation securit s relevant to info ement and audit n	IT and information formal IT security. formation Security g information secu k. alysis of assets in the ocedures y in the organization rmation security s nanagement	n security is managed Management System urity management, o he organization on using metrics uch as vulnerability	d in an organization, n (ISMS) e.g. ISO 27001, IT- management, BCM
3	Recommen Attendance	ded prerequisites for of the course "Compu	or participation uter Security" is re	ecommended.		
4	Form of exa	mination				

	<ul> <li>Course related exam:</li> <li>[20-00-1123-vl] (Technical examination, Oral/written examination, Default RS)</li> <li>The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.</li> <li>Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).</li> </ul>			
5	<b>Prerequisite for</b> Pass exam (100%	the award of credit points		
6	Grading Course related exam: • [20-00-1123-vl] (Technical examination, Oral/written examination, Weighting: 100 %)			
7	Usability of the B.Sc. Informatik M.Sc. Informatik May be used in c	module ther degree programs.		
8	Grade bonus co	mpliant to §25 (2)		
9	References			
Co	urses			
	<b>Course nr.</b> 20-00-1123-vl	<b>Course name</b> Information Security Management		
	<b>Instructor</b> Prof. Ph.D. Sebas	tian Faust	<b>Type</b> Lecture	SWS 2

Mo Sid	<b>dule name</b> e-channel res	ilient cryptography				
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle
Lar Eng	nguage	5 Gr	90 H	Module owner Prof. Ph.D. Sebas	tian Faust	Every 2. Semester
1	English       Prof. Ph.D. Sebastian Faust         1       Teaching content         Cryptographic schemes are classically secure against black-box attacks, where an attacker exploits weaknesses of the underlying cryptographic algorithm. When cryptography is implemented in practice, so-called side-channel attacks are a further threat to their security. Most of cryptography can be broken by side-channel attacks and countless examples illustrate that almost all the devices that are in use today are affected by them. Starting in the late 1990s, when Kocher showed that smart cards can be broken using timing or power analysis attacks, there has been a plethora of different side-channel attacks been discovered. Most recently, examples such as Foreshadow illustrate that even advanced computing machinery is vulnerable to side-channel attacks. Leakage resilient cryptography is the discipline that formalises these practical attacks in order to use formal methods for demonstrating security against them. In particular, it defines new security models, and design cryptographic schemes that are provable secure within them.					
2	<ul> <li>2 Learning objectives Upon successful completion of the module, students will be familiar with the most influential papers on side-channel attacks and leakage resilient cryptography in order to: <ul> <li>Present and understand popular side channel attacks (e.g., power analysis attacks, timing attacks, fore-shadow etc.)</li> <li>Present and understand common countermeasures against side-channel attacks (e.g., constant time cryptography, randomized execution, masking schemes, algorithmic countermeasures, etc.)</li> <li>Present security models in leakage resilient cryptography and the formal security analysis of side channel countermeasures (e.g., memory leakage models and computation leakage models) </li> </ul></li></ul>					ential papers on side- timing attacks, fore- (e.g., constant time es, etc.) alysis of side channel
3	Recommend Recommend The semina recommend	<b>ded prerequisites fo</b> led: r is aimed at master ed, but not mandato	or participation students. Basic l ry.	ecture IT security	or basic knowledge	in cryptography are
4	Form of exa Course relat • [20-00 The form of two of the fo Colloquium	amination red exam: )-1088-se] (Study ac the examination wil ollowing forms is pos (optional: including	hievement, Oral/v ll be announced at ssible: presentation), Ter	vritten examinatior the beginning of t m Paper.	n, Default RS) he course. One or a	combination of max.
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	<ul> <li>Grading Course related exam:</li> <li>[20-00-1088-se] (Study achievement, Oral/written examination, Weighting: 100 %)</li> </ul>					)
7	Usability of B.Sc. Inform M.Sc. Inform May be used	<b>the module</b> natik natik l in other degree pro	grams.			
8	Grade bonus compliant to §25 (2)					

9	References			
Co	urses			
	<b>Course nr.</b> 20-00-1088-se	<b>Course name</b> Side-channel resilient cryptography		
	<b>Instructor</b> Prof. Ph.D. Seba	stian Faust	<b>Type</b> Seminar	<b>SWS</b> 2

## 2.7 Optional Subjects AIS-VC: Visual Computing

Mo Cor	<b>dule name</b> nputer Graph	ics I				
<b>Mo</b>	<b>dule nr.</b>	<b>Credit points</b>	Workload	Self-study	Module duration	Module cycle
Lar Ger	nguage	0.01	100 11	Module owner Prof. Dr. Bernt Sc	hiele	
1	<b>Teaching co</b> Introduction OpenGL, ray	ontent a to basic principles o v tracing, illumination	of computer graph n modelling, ongo	ics, in particular in ing development in	nput and output devi n computer grapics.	ces, rendering using
2	Learning of After success and change effectively su utilize varior	<b>ojectives</b> sful completion of the variable parts (Vert tore objects in the 31 us shading-technique	e modul, students a tex-Shader, Fragn D-space, as well as s and lighting-mod	are able to understa nent-Shader, etc.). s appropriately cho dels to adapt all ste	and all components of They are able to a pose the camera and ps on the way to the	f the graphic pipeline rrange, change and the perspective, and displayed 2D-Image.
3	<ul> <li>3 Recommended prerequisites for participation Recommended:         <ul> <li>Programming</li> <li>Basic algorithm and data structure</li> <li>Linear algebra</li> <li>Analysis</li> <li>Topics of lecture Visual Computing</li> </ul> </li> </ul>					
4	Form of exa Course relat • [20-00 The form of two of the fo Written exa (optional: in	mination ed exam: )-0040-iv] (Technical the examination wil pllowing forms is pos m (duration 60 or cluding tests).	l examination, Ora l be announced at sible. 90 or 120 minut	al/written examina the beginning of t tes), oral exam (d	tion, Default RS) he course. One or a luration 15 or 30 m	combination of max. ninutes), homework
5	Prerequisite Pass exam (	e for the award of c 100%).	redit points			
6	Grading Course relat • [20-00	ed exam: )-0040-iv] (Technica	l examination, Ora	al/written examina	tion, Weighting: 100	9%)
7	<ul> <li>7 Usability of the module <ul> <li>B. Sc. Informatik</li> <li>M. Sc. Informatik</li> <li>M. Sc. Computer Science</li> <li>M. Sc. Autonome Systeme und Robotik</li> <li>M.Sc. IT Sicherheit</li> </ul> </li> </ul>					
8	Grade bonu In this cours ment of up t Darmstadt a	a crediting of lecture of 1.0 according to 2. and the crediting rule	(2) re-accompanying a 5(2) of the 6th an es decided by the I	achievements takes nendment of the Ge Department of Com	place, which can leac eneral Examination R aputer Science on Jul	d to a grade improve- legulations of the TU ly 14, 2022.

9	<ul> <li>References         <ul> <li>Real-Time Rendering: Tomas Akenine-Möller, Eric Haines, Naty Hoffman A.K. Peters Ltd., 3rd edition, ISBN 987-1-56881-424-7</li> <li>Fundamentals of Computer Graphics: Peter Shirley, Steve Marschner, third edition, ISBN 979-1-56881-469-8</li> <li>Additional literature will be given in the lecture.</li> </ul> </li> </ul>						
Co	urses						
	<b>Course nr.</b> 20-00-0040-iv	Course name Computer Graphics I					
	Instructor     Type     SWS       Integrated course     4						

Mo	dule name	a				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
20-	00-0014	5 CP	150 h	105 h	1 Term	Summer term
Lar Ger	<b>iguage</b> man			Module owner Prof. Dr. phil. na	t. Marc Fischlin	
1	1Teaching content- Basics of perception- Basic Fourier transformation- Images, filtering, compression & processing- Basic object recognition- Geometric transformations- Basic 3D reconstruction- Surface and scene representations- Rendering algorithms- Color: Perception, spaces & models- Basic visualization					
2	2 Learning objectives After successful participation in the course students are able to describe the foundational concepts as well as the basic models and methods of visual computing. They explain important approaches for image synthesis (computer graphics & visualization) and analysis (computer vision) and can solve basic image synthesis and analysis tasks.					
3	Recommended prerequisites for participation Recommended: Participation of lecture "Mathematik I/II/III".					
4	Form of exa Course relat • [20-00	amination ed exam: )-0014-iv] (Technical	examination, Ora	al/written examina	tion, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0014-iv] (Technical	examination, Ora	al/written examina	tion, Weighting: 100	%)
7	<ul> <li><sup>7</sup> Usability of the module         B.Sc. Informatik         B.Sc. Wirtschaftsinformatik         B.Sc. Psychologie in IT         Joint B.A. Informatik         B.Sc. Sportwissenschaft und Informatik         M.Sc. Sportwissenschaft und Informatik         B.Sc. Computational Engineering         B.Sc. Informationssystemtechnik         May be used in other degree programs     </li> </ul>					
8	Grade bonu In dieser Vo Novelle der A um bis zu 1.	<b>Is compliant to §25</b> rlesung findet eine A APB und den vom FB 2 .0 führen kann.	<b>(2)</b> .nrechnung von vo 20 am 30.3.2017 b	orlesungsbegleitend eschlossenen Anrec	len Leistungen statt, hnungsregeln zu eine	die lt. 25 (2) der 5. er Notenverbesserung

9	References Literature recom - R. Szeliski, "Co - B. Blundell, "Ar	mendations will be updated regularly, an example might be: mputer Vision: Algorithms and Applications", Springer 2011 Introduction to Computer Graphics and Creative 3D Environn	nents", Springer 2008			
Co	urses					
	<b>Course nr.</b> 20-00-0014-iv	Course name Visual Computing				
	Instructor     Type     SWS       Integrated course     3					

Mo Ima	Module name Image Processing								
<b>Mo</b> 20-	odule nr.Credit pointsWorkloadSelf-studyModule durationModule cycle0-00-01553 CP90 h60 h1 TermEvery 2. Semester								
Lan Ger	i <b>guage</b> man			<b>Module owner</b> Prof. Dr. Bernt So	chiele				
1	Teaching content         Fundamentals of image processing:         - Image properties         - Image transformations         - Simple and complex filtering         - Image compression,         - Segmentation         - Classification								
2	<b>Learning objectives</b> After successfully completing the course, students have an overview over the mechanisms used in and the abilities of modern image processing techniques. They are able to solve basic to medium level problems in image processing.								
3	Recommended prerequisites for participation								
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>[20-00-0155-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul>								
5	Prerequisite for the award of credit points Pass exam (100%)								
6	Grading Course relat • [20-00	ed exam: )-0155-iv] (Technical	examination, Ora	ıl/written examina	tion, Weighting: 100	%)			
7	Usability of the module         B.Sc. Informatik         M.Sc. Informatik         B.Sc. Computational Engineering         M.Sc. Computational Engineering         M.Sc. Wirtschaftsinformatik         B.Sc. Psychologie in IT         Joint B.A. Informatik         B.Sc. Sportwissenschaft und Informatik         M.Sc. Sportwissenschaft und Informatik								
0	May be used	l in other degree pro	grams.						
ð	Grade Donu	is compliant to §25	(4)						
9	References- Gonzalez, R.C., Woods, R.E., ""Digital Image Processing"", Addison- Wesley Publishing Company, 1992- Haberaecker, P., ""Praxis der Digitalen Bildverarbeitung und Mustererkennung"", Carl Hanser Verlag, 1995- Jaehne, B., ""Digitale Bildverarbeitung"", Springer Verlag, 1997								
COL	Courses								

<b>Course nr.</b> 20-00-0155-iv	Course name Image Processing		
Instructor		<b>Type</b> Integrated course	SWS 2

Mo	dule name							
Cor	nputer Vision	I	1					
<b>Mo</b> 20-	<b>dule nr.</b> 00-0157	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module duration 1 Term	Module cycle Every 2. Semester		
Lar Eng	<b>iguage</b> glish			Module owner Prof. Dr. Bernt So	chiele			
1	Teaching content         - Basics of image formation         - Linear and (simple) nonlinear image filtering         - Foundations of multi-view geometry         - Camera calibration and pose estimation         - Foundations of 3D reconstruction         - Foundations of motion estimation from video         - Template and subspace methods for object recognition         - Object classification with bag of words         - Object detection         - Basics of image segmentation							
2	<b>Learning objectives</b> After successfully attending the course, students are familiar with the basics of computer vision. They understand fundamental techniques for the analysis of images and videos, can name their assumptions and mathematical formulations, as well as describe the resulting algorithms. They are able to implement these techniques in order to solve basic image analysis tasks on realistic imagery.							
3	Recommended prerequisites for participation Particiation of lecture Visual Computing is recommended.							
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>• [20-00-0157-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul>							
5	Prerequisite Pass exam (2	e for the award of c 100%)	redit points					
6	Grading Course relate • [20-00	ed exam: )-0157-iv] (Technica	l examination, Ora	al/written examina	tion, Weighting: 100	9%)		
7	Usability of the module B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs							
8	Grade bonu	s compliant to §25	(2)					
9	References							

- Literature recommendations will be updated regularly, an example might be: R. Szeliski, ""Computer Vision: Algorithms and Applications"", Springer 2011 D. Forsyth, J. Ponce, ""Computer Vision A Modern Approach"", Prentice Hall, 2002

## C

Cot	irses			
	<b>Course nr.</b> 20-00-0157-iv	Course name Computer Vision		
	Instructor		Type	SWS
			integrated course	4

Mo	dule name							
Cor	nputer Vision	II						
<b>Mo</b> 20-	<b>dule nr.</b> 00-0401	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module duration 1 Term	Module cycle Every 2. Semester		
Language English			Module owner Prof. Dr. Bernt So	chiele	-			
1	Teaching content         - Computer vision as (probabilistic) inference         - Robust estimation and modeling         - Foundations of Bayesian networks and Markov random fields         - Basic inference and learning methods in computer vision         - Image restoration         - Stereo         - Optical flow         - Bayesian tracking of (articulated) objects         - Semantic segmentation         - Current research topics							
2	<b>Learning objectives</b> After successfully attending the course, students have developed a more in-depth understanding of computer vision. They formulate image and video analysis tasks as inference problems, taking challenges of real applications into account, e.g. regarding robustness. They solve the inference problem using discrete or continuous inference algorithms, and apply these to realistic imagery. They quantitatively evaluate the application specific results.							
3	<b>Recommended prerequisites for participation</b> Participation of lecture Visual Computing and Computer Vision I is recommended.							
4	Form of exa Course relate • [20-00	n <b>mination</b> ed exam: )-0401-iv] (Technica	l examination, Ora	al/written examina	tion, Default RS)			
5	Prerequisite Pass exam (2	e for the award of c 100%)	redit points					
6	Grading Course relat • [20-00	ed exam: )-0401-iv] (Technica	l examination, Ora	al/written examina	tion, Weighting: 100	9%)		
7	Usability of the module         B.Sc. Informatik         M.Sc. Informatik         B.Sc. Computational Engineering         M.Sc. Computational Engineering         M.Sc. Wirtschaftsinformatik         B.Sc. Psychologie in IT         Joint B.A. Informatik         B.Sc. Sportwissenschaft und Informatik         M.Sc. Sportwissenschaft und Informatik         Can be used in other degree programs.							
8	Grade bonu	s compliant to §25	(2)					
9	References							

Literature recommendations will be updated regularly, an example might be:

- S. Prince, "Computer Vision: Models, Learning, and Inference", Cambridge University Press, 2012
  R. Szeliski, ""Computer Vision: Algorithms and Applications"", Springer 2011

## Courses Course nr. Course name 20-00-0401-iv Computer Vision II SWS Туре Instructor Integrated course 4

Mo	Module name							
<b>Mo</b>	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle		
Lar Ger	iguage	0.01	100 11	Module owner Prof. Dr. Bernt Sc	hiele	Every 2. beniester		
1	<ul> <li>Teaching content         This lecture will give a detailed introduction to the scientific topics of information visualization and Visual Analytics, and will cover current research areas as well as practical application scenarios of Visual Analytics.     <ul> <li>Overview of information visualization and Visual Analytics (definitions, models, history)</li> <li>Data representation and data transformation</li> <li>Mapping of data to visual structures</li> <li>Introduction to human cognition</li> <li>Visual representations and interaction for bivariate and multivariate Data, time series, networks and geographic data</li> <li>Basic data mining techniques</li> <li>Visual Analytics - Analytics reasoning - Data mining - Statistics Analytical techniques and scaling</li> <li>Evaluation of Visual Analytics Systems</li> </ul> </li></ul>							
2	Learning objectives         After successfully attending the course, students will be able to         • use information visualization methods for specific data types         • design interactive visualization systems for data from various application domains         • couple visualization and automated methods to solve large-scale data analysis problems         • apply knowledge about key characteristics of the human visual and cognitive system for information visualization and visual analytics							
3	<b>Recommend</b> Interesse an Die Veransta Diplomstudi	<b>ded prerequisites fo</b> Methoden der Comp Iltung richtet sich an engänge und weitere	or participation putergrafik und Vi Informatiker, Wir	sualisierung tschaftsinformatike Treisen (z.B. Biolog	er, Mathematiker in E en, Psychologen).	Bachelor, Master und		
4	Form of exa Course relat • [20-00	ed exam: 0-0294-iv] (Technical	examination, Ora	al/written examina	tion, Default RS)			
5	<b>Prerequisite</b> Pass exam (2	e for the award of c 100%)	redit points					
6	Grading         Course related exam:         • [20-00-0294-iv] (Technical examination, Oral/written examination, Weighting: 100 %)							
7	Usability of	the module						

	B.Sc. Informatik					
	M.Sc. Informatik					
	B.Sc. Computational Engineering					
	M.Sc. Computati	onal Engineering				
	M.Sc. Wirtschaft	sinformatik				
	B.Sc. Psychologie	e in IT				
	Joint B.A. Inform	atik				
	B.Sc. Sportwisse	nschaft und Informatik				
	M.Sc. Sportwisse	nschaft und Informatik				
	May be used in o	ther degree programs.				
8	Grade bonus compliant to §25 (2)					
	In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2) der 5.					
	Novelle der APB u	nd den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsreg	geln zu einer Notenverbe	sserung		
	um bis zu 1.0 fül	iren kann.				
9	References					
	Will be announce	d in lecture, an example might be:				
	C. Ware: Informa	tion Visualization: Perception for Design				
	Ellis et al: Maste	ring the Information Age				
Col	17606	0 0				
COL		0				
	Course nr.	Course name				
	20-00-0294-iv	Information Visualization and Visual Analytics	T			
	Instructor		Туре	SWS		
			Integrated course	4		

Mo Adv	dule name vanced User In	iterfaces						
<b>Mo</b>	<b>dule nr.</b> 00-0570	<b>Credit points</b>	Workload	Self-study	Module duration	Module cyc Every 2 Se	<b>cle</b> mester	
Lar Gei	nguage		100 11	Module owner Prof. DrIng. Mic	hael Gösele			
1	<b>Teaching co</b> - Requirement - Design and - Implementa	<b>ntent</b> nts analysis of a give presentation of a us ation of a prototype	en problem ser interface conce	ept				
2	<b>Learning ob</b> Students hav adaptive use	<b>jectives</b> we been provided ins r interfaces for a giv	ights into the prin ren problem.	ciples and methods	to realize multimed	ial, collaborat	ive and	
3	Recommend - Interesse au - Wünschens - gute Progra	Recommended prerequisites for participation - Interesse an neuen, innovativen Benutzungsschnittstellen - Wünschenswert sind Grundkenntnisse der Human Computer Interaction - gute Programmierkenntnisse (C#/WPF und/oder Java)						
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>• [20-00-0570-pr] (Study achievement, Oral/written examination, Default RS)</li> </ul>							
5	<b>Prerequisite</b> Pass exam (1	e for the award of c	redit points					
6	Grading Course relate • [20-00	ed exam: -0570-pr] (Study ac	hievement, Oral/v	written examinatio	n, Weighting: 100 %	)		
7	Usability of the module         B.Sc. Informatik         M.Sc. Informatik         M.Sc. Wirtschaftsinformatik         B.Sc. Psychologie in IT         Joint B.A. Informatik         B.Sc. Sportwissenschaft und Informatik         M.Sc. Sportwissenschaft und Informatik							
8	Can be used	in other degree prop s compliant to 825	grams.					
			(4)					
9	References Depending c	n topic.						
Co	urses							
	<b>Course nr.</b> 20-00-0570-	pr Advanced Use	r Interfaces					
	<b>Instructor</b> Prof. Dr. rer.	nat. Eberhard Müh	lhäuser		<b>Type</b> Internsh	p	SWS 4	

Mo Phy	dule name	Simulation and Anir	nation					
Mo	dule nr.	Credit points	Workload	Self-study	Module of 1 Term	duration	Module cyc Every 2. Se	<b>cle</b>
Lar Ger	nguage rman/English		100 11	Module owner Prof. DrIng. Mic	chael Gösel	e	<u>  2.01                                   </u>	
1	<ul> <li>Teaching content <ul> <li>Basics of physically based simulation and animation</li> <li>Equations of motion and modeling of rigid bodies, mass-spring systems, deformable bodies and fluids</li> <li>Approximate numerical methods for the efficient solution of ordinary and partial differential equations</li> <li>Parallel computing for physically based simulations</li> <li>Collision detection and resolution</li> </ul> </li> </ul>							
2	Learning objectives         After completing the module successfully, the students can         - Describe requirements for methods of physically based simulations for computer animation         - Apply concepts of physically based simulations         - Transfer learned concepts to other simulation applications         - Evaluate the suitability of algorithms and numerical methods for physically based simulation         - Describe open research questions in physics-based simulation and animation							
3	Recommended prerequisites for participation           - Basic knowledge of numerical computing, algorithms and data structures, computer graphics							
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>• [20-00-0682-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul>							
5	Prerequisite Pass exam o	e <b>for the award of c</b> f Modul (100%)	redit points					
6	Grading Course relat • [20-00	ed exam: )-0682-iv] (Technica	l examination, Ora	al/written examina	tion, Weig	hting: 100	%)	
7	Usability of the module B.Sc. Informatik M.Sc. Informatik Can be used in other degree programs							
8	Grade bonu	s compliant to §25	(2)					
9	References							
Co	urses							
	<b>Course nr.</b> 20-00-0682-	iv Physically bas	ed Simulation and	Animation				
	InstructorTypeSWSProf. DrIng. Michael GöseleIntegrated course4							

Mo Ser	Module name Serious Games Project Seminar								
<b>Mo</b>	Module nr.Credit pointsWorkloadSelf-studyModule durationModule cycle18 do 20700 CP270 h105 h1 TermEvery Semester								
Lar Ger	nguage man/English	9 Gr	270 II	Module owner PD DrIng. Stefar	n Göbel	Every Semester			
1	Teaching content         In this project the students will design concepts and implement prototypes in the field of serious games (e.g. in education, health and sports).         The topics relate to current research questions in the field, partly in cooperation with partners from								
2	the games industry and/or Serious Games users.Learning objectivesAfter successfully attending the course, the students can conceptualize and prototypically implement practical tasks in the context of "Serious Games". Additionally they acquire practical knowledge in the area of project management, which they can apply to their own topic as well as transfer it to future projects. Besides, the students are able to present their findings in front of an audience applying a number of different presentation techniques and to actively participate in a scientific discussion on their topic.								
3	<b>Recommen</b> Programmir	<b>ded prerequisites fo</b> ng skills (the languag	or participation e will depended c	on the topic and ma	y be chosen at will f	or certain topics).			
4	Form of examination         Module exam:         • Module exam (Study achievement, Oral/written examination, Default RS)         Benort and/or Presentation. The type of examination will be appounced in the beginning of the lecture								
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points						
6	Grading Module exan • Modul	m: e exam (Study achie	vement, Oral/wri	tten examination, V	Veighting: 100 %)				
7	Usability of the module         B.Sc. Informatik         M.Sc. Informatik         B.Sc. Computational Engineering         M.Sc. Computational Engineering         M.Sc. Wirtschaftsinformatik         B.Sc. Psychologie in IT         Joint B.A. Informatik         B.Sc. Sportwissenschaft und Informatik         M.Sc. Sportwissenschaft und Informatik								
8	Grade bonu	is compliant to §25	(2)						
9	References								
Cot	urses								

<b>Course nr.</b> 18-de-2070-pj	Course name Serious Games Project Seminar					
<b>Instructor</b> PD DrIng. Stefa	n Göbel	<b>Type</b> Project seminar	<b>SWS</b> 5			
Mo Ser	Module name Serious Games Seminar					
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<b>Mo</b>	<b>dule nr.</b> 00-0328	<b>Credit points</b>	Workload	Self-study 90 h	<b>Module duration</b>	Module cycle
La	nguage		120 11	Module owner	haal Cäsala	livery 2. bennester
Gei	man/English			Prof. DrIng. Mic	nael Gosele	
1	In this semi education, h	nar the students wil lealth and sports).	l analyze and dis	cuss the current st	ate of the art for set	rious games (e.g. in
	the games in	relate to current re ndustry and/or Serio	us Games users.	in the field, pai	tly in cooperation	with partners from
2	2 Learning objectives After successfully completing this course the students are able to become acquainted with an unfamiliar subject in the field of "Serious Games". They are familiar with library research techniques for scientific papers and industry sources. The techniques and results mentioned in these references can be summarized, assessed and compared to each other. Besides, the students are able to present their findings in front of an audience applying a number of different presentation techniques and to actively participate in a scientific discussion on their topic					an unfamiliar subject scientific papers and arized, assessed and an audience applying ussion on their topic.
3	Recomment	ded prerequisites fo	or participation			
4	Form of exa Course relat • [20-00	amination ed exam: )-0328-se] (Study ac	hievement, Oral/v	vritten examination	n, Default RS)	
5	<b>Prerequisit</b> Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0328-se] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %)	)
7	Usability of B.Sc. Inform M.Sc. Inform B.Sc. Comp M.Sc. Comp M.Sc. Wirts B.Sc. Psycho Joint B.A. In B.Sc. Sportv M.Sc. Sportv Can be used	the module natik natik utational Engineering putational Engineerin chaftsinformatik ologie in IT formatik vissenschaft und Info wissenschaft und Info	g g ormatik ormatik grams.			
8	Grade bonu	is compliant to §25	(2)			
9	References					
Co	urses					

	<b>Course nr.</b> 20-00-0328-se	<b>Course name</b> Serious Games Seminar		
	Instructor Prof. DrIng. Mic	chael Gösele	<b>Type</b> Seminar	SWS 2

Mo	Module name						
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
18-	de-2050	6 CP	180 h	120 h	1 Term	Summer term	
Lar Ger	<b>nguage</b> rman∕English			<b>Module owner</b> PD DrIng. Stefa	n Göbel		
1	Teaching content         Introduction to the topic of ""Serious Games"": scientific and technical foundations, application areas and trends.         Individual lectures include:         Introduction to Serious Games         Game Development, Game Design         Game Technology, Tools and Engines         Personalization and Adaptation         Interactive Digital Storytelling         Authoring and Content Generation         Multiplayer Games         Game Interfaces and Sensor Technology         Effects, Affects and User Experience         Mobile Games         Serious Games Application Domains and Best Practice Examples						
2	Learning objectives         After successfully completing this course the students are able to explain the concept of "Serious Games" and can transfer it to different application domains (like education or health). They can describe the general approach for developing computer games and can apply basic principles of game design, personalisation / adaptation and interactive digital storytelling. Aside from that students are able to sketch out other current research questions						
3	Recommen	ded prerequisites fo	or participation				
4	<ul> <li>Form of examination</li> <li>Module exam: <ul> <li>Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)</li> <li>The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 8 students register, the examination will be an oral examination (duration: 30 min.). The type of examination will be appropriate the beginning of the lecture</li> </ul></li></ul>					., Default RS) stimate that less than type of examination	
5	Prerequisite for the award of credit points Pass exam (100%)						
6	Grading Module exan • Modul	n: e exam (Technical ex	kamination, Oral/	written examinatio	on, Weighting: 100 %	))	
7	Usability of	the module					

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.				
8	Grade bonus con In dieser Vorlesu	npliant to §25 (2) ng findet eine Anrechnung von vorlesungsbegleitenden Leistu	ngen statt. die lt. 25 (2	2) der 5.	
	Novelle der APB u um bis zu 1.0 fül	nd den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsreg aren kann.	geln zu einer Notenverbe	sserung	
9	References	aatura			
Coi					
	Course nr.	Course name			
	18-de-2050-vl	Serious Games			
	Instructor		Туре	SWS	
	PD DrIng. Stefa	n Göbel	Lecture	3	
	Course nr.	Course name			
	18-de-2050-ue Serious Games				
	Instructor		Type	SWS	
	PD DrIng. Stefan Göbel Practice 1				

Mo Ima	Module name Image Processing					
<b>Mo</b> 20-	<b>dule nr.</b> 00-0155	Credit points 3 CP	Workload 90 h	Self-study 60 h	Module duration 1 Term	Module cycle Every 2. Semester
Lan Ger	i <b>guage</b> man			<b>Module owner</b> Prof. Dr. Bernt So	chiele	
1	Teaching content         Fundamentals of image processing:         - Image properties         - Image transformations         - Simple and complex filtering         - Image compression,         - Segmentation         - Classification					
2	<b>Learning of</b> After succes abilities of m processing.	ojectives sfully completing th odern image process	e course, student ing techniques. Th	s have an overview and are able to solve	w over the mechanis e basic to medium lev	sms used in and the el problems in image
3	Recommen	ded prerequisites fo	or participation			
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>[20-00-0155-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul>					
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0155-iv] (Technical	examination, Ora	ıl/written examina	tion, Weighting: 100	%)
7	Usability of the moduleB.Sc. InformatikM.Sc. InformatikB.Sc. Computational EngineeringM.Sc. Computational EngineeringM.Sc. WirtschaftsinformatikB.Sc. Psychologie in ITJoint B.A. InformatikB.Sc. Sportwissenschaft und InformatikM.Sc. Sportwissenschaft und Informatik					
0	May be used	l in other degree pro	grams.			
ð	Grade Donu	is compliant to §25	(4)			
9	References - Gonzalez, R.C., Woods, R.E., ""Digital Image Processing"", Addison- Wesley Publishing Company, 1992 - Haberaecker, P., ""Praxis der Digitalen Bildverarbeitung und Mustererkennung"", Carl Hanser Verlag, 1995 - Jaehne, B., ""Digitale Bildverarbeitung"", Springer Verlag, 1997					
COL	Courses					

<b>Course nr.</b> 20-00-0155-iv	Course name Image Processing		
Instructor		<b>Type</b> Integrated course	SWS 2

Mo Ser	Module name Serious Games Lab					
<b>Mo</b>	dule nr.	<b>Credit points</b>	Workload	Self-study	Module duration	Module cycle
Lar Ger	nguage man/English	0.01	100 11	Module owner PD DrIng. Stefa	n Göbel	Every bennester
1	Teaching contentIn this lab the students will design concepts and implement prototypes in the field of serious games (e.g. in education, health and sports).The topics relate to current research questions in the field, partly in cooperation with partners from					
2	<ul> <li>Learning objectives</li> <li>After successfully attending the course, the students can conceptualize and prototypically implement practical tasks in the context of "Serious Games". Besides, the students are able to present their findings in front of an audience applying a number of different presentation techniques and to actively participate in a scientific discussion on their topic.</li> </ul>					
3	<b>Recommen</b> Programmin	<b>ded prerequisites fo</b> ng skills (depending o	or participation on topic).			
4	<ul> <li>Form of examination</li> <li>Module exam: <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> <li>Report (including submission of programming code) and/or Presentation and/or Oral examination and/or</li> <li>Colloquium (testate), but never more than two out of it. The type of examination will be announced in the</li> </ul> </li> </ul>					
5	Prerequisite Pass exam (2	e for the award of c 100%)	redit points			
6	Grading Module exa • Modul	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting: 100 %)	
7	Usability of the module B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.					
8	Grade bonu	s compliant to §25	(2)			
9	References					
Coi	Courses					

<b>Course nr.</b> 18-de-2060-pr	Course name Serious Games Lab		
<b>Instructor</b> PD DrIng. Stefa	n Göbel	<b>Type</b> Internship	SWS 4

Mo	Module name					
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
18-	ad-2090	3 CP	90 h	60 h	1 Term	Winter term
Lar Ger	<b>iguage</b> man			Module owner Prof. DrIng. Jür	gen Adamy	
1       Teaching content         A Basics       • Scene Representation 2D and 3D Geomtery         • Image Acquisition       - Geometric Projections Camera Calibration         • Objective and Illumination       • Objective and Illumination         • Discrete 2D signals       - Separability, Sampling         - Transformation, Interpolation       - Convolution, Correlation         - Discrete Fourier Transformation       B Basics of Image Analysis         • Filtering       - Basics2D Filter Design         - Linear Filtering       - Nichtlinear Filtering         • Nuchtinear Filtering       - Multi-scale Representation         - Pyramids       - Filter Banks         • Image Features       - Structure         - Moments, Histograms       - Structure						
2	Learning objectives After successful completion, the module teaches mathematical basics needed to solve computer vision problems in the field of engineering. The focus is on methods that are relevant for measuring and control tasks. Applications range from visual quality inspection, visual robotics, photogrammetry, visual odometry up to visually guided driver assistance etc. The students should obtain a good understanding for the relations between the three-dimensional world and its two-dimensional projection onto the image plane of a camera. They also should learn about methods that exist to infer knowledge from the world given image data. They should develop some feeling for the different kinds of problems that arise in computer vision and how to choose an officient solution in terms of algorithms.					
3	Recommen	ded prerequisites fo	or participation			
4	<ul> <li>Form of examination Module exam: <ul> <li>Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)</li> <li>The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less that 10 students register, the examination will be an oral examination (duration: 30 min.). The type of examination will be announced in the beginning of the lecture.</li> </ul></li></ul>					., Default RS) stimate that less than type of examination
5	Prerequisite Passing the	e for the award of c final module examina	redit points ation			
6	Grading					

	Module exam:						
	Module exam (Technical examination, Oral/written examination, Weighting: 100 %)						
7	Usability of the module MSc FTiT MSc iST MSc CF MSc iST						
8	Grade bonus co	npliant to §25 (2)					
9	<ul> <li>References References / Textbooks: Lecture slides, exercise sheets and matlab-code. Further reading <ol> <li>Yi Ma, Stefano Soatto, Jana Kosecka und Shankar S. Sastry, An Invitation to 3-D Vision - From Images to Geometric Models, Springer, 2003.</li> <li>Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, 2004.</li> <li>Karl Kraus, Photogrammetrie, Band 1 Geometrische Informationen aus Photographien und Laserscanner-</li> </ol></li></ul>						
	4. Christophe 5. Bernd Jähn	M. Bishop, Pattern Recognition and Machine Learning, Sprin e, Digital Image Processing, 6. Auflage, 2005.	ger 2006.				
Cot	urses						
	<b>Course nr.</b> 18-ad-2090-vl	<b>Course name</b> Computer Vision in Engineering					
	InstructorTypeSWSDrIng. Thomas Guthier, Prof. DrIng. Jürgen AdamyLecture2						

Mo Cap	<b>dule name</b> oturing Reality	y				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
Lar Eng	iguage	0 CP	180 11	Module owner Prof. Dr. Bernt Sc	chiele	Every 2. Semester
1	<ul> <li>Teaching content         This course covers a broad range of techniques to capture and model our world with a focus on application in computer graphics and computer vision. This includes:         <ul> <li>basic tools and calibration techniques required in capturing applications</li> <li>capturing and modeling techniques for various object properties (such as geometry and reflectance)</li> <li>basic set of relevant mathematical modeling and optimization techniques</li> <li>implementation and practical application of several techniques</li> </ul> </li> </ul>					
2	<ul> <li>Learning objectives</li> <li>After successful completion of the course, students are able to analyze digitization and modeling problems for objects and scenes in computer graphics and computer vision as well as the underlying techniques. They are able to develop new setups, perform experiments and evaluate the results.</li> </ul>					
3	<ul> <li>Recommended prerequisites for participation</li> <li>Recommended:</li> <li>Participation in lecture Graphische Datenverarbeitung I or Computer Vision I</li> <li>Basic knowledge in C/C++</li> </ul>					
4	Form of exa Course relat • [20-00	n <b>mination</b> ed exam: )-0489-iv] (Technical	examination, Ora	ıl/written examina	tion, Default RS)	
5	Prerequisite Pass exam (1	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0489-iv] (Technical	examination, Ora	al/written examina	tion, Weighting: 100	%)
7	Usability of the module         B.Sc. Informatik         M.Sc. Informatik         B.Sc. Computational Engineering         M.Sc. Computational Engineering         M.Sc. Wirtschaftsinformatik         B.Sc. Psychologie in IT         Joint B.A. Informatik         B.Sc. Sportwissenschaft und Informatik         M.Sc. Sportwissenschaft und Informatik         M.Sc. Sportwissenschaft und Informatik					
8	Grade bonu In dieser Vor Novelle der A um bis zu 1.	is compliant to §25 rlesung findet eine A APB und den vom FB 2 0 führen kann.	<b>(2)</b> nrechnung von vo 20 am 30.3.2017 b	orlesungsbegleitend eschlossenen Anrec	len Leistungen statt, hnungsregeln zu eine	die lt. 25 (2) der 5. er Notenverbesserung
9	References					

<ul> <li>Noriko Kurachi: The Magic of Computer Graphics. A K Peters/CRC Press</li> <li>Richard Szeliski: Algorithms and Applications, Springer</li> <li>Marcus Magnor, Oliver Grau, Olga Sorkine-Hornung, Christian Theobalt: Digital Representations of the Real</li> <li>World: How to Capture, Model, and Render Visual Reality</li> <li>Wolfgang Förstner, Bernhard P. Wrobel: Photogrammetric Computer Vision - Geometry, Orientation and Reconstruction</li> </ul>					
<b>Course nr.</b> 20-00-0489-iv	Course name Capturing Reality				
<b>Instructor</b> Prof. Dr. Bernt S	chiele	<b>Type</b> Integrated course	SWS 4		

Mo Geo	dule name	ods of CAE/CAD				
<b>Mo</b> 20-	<b>dule nr.</b> 00-0140	Credit points 6 CP	Workload 180 h	Self-study 135 h	Module duration 1 Term	Module cycle Every 2. Semester
Lar Gei	<b>nguage</b> rman			<b>Module owner</b> Prof. Dr. rer. nat.	Oskar von Stryk	
1	<ul> <li>Teaching content <ul> <li>parametric curve models</li> <li>parametric surface models</li> <li>topology and volumetric CAD models</li> <li>CAD operations on surfaces</li> <li>tesselation</li> <li>approximation of curves and surfaces</li> <li>finite element method and computational fluid dynamics</li> <li>various applications from the area of CAD</li> </ul> </li> </ul>					
2	Learning of After succes geometric n surfaces and computer ai	bjectives ssfully attending the nodelling and simula d are able to analyze ided design (CAD). T	course, students u ation. They unde and compare the hey can use the p	understand the fou rstand multiple pa n. They know class resented technique	ndations of compute trametric representa sical data structures s to model and visua	er-aided methods for tions for curves and and algorithms from lize 3D geometry.
3	<b>Recommen</b> Basic knowl	<b>ded prerequisites fo</b> edge in Computer So	or participation ience.			
4	Form of exa Course relat • [20-00	amination ted exam: D-0140-iv] (Technica	l examination, Ora	al/written examina	tion, Default RS)	
5	<b>Prerequisit</b> Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ted exam: D-0140-iv] (Technica	examination, Ora	al/written examina	tion, Weighting: 100	%)
7	<ul> <li>7 Usability of the module</li> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> <li>B.Sc. Computational Engineering</li> <li>M.Sc. Computational Engineering</li> <li>M.Sc. Wirtschaftsinformatik</li> <li>B.Sc. Psychologie in IT</li> <li>Joint B.A. Informatik</li> <li>B.Sc. Sportwissenschaft und Informatik</li> <li>M.Sc. Sportwissenschaft und Informatik</li> </ul>					
8	<ul> <li>8 Grade bonus compliant to §25 (2)         <ul> <li>In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2)</li> <li>Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesse</li> <li>um bis zu 1.0 führen kann</li> </ul> </li> </ul>					die lt. 25 (2) der 5. er Notenverbesserung
9	References					

	Vorlesungsfolien Lee: Principles of CAD / CAM / CAE Systems, Addison-Wesley. Piegl, Tiller: The NURBS Book, Springer Verlag. Farin: Kurven und Flächen im Computer Aided Geometric Design, vieweg Shah, Mäntylä: Parametric and Feature-based CAD/CAM, Wiley & Sons				
Co	urses				
	<b>Course nr.</b> 20-00-0140-iv	<b>Course name</b> Geometrical Methods of CAE/CAD			
	Instructor		<b>Type</b> Integrated course	<b>SWS</b> 3	

Mo Pro	Module name Programming Massively Parallel Processors						
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
20-	00-0419	6 CP	180 h	120 h	1 Term	Every 2. Semester	
Lar Eng	<b>iguage</b> glish			Module owner Prof. Dr. Bernt Sc	hiele		
1	<b>Teaching co</b> - foundation - parallel alg - efficient pr - practical pr	ontent is of massively paralle corithms ogramming of massiv cogramming projects	el processors with vely parallel syster co-advised by dor	a focus on modern ns nain scientists	accelerator hardwar	re	
2	Learning ol After succes parallel syst understand	<b>ojectives</b> sful completion of the tems. They can deve basic parallel algorithe	he course, studen elop novel applica hms and are able t	ts are able to analy tions and systemations independently un	ze problems in the tically improve their nderstand and analyz	context of massively performance. They ze current literature.	
3	Recomment Programmin Recommend	<b>ded prerequisites fo</b> ng skills in C/C++ led: Systemnahe und	or participation l Parallele Program	nmierung			
4	Form of exa Course relat • [20-00	nmination red exam: )-0419-iv] (Technica)	l examination, Ora	al/written examina	tion, Default RS)		
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points				
6	Grading Course relat • [20-00	ed exam: )-0419-iv] (Technica	l examination, Ora	al/written examina	tion, Weighting: 100	%)	
7	<ul> <li>7 Usability of the module</li> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> <li>B.Sc. Computational Engineering</li> <li>M.Sc. Computational Engineering</li> <li>M.Sc. Wirtschaftsinformatik</li> <li>B.Sc. Psychologie in IT</li> <li>Joint B.A. Informatik</li> <li>B.Sc. Sportwissenschaft und Informatik</li> <li>M.Sc. Sportwissenschaft und Informatik</li> </ul>						
	Can be used	in other degree prog	grams.				
8	<ul> <li>Grade bonus compliant to §25 (2)</li> <li>In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25(2) der 5. Novelle der APB und den vom FB 20 am 02.10.2012 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.</li> </ul>						
9	Will be anno	ounced in lecture.					
Co	urses						

<b>Course nr.</b> 20-00-0419-iv	Course name Programming Massively Parallel Processors		
Instructor		<b>Type</b> Integrated course	SWS 4

3.4	1.1						
Adv	dule name vanced Visual	Computing Lab					
Mo	dule nr	Credit points	Workload	Self-study	Module duration	Module cv	cle
20-00-0537 6 CP 180 h 120 h 1 Term Every 2. Semester						mester	
Lar	iguage	1	•	Module owner			
Ger	man/English			Prof. Dr. Bernt So	chiele		
1	Teaching co	ontent					
	Students wo	ork in this lab on sel	ected advanced to	pics in the area of	visual computing.	Project results	will be
	should be di	a talk at the end of	the course. The sp	ecific topics addres	sed in the lab chan	ge every semes	ster and
2	Learning of	niectives	if one of the instru	ctor3.			
	After succes	sful completion of t	his course, the st	udents will be able	e to independently	analyze and s	olve an
	advanced pr	oblem in the area of	visual computing	and to evaluate th	e results.		
3	Recommen	ded prerequisites for	or participation				
	Programmin Programmin	ıg skills, e.g. Java, C	++				
	Participation	in at least one basic	c lectures and one	lab in the are of Vi	sual Computing.		
4	Form of exa	mination			1 0		
	Course relat	ed exam:					
	• [20-00	)-0537-pr] (Study ac	chievement, Oral/v	written examination	n, Default RS)		
-	D		1. 1.				
5	Prerequisite Pass exam (	e for the award of c	redit points				
6	Grading						
	Course relat	ed exam:					
	• [20-00	)-0537-pr] (Study ac	chievement, Oral/v	written examination	n, Weighting: 100 9	6)	
<u> </u>	··· 1 ·1·. 6						
7	B Sc. Inform	the module					
	M.Sc. Inform	natik					
	B.Sc. Comp	utational Engineerin	g				
	M.Sc. Comp	utational Engineerin	ıg				
	M.Sc. Wirtso B.Sc. Psycho	chaftsinformatik					
	Joint B.A. In	formatik					
	B.Sc. Sportv	vissenschaft und Info	ormatik				
	M.Sc. Sport	wissenschaft und Inf	formatik				
	Can be used	in other degree pro	grams.				
8	Grade bonu	is compliant to §25	(2)				
		1 0					
9	References						
	Will be anno	ounced in lecture.					
Cot	ırses						
	Course nr.	Course name		_			
	20-00-0537-	pr Advanced Visi	ual Computing Lai	)			014/0
	Prof. DrIng	. Michael Gösele			Interns	nip	5 VV S 4

Mo Aus	Module name Augmented Vision						
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
Lar Ger	nguage	0 CP	180 11	Module owner Prof. Dr. Bernt Sc	chiele	Every 2. Semester	
1	Image: Constant in the image: Constant is constant in the image: Constant in the image: Constant is constant in the image: Cons					elation to Computer s as well as relevant projects including in cation".	
2	Learning of After success and Augmer In particula which metho	<b>ojectives</b> Suffully attending the control of the students under the students under to ds can be applied in	ourse, students are ons. They know th rstand the potent with environmen	e familiar with the o e standards used fo ial of Computer Vi it.	challenges and the rec or the specification of sion based tracking a	quirements of Virtual VR/AR-applications. and they can decide	
3	Recommene Grundlagen	<b>ded prerequisites fo</b> der Graphischen Dat	or participation enverarbeitung (C	GDV)			
4	Form of exa Course relat • [20-00	m <b>ination</b> ed exam: )-0160-iv] (Technical	examination, Ora	al/written examina	tion, Default RS)		
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points				
6	Grading Course relat • [20-00	ed exam: )-0160-iv] (Technical	examination, Ora	al/written examina	tion, Weighting: 100	%)	
7	<ul> <li>7 Usability of the module</li> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> <li>B.Sc. Computational Engineering</li> <li>M.Sc. Computational Engineering</li> <li>M.Sc. Wirtschaftsinformatik</li> <li>B.Sc. Psychologie in IT</li> <li>Joint B.A. Informatik</li> <li>B.Sc. Sportwissenschaft und Informatik</li> <li>M.Sc. Sportwissenschaft und Informatik</li> <li>May be used in other degree programs.</li> </ul>						
8	Grade bonu	s compliant to §25	(2)				

9	References					
	Dörner, R., Broll	, W., Grimm, P., Jung, B. Virtual und Augmented Reality (VR /	AR)			
Co	urses					
	Course nr.	Course name				
	20-00-0160-iv	Virtual and Augmented Reality				
	Instructor		Туре	SWS		
			Integrated course	4		

Mo 3D	dule name	Visualization				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
20-	00-0216	3 CP	90 h	60 h	1 Term	Every 2. Semester
Ger	man/English			Prof. Dr. Bernt Sc	hiele	
1	<ul> <li>Teaching content         This seminar focuses on current research topics and the latest results in the areas of physically-based simulation, animation, real-time rendering and visualization.         - participants independently familiarize themselves with the assigned seminar topic by working with the provided scientific papers (usually texts written in English)         - classification and interpretation of the gathered research results         - preparation of a textual summary and a slide-based presentation on the subject         - presentation in front of an audience with mixed prior knowledge on the topic and discussion     </li> </ul>					
2	Learning of Successful p can extract t and present actively part	<b>Djectives</b> articipation in the co the essential aspects ation, targeting an a cicipate in a scientific	ourse enables stud of the examined v udience with mixe discussion on the	ents to get expertis vorks and are able ed prior experience presented topics.	e by working with sc to concisely present t e on the subject. The	ientific papers. They them as textual form students are able to
3	Recomment GDV I, (GDV	<b>ded prerequisites fo</b> / II)	or participation			
4	Form of exa Course relat • [20-00	<b>mination</b> ed exam: )-0216-se] (Study ac	hievement, Oral/v	vritten examination	n, Default RS)	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points			
6	Grading Course relat • [20-00	ed exam: )-0216-se] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %)	)
7	<ul> <li>7 Usability of the module <ul> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> <li>B.Sc. Computational Engineering</li> <li>M.Sc. Computational Engineering</li> <li>M.Sc. Wirtschaftsinformatik</li> <li>B.Sc. Psychologie in IT</li> <li>Joint B.A. Informatik</li> <li>B.Sc. Sportwissenschaft und Informatik</li> <li>M.Sc. Sportwissenschaft und Informatik</li> </ul></li></ul>					
8	Grade bonu	is compliant to §25	(2)			
9 Coi	References Selected arti in English. 1 <b>rses</b>	icles from ACM SIGG	RAPH, EUROGRPA	AHICS, IEEE and si	milar Conferences. A	ll articles are written

<b>Course nr.</b> 20-00-0216-se	<b>Course name</b> 3D Animation & Visualization		
Instructor		<b>Type</b> Seminar	SWS 2

Mo Am	Module name Ambient Intelligence						
Мо	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
20-	00-0390	6 CP	180 h	120 h	1 Term	Every 2. Semester	
Lar Gei	nguage rman			Module owner Prof. Dr. Bernt Sc	hiele		
1	1 <b>Teaching content</b> The course will provide an overview of a new vision for Human-Computer-Interaction (HCI) in which people are surrounded by intelligent and intuitive interfaces embedded in the everyday objects around them. In specific the course addresses the emergence of Ambient Mobility and the ubiquitous, pervasive information access, retrieva and display on mobile devices. It will focus on understanding enabling technologies and studying applications and experiments, and, to lesser extent, it will adress the sociocultural impact. Additional topics of the lecture include system architectures for distributed systems, context awareness and management, user models and their implications, sensing and interaction in smart environments. The lecture discusses recent topics and research						
2	Learning of After succes results in the intelligent no spaces, norm networks and will be able	<b>bjectives</b> ssfully attending the ne domain of Ambier etworks and objects, t adic communications nd wearable computin to plan and realize th	lecture, the stude at Intelligence. Th echnologies for mo , real-time commu g - can be discusse e different project	nts will be able to ne most important obile, augmented re nication and relate ed and classified. Af phases required to	describe technology concepts to create so ality, ubiquitous and p d middle ware, embed ter completing the pr develop an Ambient-	trends and research mart environments - pervasive information dded systems, sensor actical part, students Intelligence solution.	
3	<b>Recommen</b> Master-Stuc Participation	<b>ded prerequisites fo</b> lents n in lecture "Visual C	or participation omputing" and "M	Iultimodale Interak	tion mit intelligenter	n Umgebungen"	
4	Form of exa Course relat • [20-00	<b>amination</b> ted exam: D-0390-iv] (Technical	l examination, Ora	al/written examina	tion, Default RS)		
5	<b>Prerequisit</b> Pass exam (	e for the award of c 100%)	redit points				
6	Grading Course relat • [20-00	ted exam: D-0390-iv] (Technical	l examination, Ora	al/written examina	tion, Weighting: 100	%)	
7	<ul> <li>7 Usability of the module</li> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> <li>B.Sc. Computational Engineering</li> <li>M.Sc. Computational Engineering</li> <li>M.Sc. Wirtschaftsinformatik</li> <li>B.Sc. Psychologie in IT</li> <li>Joint B.A. Informatik</li> <li>B.Sc. Sportwissenschaft und Informatik</li> <li>M.Sc. Sportwissenschaft und Informatik</li> </ul>						
	Can be used	l in other degree prog	grams.				
8	Grade bonus compliant to §25 (2)						

	In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.			
9	<b>References</b> Will be given according to actual topics.			
Co	urses			
	<b>Course nr.</b> 20-00-0390-iv	Course name Ambient Intelligence		
	Instructor	·	<b>Type</b> Integrated course	SWS 4

Mo Cor	Module name Computer Graphics II						
<b>Mo</b>	<b>dule nr.</b> 00-0041	<b>Credit points</b>	Workload	Self-study	Module duration	Module cycle	
Lar	iguage	0.01	100 11	Module owner	hiele	livery 2. bemester	
1	1       Teaching content         Foundations of the various object- and surface-representations in computer graphics. Curves and surfaces (polynomials, splines, RBF) Interpolation and approximation, display techniques, algorithms: de Casteljau, de Boor, Oslo, etc. Volumes and implicit surfaces. visualization techniques, iso-surfaces, MLS, surface rendering, marching cubes. Meshes, mesh compression, mesh simplication, multiscale expansion, subdivision. Pointclouds: rendering techniques, surface reconstruction, voronoi-diagram and delaunay-triangulation						
2	Learning of After success i.e., to use, a representati and pointcle	<b>ojectives</b> Sful completion of the adapt, display (rende ons, iso-surfaces, vo ouds.	module, students r), and effectively lume representati	are able to handle v store these objects ons, implicite surfa	arious object- and sur s. This includes math aces, meshes, subdiv	face-representations, nematical polynomial ision control meshes	
3	Recommend Recommend • Algorit • Grund • Grund • C / C +	<b>ded prerequisites fo</b> led: thmen und Datenstru lagen aus der Höhere ische Datenverarbeitt - +	<b>r participation</b> akturen en Mathematik ang I				
4	Form of exa Course relat • [20-00 The form of two of the for Written exa (optional: in	mination ed exam: )-0041-iv] (Technical the examination wil ollowing forms is pos m (duration 60 or cluding tests)	examination, Ora l be announced at sible. 90 or 120 minut	al/written examina the beginning of t tes), oral exam (c	tion, Default RS) he course. One or a luration 15 or 30 n	combination of max. ninutes), homework	
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points				
6	Grading Course relat • [20-00	ed exam: )-0041-iv] (Technical	examination, Ora	al/written examina	tion, Weighting: 100	)%)	
7	<ul> <li>7 Usability of the module</li> <li>B. Sc. Informatik</li> <li>M. Sc. Informatik</li> <li>M. Sc. Computer Science</li> <li>M.Sc. IT Sicherheit</li> </ul>						
8	May be used Grade bonu	l in other degree pro is compliant to §25	grams. (2)				
	In this cours ment of up t Darmstadt a	e a crediting of lecture to 1.0 according to 2 and the crediting rule	re-accompanying a 5(2) of the 6th an s decided by the I	achievements takes aendment of the Ge Department of Com	place, which can lead eneral Examination R uputer Science on Jul	d to a grade improve- legulations of the TU ly 14, 2022.	

9	<ul> <li>References</li> <li>Real-Time Rendering: Tomas Akenine-Möller, Eric Haines, Naty Hoffman A.K. Peters Ltd., 3rd edition, ISBN 987-1-56881-424-7</li> <li>Additional literature will be given in the lecture.</li> </ul>					
Co	Courses					
	<b>Course nr.</b> 20-00-0041-iv	Course name Computer Graphics II				
	Instructor     Type     SWS       Integrated course     4					

Mo Pro	<b>Module name</b> Probabilistic Graphical Models							
<b>Mo</b> 20-	<b>dule nr.</b> 00-0449	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module duration	Module cycle Every 2. Semester		
Lar Eng	<b>iguage</b> glish			Module owner Prof. Ph. D. Stefan Roth				
1	<ul> <li>Refresher of probability &amp; Bayesian decision theory         <ul> <li>Directed and undirected models and their properties</li> <li>Inference in tree graphs</li> <li>Approximate inference in general graphs: Message passing and mean field</li> <li>Learning of directed and undirected models</li> <li>Sampling methods for learning and inference</li> <li>Modeling in example applications, including topic models</li> <li>Deep networks</li> <li>Semi-supervised learning</li> </ul> </li> <li>Learning objectives</li> </ul>							
2	Learning objectivesAfter successfully attending the course, students have developed an in-depth understanding of probabilisticgraphical models. They describe and analyze properties of graphical models, and formulate suitable modelsfor concrete estimation and learning tasks. They understand inference algorithms, judge their suitability andapply them to graphical models in relevant applications. Moreover, they determine which learning algorithmsare suitable to estimate the model parameters from example data, and apply these.Becommended prerequisites for participation							
3	<b>Recommended prerequisites for participation</b> Recommended: Participation in "Statistisches Maschinelles Lernen".							
4	Form of examination         Course related exam:         • [20-00-0449-iv] (Technical examination, Oral/written examination, Default RS)							
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points					
6	Grading Course relat • [20-00	ed exam: )-0449-iv] (Technica	l examination, Ora	al/written examina	tion, Weighting: 100	9%)		
7	Usability of the module         B.Sc. Informatik         M.Sc. Informatik         B.Sc. Computational Engineering         M.Sc. Computational Engineering         M.Sc. Wirtschaftsinformatik         B.Sc. Psychologie in IT         Joint B.A. Informatik         B.Sc. Sportwissenschaft und Informatik         M.Sc. Sportwissenschaft und Informatik         Can be used in other degree programs.							
8	Grade bonu	is compliant to §25	(2)					
9	References							

Literature recommendations will be updated regularly, an example might be: - D. Barber: "Bayesian Reasoning and Machine Learning", Cambridge University Press 2012

		•	•							
- D.	. Koller,	N. Friedman:	"Probabilistic	Graphical	Models:	Principl	les and	Techniques"	, MIT Press	3 2009

Co	Courses								
	<b>Course nr.</b> 20-00-0449-iv	<b>Course name</b> Probabilistic Graphical Models							
	Instructor		<b>Type</b> Integrated course	SWS 4					

Mo Vist	<b>dule name</b> 1al Computing	g Lab						
<b>Mo</b> 20-	<b>dule nr.</b> 00-0418	<b>Credit points</b> 6 CP	Workload	Self-study 120 h	Module du 1 Term	iration	Module cyc Every 2, Se	<b>:le</b> mester
Lar Ger	<b>iguage</b> man/English		100 11	Module owner Prof. Dr. Bernt Schiele				
1	<b>Teaching co</b> Students wor a talk at the discussed dir	ntent k in this lab on sele end of the course. T rectly with one of the	cted topics in the The specific topics e instructors.	area of visual comp addressed in the l	outing. Projec ab change e	ct results very sem	will be prese sester and sho	nted in ould be
2	<b>Learning ob</b> After success in the area o	<b>jectives</b> ful completion of this f visual computing a	s course, the stude and to evaluate the	nts will be able to in e results.	ndependently	y analyze	and solve a p	oroblem
3	Recommended prerequisites for participationPractical programming skills, e.g. Java, C++Basic knowledge or interest within Visual ComputingParticipation in one basic lecture within Visiual Computing							
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>[20-00-0418-pr] (Study achievement, Oral/written examination, Default RS)</li> </ul>							
5	Prerequisite for the award of credit points Pass exam (100%)							
6	Grading Course relate • [20-00	ed exam: -0418-pr] (Study ac	hievement, Oral/v	vritten examinatio	n, Weighting	g: 100 %)	)	
8	<ul> <li>7 Usability of the module <ul> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> <li>B.Sc. Computational Engineering</li> <li>M.Sc. Computational Engineering</li> <li>M.Sc. Wirtschaftsinformatik</li> <li>B.Sc. Psychologie in IT</li> <li>Joint B.A. Informatik</li> <li>B.Sc. Sportwissenschaft und Informatik</li> <li>M.Sc. Sportwissenschaft und Informatik</li> <li>Can be used in other degree programs.</li> </ul> </li> <li>8 Grade bonus compliant to \$25 (2)</li> </ul>							
9	<b>References</b> Will be appo	unced in course						
Cot	irses							
	<b>Course nr.</b> 20-00-0418-	Course nameprLab Visual Cor	mputing					
	Instructor				]   I	<b>Гуре</b> Internshi <sup>-</sup>	р	SWS 4

Mo	Module name							
Sca	le Space and	PDE methods in imag	ge analysis and pr	ocessing				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle		
20-	00-0469	3 CP	90 h	60 h	1 Term	Every 2. Semester		
Lar Eng	i <b>guage</b> slish			Module owner Prof. Dr. Bernt Sc	hiele			
1	<ul> <li>Image analysis &amp; processing deals with the investigation of images and the application of specific tasks on them, like enhancement, denoising, deblurring, and segmentation. In this course, mathematical methods that are commonly used are presented and discussed. The focus will be on the axiomatic choice for the models, their mathematical properties, and their practical use.</li> <li>Some key words:         <ul> <li>Filtering (Edge detection, enhancement, Wiener, Fourier,)</li> <li>Images &amp; Observations: Scale space, regularisation, distributions</li> <li>Objects: Differential structure, invariants, feature detection</li> <li>Deep structure: Catastrophes &amp; multi-scale hierarchy</li> <li>Variational Methods &amp; Partial Differential Methods: Perona Malik, anisotropic diffusion, total variation, Mumford-Shah, Chan-Vese, geometric PDEs, level sets</li> <li>Curve Evolution: Normal motion, mean curvature motion, Euclidean shortening flow.</li> </ul> </li> <li>2 Learning objectives         <ul> <li>After suggesful participation in the source students are able to departie the foundational methomatical apprentic</li> </ul> </li> </ul>							
2	Learning objectives After successful participation in the course students are able to describe the foundational mathematical concepts as well as the basic models and methods of image analysis and processing. They explain important approaches for scale space and PDE methods and can evaluate, transfer, and explain representative technical papers.							
3	Recommended prerequisites for participation Da Bildanalyse und -verarbeitung eine Mischung aus verschiedenen Disziplinen, wie Physik, Mathematik, Vision, Informatik und Engineering, ist, ist dieser Kurs gezielt auf ein breites Publikum zugeschnitten. Daher werden nur Grundkenntnisse in Analysis angenommen. Weitere notwendige mathematische Werkzeuge werden in den Sitzungen skizziert.							
4	Form of exa Course relat • [20-00	amination ed exam: )-0469-se] (Study acl	hievement, Oral/v	vritten examination	ı, Default RS)			
5	Prerequisite Pass exam (	e for the award of cr 100%)	redit points					
6	Grading Course relat • [20-00	ed exam: )-0469-se] (Study acl	hievement, Oral/v	vritten examination	n, Weighting: 100 %)	)		
7	Usability of B.Sc. Inform M.Sc. Inform B.Sc. Comp M.Sc. Comp M.Sc. Wirtse B.Sc. Psycho Joint B.A. In B.Sc. Sportv M.Sc. Sportv Can be used	the module natik natik utational Engineering outational Engineering chaftsinformatik ologie in IT formatik vissenschaft und Info wissenschaft und Info	g gormatik prmatik grams.					

8	Grade bonus compliant to §25 (2)					
9	References					
	Main:					
	- B. M. ter Haar Romeny, Front-End Vision and Multi-scale Image Analysis, Dordrecht, Kluwer Academic Publishers,					
	2003.					
	Recommended:					
	- T. Lindeberg: Scale-Space Theory in Computer Vision, Dordrecht, Kluwer Academic Publishers, 1994.					
	- J. Weickert: Anisotropic Diffusion in Image Processing, Teubner-Verlag, Stuttgart, Germany, 1998.					
	G. Aubert & P. Ko	ornprobst: Mathematical problems in image processing: Partia	l Differential Equations	and the		
	Calculus of Varia	tions (second edition), Springer, Applied Mathematical Science	es, Vol 147, 2006.			
Co	urses					
	Course nr.	Course name				
	20-00-0469-se Scale space and PDE methods in image analysis and processing					
	Instructor		Туре	SWS		
			Seminar	2		

Мо	dule name							
Vist	al Analytics:	Interactive Visualiza	ation of Very Large	Data				
<b>Mo</b>	<b>dule nr.</b> 00-0268	Credit points	Workload 90 h	Self-study 60 h	Module duration	<b>Module cy</b> Every 2 Se	<b>cle</b> mester	
Lar		5.01	70 H	Module owner				
Ger	man			Prof. Dr. Bernt Sc	chiele			
1	<b>Teaching co</b> This seminat the visualizat will also wri	ontent r is targeted at comp ation of extremely la te a paper about this	uter science studer rge data. Students s topic.	nts with an interest will analyze and p	in information visual resent a topic from v	lization, in pa isual analytic	articular cs. They	
2	2 Learning objectives After successfully completing the course, students are able to analyze and understand a scientific problem based on the literature. Students are able to present and discuss the topic.							
3	Recommended prerequisites for participation Interesse sich mit einer graphisch-analytischen Fragestellung bzw. Anwendung aus der aktuellen Fachliteratur zu befassen. Vorkenntnisse in Graphischer Datenverarbeitung, Informationssysteme oder Informationsvisualisierung							
4	<ul> <li>Form of examination Course related exam:</li> <li>• [20-00-0268-se] (Study achievement, Oral/written examination, Default RS)</li> </ul>							
5	Prerequisite for the award of credit points Pass exam (100%)							
6	<ul> <li>Grading Course related exam:</li> <li>[20-00-0268-se] (Study achievement, Oral/written examination, Weighting: 100 %)</li> </ul>							
7	7       Usability of the module         B.Sc. Informatik         M.Sc. Informatik         B.Sc. Computational Engineering         M.Sc. Computational Engineering         M.Sc. Wirtschaftsinformatik         B.Sc. Psychologie in IT         Joint B.A. Informatik         B.Sc. Sportwissenschaft und Informatik         M.Sc. Sportwissenschaft und Informatik							
8	May be used	l in other degree pro	ograms.					
0	State Dollt	is compliant to \$25	(4)					
9	References							
Cot	ırses							
	<b>Course nr.</b> 20-00-0268-	se Visual Analyti	cs: Interactive Visi	alization of verv la	arge amounts of data			
	Instructor				Type Seminar		SWS 2	

Mo Vist	<b>Module name</b> Visualization and Animation of Algorithms and Data Structures							
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle		
Lar Ger	nguage man	0.01	100 11	Module owner Prof. Dr. Bernt Sc	thiele	Every 2. Semester		
1	<b>Teaching co</b> The student process. The The competer * Becoming	ontent is will be enabled to e contents will be usa encies gained especia familiar with a comp	create animations ble for studying tl illy include: ilex software syste	of algorithms and topics covered a m for animating al	data structures to e nd can be used in the gorithms and data st	nhance the learning e ICS / GdI 2 lecture. tructures		
	<ul> <li>* Familiarization with a scripting language, a Java-based API and a framework for generators for creating animations.</li> <li>* Design and implementation of at least two generators for algorithm or data structure animations</li> <li>* Learning criteria for determining if animations support learning processes</li> <li>* Creation and provision of contents ready for use in teaching and self-study</li> <li>* Competent use of the CS learning platform for submitting feedback and finished tasks</li> </ul>							
2	<ul> <li>2 Learning objectives After taking part in this lab, students will be able to <ul> <li>use the provided API for animating algorithms.</li> <li>analyze a given algorithm with regard to its central elements.</li> <li>construct one visualization each for the central elements of two chosen algorithms. <ul> <li>generalize the generated visualizations by an appropriate support of adjustable parameters.</li> <li>critically reflect whether the created visualization will support the learning process of the viewer.</li> </ul></li></ul></li></ul>							
3	<b>Recommen</b> Participants taught in IC	<b>ded prerequisites fo</b> need good Java prog S 2.	or participation ramming skills an	d should be familia	r with the algorithms	s and data structures		
4	Form of exa Course relat • [20-00	mination ed exam: )-0344-pr] (Study ac	hievement, Oral/v	vritten examination	n, Default RS)			
5	Prerequisite Pass exam (	e for the award of c 100%)	redit points					
6	Grading Course relat • [20-00	ed exam: )-0344-pr] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %)	)		
7	Usability of	the module						
8	Grade bonu	is compliant to §25	(2)					
9	References							
Coi	ırses							

<b>Course nr.</b> 20-00-0344-pr	<b>Course name</b> Visualization and Animation of Algorithms and Data Structur	res	
Instructor		<b>Type</b> Internship	SWS 4

Mo Apr	Module name Applied Topics in Computer Graphics							
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle		
Lan	nguage man	5.01	70 H	Module owner Prof. Dr. Ing. Michael Gösele				
1	<b>Teaching co</b> Selected pap - Visualization - Simulation - Geometry p - Semantics a	ontent pers from the followi on / Rendering processing and mode and 3D	ng fields of compu ling	iter graphics:				
2	<ul> <li>Learning objectives         After successfully completing the course, students know selected current topics in computer graphics. They are able to independently analyze the content of a scientific publications, to understand and to present the problem as well as the proposed solution. Furthermore, they can analyze and present directions for further improvements in the area.     </li> </ul>							
3	<b>Recommended prerequisites for participation</b> Prior knowledge of GDV or geom. methods of CAD/CAE is advantageous							
4	<ul> <li>Form of examination Course related exam:</li> <li>• [20-00-0724-se] (Study achievement, Oral/written examination, Default RS)</li> </ul>							
5	Prerequisite Pass exam (2	e for the award of c 100%)	redit points					
6	Grading Course relat • [20-00	ed exam: )-0724-se] (Study ac	hievement, Oral/v	vritten examination	n, Weighting: 100 %)	)		
7	Usability of the moduleB.Sc. InformatikM.Sc. InformatikB.Sc. Computational EngineeringM.Sc. Computational EngineeringM.Sc. WirtschaftsinformatikB.Sc. Psychologie in ITJoint B.A. InformatikB.Sc. Sportwissenschaft und InformatikM.Sc. Sportwissenschaft und Informatik							
8	Can be used Grade bonu	in other degree prog	grams. (2)					
9 Со1	References Will be given	n in seminar.						

<b>Course nr.</b> 20-00-0724-se	<b>Course name</b> Applied Topics in Computer Graphics		
<b>Instructor</b>		<b>Type</b>	SWS
Prof. DrIng. Michael Gösele		Seminar	2

Module name							
User-Centered Design in Visual Computing							
<b>Module nr.</b>		Credit points	Workload	Self-study	Module duration	Module cycle	
Language		5 G	90 II	Module owner	1 101111	Every 2. Semester	
German			Prof. DrIng. Michael Gösele				
1	Teaching contentDeveloping user-centered software leads to a more efficient usage and increases the acceptance by the human user.The higher acceptance leads to a better dissemination and exploitation of the developed solutions. The lecture"User Centered Design in Visual Computing" aims at enabling students from the department of computer scienceto acquire knowledge about models, methods, and techniques for user-centered development of visualizationsand interactive visual representations. This course will introduce methods that lead to designing more efficientsolutions with higher acceptance. Furthermore, the lecture will explain evaluation methods that allow measuringacceptance and efficiency. User Centered Design introduces the mentioned topics with a special focus on visualcomputing and graphical user interfaces.Content:UsabilityUser interfacesInteraction designPrototypingGraphics design and information visualizationEvaluation during and after software developmentApplications and examples						
2	<ul> <li>Learning objectives</li> <li>After a successful participation, students will be able to:</li> <li>Identify and argue about adequate methods for developing user-centered software</li> <li>Apply techniques for user-centered visual interfaces</li> <li>Identify and choose adequate evaluation methods for the chosen techniques in the different stages of software development</li> <li>Recommend improvements for information acquisition and navigation based on studies and evaluations</li> </ul>						
3	<ul> <li>Recommended prerequisites for participation</li> <li>Basics of visual computing, as e.g. taught in the introductory course HCS and in the course GDV I</li> </ul>						
4	<ul> <li>Form of examination</li> <li>Course related exam:</li> <li>[20-00-0793-iv] (Technical examination, Oral/written examination, Default RS)</li> </ul>						
5	Prerequisite for the award of credit points Pass exam (100%)						
6	Grading Course related exam: • [20-00-0793-iv] (Technical examination, Oral/written examination, Weighting: 100 %)						
7	Usability of the module						
	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT M.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik						
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8	Grade bonus con	npliant to §25 (2)					
	In dieser Vorlesu	ng findet eine Anrechnung von vorlesungsbegleitenden Leistu	ngen statt, die lt. 25 (2	2) der 5.			
	Novelle der APB u	nd den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsreg	geln zu einer Notenverbe	sserung			
9	References						
-							
Co	urses						
	Course nr.	Course name					
	20-00-0793-iv User-Centered Design in Visual Computing						
	Instructor Type SWS						
	Prof. DrIng. Mic	hael Gösele	Integrated course	2			

Mo Hai	Module name Hands-On HCI						
<b>Mo</b> 20-	Module nr.Credit pointsWorkload20-00-11166 CP180 b			Self-study 120 h	Module duration	Module cycle Every 2. Semester	
Lar Eng	<b>iguage</b> dish	I	I	<b>Module owner</b> Prof. Dr. Arjan Ku	ıijper		
1	<b>1</b> Teaching content You might have previously heard of or even tried out virtual/augmented reality, 3D printing, wearable or tangible user interfaces. The area of Human-Computer Interaction covers all these exciting topics and offers an opportunity to build new prototypes and try them out with people in the user studies. If you would like to better connect theory and practice in the area of Human-Computer Interaction (HCI), then the course of Hands-On Human-Computer Interaction (HCI), then the course of Hands-On Human-Computer Interaction (Hands-On HCI) is for you. The goal of the class is to walk you through the whole research cycle in HCI. It can play a great preparation role for your future bachelor/master thesis in HCI or lay a first brick in group denies and offers.						
2	Learning of After complet - differentiat - distinguish - effectively t - differentiat - Formulate a - create a sui - conduct a s - Analyze, ev - Analyze an - Understanc - Write the k	ojectives eting the module, stu- ce between and apply three types of empir read a scientific publice and define research of itable study design b study using quantitatival valuate and interpret d interpret qualitatival the peer review pro- d and apply evaluation nowledge gained as	idents can v three approaches rical research. ication. ICI contributions. questions, hypothe ased on the previous ive and qualitative quantitative data ve data on the basis boxess and write revo on techniques with a scientific publication	s to HCI research. eses and experimer ously developed res e methods to collect on the basis of sta is of grounded theo views for a scientifi and without users ation and present it	ntal variables. search questions. et data. tistical methods. ory. c publication. s. t to a specialist audie	nce.	
3	Recommend Recommend	ded prerequisites for led: Human-Comput	or participation er Interaction (TK	2)			
4	Form of exa Course relat • [20-00 The form of two of the for Written exan including ter	mination ed exam: )-1116-iv] (Technica the examination wil ollowing forms is pos n (duration 60 or 90 sts).	l examination, Ora l be announced at sible. or 120 minutes),	al/written examina the beginning of t oral exam (duration	tion, Default RS) he course. One or a n 15 or 30 minutes),	combination of max. homework (optional:	
5	Prerequisite Pass exam (1	e for the award of c 100%)	redit points				
6	<ul> <li>Grading Course related exam:</li> <li>[20-00-1116-iv] (Technical examination, Oral/written examination, Weighting: 100 %)</li> </ul>						
7	<ul> <li><sup>7</sup> Usability of the module</li> <li>B.Sc. Informatik</li> <li>M.Sc. Informatik</li> <li>May be used in other degree programs.</li> </ul>						
8	Grade bonu	is compliant to §25	(2)				

9	References			
Co	urses			
	<b>Course nr.</b> 20-00-1116-iv	Course name Hands-On HCI		
	<b>Instructor</b> Prof. Dr. Arjan K	uijper	<b>Type</b> Integrated course	SWS 4

## 2.8 Optional Subjects AIS-EC: Economics

Mo Inti	<b>dule name</b> roduction to B	usiness Administrati	on			
<b>Mo</b>	<b>dule nr.</b> 10-1028/f	Credit points	Workload 90 h	Self-study	Module duration	Module cycle
Lar Ger	nguage man			Module owner Prof. Dr. rer. pol.	Dirk Schiereck	
1	1 Teaching content This course serves as an introduction into studies of business administration for students of other siences. The course will provide a broad spectrum of knowledge from the "birth" of business administration as an university science field until its fragmentation into many specialized disciplines. Core topics will include basics of business administration (definitions and German legal forms), some Marketing concepts, introduction into Production Management (business process optimization and quality management), basic knowledge of organisational and personnel related topics, fundamental concepts of finance and investment as well as internal and external reporting standards.					
2	<ul> <li>Learning objectives         The couse encourages students who have not been confronted with business studies before to think economicially. Furthermore, it should enable students to better understand actions of managers and corporations in general.     </li> <li>After the course students are able to         <ul> <li>comprehend the development in the history of business administration,</li> <li>apply essential marketing concepts,</li> <li>use fundamental methods in production management,</li> <li>economically valuate investment alternatives and</li> <li>understand important interrelations in financial accounting.</li> </ul> </li> </ul>					o think economicially. porations in general.
3	Recomment None	ded prerequisites fo	or participation			
4	Form of exa Module exa • Modul	<b>mination</b> n: e exam (Technical ex	xamination, Exam	ination, Duration:	90 Min., Default RS)	
5	<b>Prerequisit</b> Passing the	e for the award of c	redit points			
6	Grading Module exan • Modul	n: e exam (Technical ex	xamination, Exam	ination, Weighting	: 100 %)	
7	Usability of the module					
8	Grade bonus compliant to §25 (2)					
9	References Thommen, J Domschke, V Further liter	JP. & Achleitner, A W. & Scholl, A. (2008 ature will be annour	K. (2006): Allgem 3): Grundlagen de aced in the lecture	eine Betriebswirtse er Betriebswirtscha	chaftslehre, 5. Aufl., ftslehre, 3. Aufl., Hei	Wiesbaden. delberg.

Co	Courses						
	<b>Course nr.</b> 01-10-0000-vl	<b>Course name</b> Introduction to Business Administration					
	Instructor		<b>Type</b> Lecture	SWS 2			

Mo	dule name	ting and Danaming				
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cvcle
01-	14-1B01	5 CP	150 h	60 h	1 Term	Every Semester
Lan Ger	n <b>guage</b> rman			Module owner Prof. Dr. rer. pol.	Reiner Quick	
1	1 Teaching content Financial Accounting: Fundamentals of accounting and bookkeeping, inventory, balance sheet, recording of assets and debt, recording of expenses and revenues, selected transactions (sales and purchases, non-current assets, current assets, accruals, wage and salary, distribution of earnings), annual closing entry. Financial Reporting: Fundamentals of accounting based on the rules of the German Commercial Code (HGB) accounting concepts, purpose of accounting, bookkeeping, inventory, recognition and measurement of assets and liabilities income statement, notes management report.					
2	<ul> <li>2 Learning objectives</li> <li>After the course students are able to <ul> <li>understand the core principles of bookkeeping, inventory and preparation of the balance sheet</li> <li>book stocks and profit</li> <li>solve specific bookkeeping problems in the fields of sales and purchases, non-current and current assets, accruals, wage and salary, distribution of earnings</li> <li>understand of the steps prior to the preparation of annual financial statements according to the German Commercial Code (HGB)</li> <li>analyze of the recognition and measurement of assets and liabilities</li> <li>understand of Income statements, notes and management reports</li> <li>solve accounting cases in the context of the German Commercial Code (HGB)</li> </ul> </li> </ul>					ance sheet at and current assets, rding to the German
3	<b>Recommen</b> Prerequisite Previous Kno	<b>ded prerequisites fo</b> s: none owledge: see initial s	<b>or participation</b> kills			
4	Form of exa Module exa • Modul • Modul Supplement The academ	mination n: e exam (Technical ex e exam (Study achie to Assessment Meth- ic achievement needs	amination, Writte vement, Oral/writ ods: s to be passed to t	en examination, Du tten examination, I ake part in the mo	uration: 90 Min., Defa Duration: 45 Min., De dule exam.	ault RS) efault RS)
5	<b>Prerequisite</b> Passing the I	e for the award of c Examination	redit points			
6	Grading Module exam: • Module exam (Technical examination, Written examination, Weighting: 2) • Module exam (Study achievement, Oral/written examination, Weighting: 1)					
7	Usability of the module B.Sc. Wirtschaftsingenieurwesen, B.Sc. Wirtschaftsinformatik					
8	Grade bonus compliant to §25 (2)					
9	<b>References</b> Quick, R./ V Quick, R./W Further liter	Vurl, HJ: Doppelte l olz, M.: Bilanzierung ature will be announ	Buchführung, 2. A g in Fällen. 4. Aufl aced in the lecture	ufl., Wiesbaden: G age. Schäffer Poes	abler. chel, Stuttgart	

Co	Courses						
	<b>Course nr.</b> 01-14-0001-vu	Course name Bookkeeping					
	Instructor Prof. Dr. rer. pol. Reiner Quick		<b>Type</b> Lecture and practice	SWS 2			
	<b>Course nr.</b> 01-14-0003-vu	<b>Course name</b> Financial Accounting					
	Instructor Prof. Dr. rer. pol.	Reiner Quick	<b>Type</b> Lecture and practice	<b>SWS</b> 2			
	<b>Course nr.</b> 01-14-0001-tt	Course name Bookkeeping					
	Instructor Prof. Dr. rer. pol.	Reiner Quick	<b>Type</b> Tutorial	<b>SWS</b> 1			
	<b>Course nr.</b> 01-14-0003-tt	<b>Course name</b> Financial Accounting					
	Instructor Prof. Dr. rer. pol. Reiner Quick		<b>Type</b> Tutorial	<b>SWS</b> 1			

	1 1						
Intr	Introduction to project management						
<b>Mo</b> 01-	dule nr. 19-0B03	Credit points 3 CP	Workload 90 h	Self-study 60 h	Module duration 1 Term	Module cycle Every Semester	
Lar Ger	i <b>guage</b> man			Module owner Prof. Dr. rer. pol.	Andreas Pfnür	-	
1	I         Teaching content           Basic concepts, project organisation, planning a work breakdown structure, quantity and cost estimation, time, cost and capacity planning, project control, project risk management, financial planning of projects, selected problems of project leadership, Selected applications and case studies from project management					cost estimation, time, of projects, selected ement	
2	<ul> <li>2 Learning object leadership, selected applications and case studies from project management</li> <li>2 Learning objectives</li> <li>After the course students are able to <ul> <li>understand the basic tasks and challenges of project management,</li> <li>know different alternatives of the organization of the project management and to evaluate their specific advantages and disadvantages,</li> <li>demonstrate the various ways in which project committees can be set up and how they can be integrated into a company's organisation,</li> <li>understand and develop a project structure plan,</li> <li>understand and evaluate the procedures for estimating quantities and project costs,</li> <li>apply and evaluate state-of-the-art models and procedures for time, cost and resource planning,</li> <li>carry out in-depth procedures of project controlling and to learn how to apply them in specific situations.</li> <li>understand the basics of financial planning of a project.</li> </ul> </li> </ul>						
3	<b>Recommend</b> Prerequisites Previous Kno	<b>ded prerequisites fo</b> s: none owledge: see initial s	<b>or participation</b> kills				
4	Form of exa Module exar • Module	mination n: e exam (Technical ex	kamination, Writte	en examination, Du	ıration: 90 Min., Defa	ault RS)	
5	<b>Prerequisite</b> Passing the e	e for the award of c	redit points				
6	<ul> <li>Grading</li> <li>Module exam:</li> <li>Module exam (Technical examination, Written examination, Weighting: 100 %)</li> </ul>						
7	Usability of the module B.Sc. Wirtschaftsingenieurwesen, B.Sc. Wirtschaftsinformatik						
8	Grade bonu	s compliant to §25	(2)				
9	References						

Burghardt, M. (2008): Projektmanagement. Leitfaden für die Planung, Überwachung und Steuerung von Projekten (8., überarb. und erw. Aufl.). Erlangen: Publicis Corp. Publ.

Kerzner, H. (2006): Project Management - A Systems Approach to Planning, Scheduling, and Controlling (9. Aufl.). Hoboken, NJ: Wiley.

Madaus, B. (2000): Handbuch Projektmanagement (6., überarb. und erw. Aufl.). Stuttgart: Schäffer-Poeschel. Schwarze (2001) Projektmanagement mit Netzplantechnik, Herne, 8. Auflg.

Further literature will be announced in the lecture.

## Courses

<b>Course nr.</b> 01-19-5100-vu	<b>Course name</b> Introduction to Project Management		
Instructor Prof. Dr. rer. pol.	Andreas Pfnür	<b>Type</b> Lecture and practice	<b>SWS</b> 2

Mo Tec	Module name Technology and Innovation Management						
Mo 01	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle	
Lar Eng	<b>iguage</b> glish	0 CP	160 11	Module owner Prof. Dr. Alexand	er Kock	Every Semester	
1	Image: Initial						
2	<ul> <li>2 Learning objectives After the course the students are able to <ul> <li>identify and evaluate problems emerging from managing innovation.</li> <li>explain, evaluate and apply theories of Technology and Innovation Management.</li> <li>evaluate fundamental design factors of corporate innovation systems. <ul> <li>derive improvement procedures for innovation processes in firms.</li> <li>apply tools of technology management.</li> <li>make relevant recommendations for corporate practice.</li> </ul></li></ul></li></ul>						
3	<b>Recomment</b> Prerequisite Previous Kno	<b>ded prerequisites fo</b> s: none owledge: see initial s	<b>or participation</b> kills				
4	Form of exa Module exar • Modul Supplement Oral/writter Written: exa Oral: team of	mination m: e exam (Technical ex to Assessment Methon: Type and duration om (duration 60 - 90 or individual exam (d	amination, Oral/ ods of exam are anno minutes) luration 15 - 20 m	written examinatio ounced by the begir inutes per participa	n, Default RS) nning of the course ant)		
5	Prerequisite Passing the I	e <b>for the award of c</b> Examination	redit points				
6	Grading Module exan • Modul	m: e exam (Technical ex	amination, Oral/	written examinatio	n, Weighting: 100 %	))	
7	Usability of M.Sc. Wirtsc ment, M.Sc.	<b>the module</b> chaftsingenieurwesen Logistics and Supply	, M.Sc. Wirtschaft 7 Chain Managem	sinformatik, M.Sc. 1 ent	Entrepreneurship and	l Innovation Manage-	
8	Grade bonus compliant to §25 (2)						
9	References Hauschildt, J., Salomo, S., Schultz. C., Kock, A. (2016): Innovationsmanagement, 6. Aufl. Vahlen Verlag, Tidd/Bessant (2013): Managing Innovation: Integrating Technological, Market and Organizational Change. Further literature will be announced in the lecture.						
Coi	Courses						

<b>Course nr.</b> 01-10-1M01-vu	<b>Course name</b> Technology and Innovation Management		
<b>Instructor</b> Prof. Dr. Alexand	er Kock	<b>Type</b> Lecture and practice	SWS 4

Mo Intr	dule name	nnovation Manageme	ent				
<b>Mo</b>	<b>dule nr.</b> 22-2B01	Credit points	Workload 90 h	Self-study	Module duration	Module cycle	
Lar Eng	<b>iguage</b> glish	0.01		Module owner Prof. Dr. Alexand	er Kock	livery bennester	
1	1 <b>Teaching content</b> The lecture offers students an introduction to the topic of innovation management in companies. In times of disruptive and radical innovations, well-founded knowledge in innovation management is an elementary core competence of companies in order to stay competitive. After learning the conceptual basics, students learn about managing the different stages of the innovation process, from initiative to the adoption of an innovation. In addition, strategic aspects and the human side of innovation management will be introduced. The lecture thus forms an excellent thematic orientation and introduction for undergraduate students for the advanced courses of the master studies.						
2	<ul> <li>2 Learning objectives After the course students are able to <ul> <li>give an overview of the components of the innovation process and management.</li> <li>identify and evaluate problems that arise in the management of innovations.</li> <li>explain, evaluate and apply theories of technology and innovation management. <ul> <li>assess the basic design factors of a firm's innovation system.</li> <li>derive actions to improve innovation processes in companies.</li> <li>apply the concepts to practice-relevant questions.</li> </ul></li></ul></li></ul>						
3	<b>Recommen</b> Prerequisite Previous Kne	<b>ded prerequisites fo</b> s: none owledge: see initial s	<b>or participation</b> kills and basics in	business administr	ration		
4	Form of exa Module exa • Modul	<b>mination</b> m: e exam (Technical ex	amination, Writte	en examination, Du	ıration: 90 Min., Def	ault RS)	
5	Prerequisite Passing the 1	e <b>for the award of c</b> Examination	redit points				
6	Grading Module exan • Modul	n: e exam (Technical ex	amination, Writte	en examination, We	eighting: 100 %)		
7	<b>Usability of the module</b> B.Sc. Wirtschaftsingenieurwesen, B.Sc. Wirtschaftsinformatik						
8	Grade bonus compliant to §25 (2)						
9	<ul> <li>References</li> <li>Hauschildt, J., Salomo, S., Schultz. C., Kock, A. (2016): Innovationsmanagement, 6. Aufl. Vahlen Verlag.</li> <li>Tidd/Bessant (2013): Managing Innovation: Integrating Technological, Market and Organizational Change.</li> </ul>						
Col	Further liter	ature will be announ	ced in the lecture				
	11303						

-	<b>Course nr.</b> 01-22-2B01-vl	<b>Course name</b> Introduction to Innovation Management		
	<b>Instructor</b> Prof. Dr. Alexand	er Kock	<b>Type</b> Lecture	<b>SWS</b> 2

Мо	dule name						
Bas	ic Principles c	of Patent and Copyri	ght Law	I			
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cy	cle
U1-	41-112/	3 CP	90 h	00 n	1 Ierm	Every Seme	ester
Ger	man			Prof. Dr. jur. Joch	en Marly		
1	1 <b>Teaching content</b> Introduction, Overview on the Intellectual Property Rights, Literature, General Right of Privacy, "The right of the own picture", Protection of the Name, The work of the author, The author, The Content of the Copyright I, the Content of the Copyright II, Limitations of the Copyright Law, Marketing companies, The Copyright Law in legal matters, Publishing contracts, International Copyright Law, Theory of the Industrial Property Rights, Object of protection and provisions of protection of a patent, The inventor, The creation of a patent, content and limitations of a patent, Infringements of right						
2	<ul> <li>Learning objectives         After the course the students are able to         • state their view on existing legal structures of solutions. Because of many problems of detail only an exemplary learing has a good prospect for a successful achievement.     </li> </ul>					only an	
3	Recommend	ded prerequisites fo	or participation				
4	Form of exa Module exar • Modul	mination n: e exam (Technical e	xamination, Oral/	written examinatio	n, Default RS)		
5	Prerequisite Passing the f	e for the award of c final module examin	<b>redit points</b> ation				
6	Grading Module exar • Modul	n: e exam (Technical e	xamination, Oral/	written examinatio	n, Weighting: 100 %	b)	
7	Usability of	the module					
8	Grade bonu	s compliant to §25	(2)				
9	9 References to be announced in class.						
Cou	ırses						
	<b>Course nr.</b> 01-41-0002-	vl Introduction t	o Patent and Copy	right Law			
	<b>Instructor</b> Prof. Dr. jur.	Jochen Marly			<b>Type</b> Lecture		SWS 2

Mo Inti	<b>dule name</b> roduction to Ec	onomics (V)						
<b>Mo</b> 01-	<b>dule nr.</b> 60-1042/f	Credit points 3 CP	Workload 90 h	Self-study 60 h	Module	duration	Module cy Every Seme	<b>cle</b> ester
Lar Ger	nguage rman/English			<b>Module owner</b> Prof. Dr. rer. pol.	Michael N	leugart		
1	Teaching con Econom Supply Elasticit Consum Opport Margin Cost the Utility 1 Macroe Long-ru	ntent nic modeling and demand ties her and producer re unity costs al analysis eory maximization conomic aggregates in growth	ent S					
2	Aggrega     Learning obj     Students are	ectives	regate demand	mics and their app	lication to	selected fie	elds of interes	st.
3	Recommend None	ed prerequisites fo	or participation					
4	Form of exam Module exam • Module	<b>nination</b> 1: exam (Technical e	xamination, Exam	ination, Duration:	90 Min., D	)efault RS)		
5	<b>Prerequisite</b> Passing the fi	for the award of c nal module examin	e <b>redit points</b> ation					
6	<b>Grading</b> Module exam • Module	ı: exam (Technical e	xamination, Exam	ination, Weighting	: 100 %)			
7	Usability of 1 none	the module						
8	8 Grade bonus compliant to §25 (2)							
9	<b>References</b> to be announ	ced in course.						
Co	urses							
	<b>Course nr.</b> 01-60-0000-v	Course name Introduction t	o Economics					
	Instructor					<b>Type</b> Lecture		SWS 2

## 2.9 Optional Subjects AIS-EI: Entrepreneurship and Management

Modu Intro	<b>ule name</b> duction to B	usiness Administratio	on			
Modu	ule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
Lang	J-1028/I	3 CP	90 h	Module owner	1 Ierm	Every Semester
Germ	ian			Prof. Dr. rer. pol.	Dirk Schiereck	
	1 <b>Teaching content</b> This course serves as an introduction into studies of business administration for students of other siences. The course will provide a broad spectrum of knowledge from the "birth" of business administration as an university science field until its fragmentation into many specialized disciplines. Core topics will include basics of business administration (definitions and German legal forms), some Marketing concepts, introduction into Production Management (business process optimization and quality management), basic knowledge of organisational and personnel related topics, fundamental concepts of finance and investment as well as internal and external reporting standards.					
<b>2 1</b> 1 1	Learning of The couse en Furthermore After the cou • compre • apply e • use fun • econor • unders	ojectives acourages students when e, it should enable stu- urse students are able ehend the development essential marketing of ndamental methods in nically valuate invest stand important inter	no have not been o idents to better us e to ent in the history oncepts, in production man ment alternatives rrelations in finan	confronted with bus nderstand actions of of business adminis nagement, and cial accounting.	iness studies before to of managers and corp stration,	o think economicially. porations in general.
3 I	<b>Recommen</b> None	led prerequisites fo	r participation			
4 I I	Form of exa Module exar • Module	<b>mination</b> n: e exam (Technical ex	amination, Exam	ination, Duration:	90 Min., Default RS)	
5 I I	Prerequisite Passing the e	e for the award of c	redit points			
6 ( 1	Grading Module exar • Modul	n: e exam (Technical ex	amination, Exam	ination, Weighting	: 100 %)	
7 1	Usability of	the module				
8 (	Grade bonu	s compliant to §25	(2)			
9 I	<b>References</b> Thommen, J Domschke, V Further liter	P. & Achleitner, A) N. & Scholl, A. (2008) ature will be announ	K. (2006): Allgem 3): Grundlagen de ced in the lecture	eine Betriebswirtso er Betriebswirtschat	chaftslehre, 5. Aufl., <sup>°</sup> ftslehre, 3. Aufl., Hei	Wiesbaden. delberg.

Co	urses			
	<b>Course nr.</b> 01-10-0000-vl	<b>Course name</b> Introduction to Business Administration		
	Instructor		<b>Type</b> Lecture	SWS 2

Mo	dule name					
Lea	dership and I	Human Resource Mai	nagement Systems	5		
<b>Mo</b>   01-	<b>dule nr.</b> 17-6201/6	Credit points	Workload 180 h	Self-study	Module duration	Module cycle Every Semester
Lar	iguage		100 11	Module owner	1 101111	
Eng	glish			Prof. Dr. Dr. Ruth	Stock-Homburg	
1	<ul> <li>Teaching content <ul> <li>Leadership:</li> <li>Central approaches and theories of employee and team leadership</li> <li>Methods of leadership research</li> <li>Success factors of employee leadership</li> <li>Leadership of the future</li> <li>Special application areas of leadership (e.g. regional distributed or virtual leadership)</li> <li>Future of Work:</li> <li>Influence of new technologies and digitization on the world of work</li> <li>Future development and design approaches in human resources management</li> <li>Approaches to measuring the sustainability of companies and individuals</li> <li>Special challenges of the future of work (e.g. telework/well-being, electronic accessibility, new technologies)</li> </ul> </li> </ul>					
2	Learning ol After the cou explain apply assess explain interpre- better work v reflect apply connect	<b>ojectives</b> urse students are able n, compare and contr the instruments and the challenges of lea n important theories ret and reflect on imp assess where they pe vith curiosity. on challenges in the learned concepts and ct their knowledge to	e to, rast the key theore tools available for ding employees a , techniques, and portant parameters rsonally stand in t future of work. l instruments in ca business cases in	etical concepts of e leading employees nd teams in an inte concepts about the s for the Future Fitm erms of their indivi ase studies. presentations of ex	mployee and team less and teams. ernational environme future of work. ess of employees, lea dual Future Fitness a	eadership. ent. ders, and companies. nd face the future of eers.
3	Recomment Sufficient En written exar	<b>ded prerequisites fo</b> nglish skills to follow n.	or participation v the lecture in Er	nglish and to unde	rstand and answer t	he English-language
4	<ul> <li>Form of examination         Module exam:         <ul> <li>Module exam (Technical examination, Oral/written examination, Default RS)             Supplement to Assessment Methods             Oral/written: Type and duration of exam are announced by the beginning of the course             Written: exam (duration 60 - 90 minutes)             Oral: team or individual exam (duration 15 - 20 minutes per participant)         </li> </ul> </li></ul>					
5	<b>Prerequisit</b> Passing the	e for the award of c Examination	redit points			
6	Grading Module exame • Modul	m: e exam (Technical ex	xamination, Oral/	written examinatio	n, Weighting: 100 %	))
7	Usability of	the module				

	M.Sc. Wirtschafts ment, M.Sc. Log	ingenieurwesen, M.Sc. Wirtschaftsinformatik, M.Sc. Entrepren stics and Supply Chain Management	eurship and Innovation M	Manage-	
8	Grade bonus co	mpliant to §25 (2)			
9	References Stock-Homburg, R. & Groß, M. (2019), Personalmanagement: Theorien - Konzepte - Instrumente, Wiesbaden, 4th Edition, Kap. IV.				
	Stock-Homburg, R., Two Steps Ab	R. (2020a), Chapter 1: The Dodo Effect and Our Future ead, TU Darmstadt. (working paper)	e Fitness, in: Stock-Ho	omburg,	
	Stock-Homburg, TU Darmstadt. (v	R. (2020b), Chapter 2: Future Orientation, in: Stock-How working paper)	omburg, R., Two Steps	Ahead,	
	Stock-Homburg, Work Navigator Groß, M., Müller- und Praxisbeispie	R. & Lukoschek, C. (2019), Measuring and Designing For (Zukunftsfähigkeit messen und gestalten mit dem Future Wo Wiegand, M., & Pinnow, D. F. (Hrsg.), Zukunftsfähige Unternel ele, Berlin: Springer Gabler. (translated from German)	uture Fitness with the ork Navigator), p. 191- hmensführung: Ideen, K	Future 207, in: onzepte	
	Further literature	e will be announced in the lecture.			
Cot	arses				
	<b>Course nr.</b> 01-17-0004-vu	Course name Leadership			
	<b>Instructor</b> Dr. rer. pol. Gisel	a Gerlach	<b>Type</b> Lecture and practice	SWS 2	
	<b>Course nr.</b> 01-17-0008-vu	Course name Future of Work			
	<b>Instructor</b> Prof. Dr. Dr. Ruth	Stock-Homburg	<b>Type</b> Lecture and practice	SWS 2	

Mo Tec	dule name	Innovation Managem	ent			
Mo 01	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle
Lar Eng	<b>iguage</b> glish	0 CP	160 11	Module owner Prof. Dr. Alexand	er Kock	Every Semester
1	1 Teaching content The lecture Technology and Innovation Management is designed for the students to learn about the challenges of managing innovation. Organizational change and innovation are the basic requirements for competitiveness and success of businesses. However, in most industries innovation is often paired with organizational challenges and barriers. In this lecture, students get to know the fundamental concepts and design of Innovation Management and the innovation process (form initiative to implementation), as well as the interaction of central actors. Furthermore, this lecture provides insights into the specialisations Innovation Behaviour and Strategic Technology and Innovation Management.					
2	<ul> <li>2 Learning objectives</li> <li>After the course the students are able to <ul> <li>identify and evaluate problems emerging from managing innovation.</li> <li>explain, evaluate and apply theories of Technology and Innovation Management.</li> <li>evaluate fundamental design factors of corporate innovation systems.</li> <li>derive improvement procedures for innovation processes in firms.</li> <li>apply tools of technology management.</li> <li>make relevant recommendations for corporate practice.</li> </ul> </li> </ul>					
3	<b>Recomment</b> Prerequisite Previous Kno	<b>ded prerequisites fo</b> s: none owledge: see initial s	<b>or participation</b> kills			
4	Form of exa Module exar • Modul Supplement Oral/writter Written: exa Oral: team of	mination m: e exam (Technical ex to Assessment Methon: Type and duration om (duration 60 - 90 or individual exam (d	amination, Oral/ ods of exam are anno minutes) luration 15 - 20 m	written examinatio ounced by the begir inutes per participa	n, Default RS) nning of the course ant)	
5	Prerequisite Passing the I	e <b>for the award of c</b> Examination	redit points			
6	Grading Module exan • Modul	m: e exam (Technical ex	amination, Oral/	written examinatio	n, Weighting: 100 %	))
7	Usability of M.Sc. Wirtsc ment, M.Sc.	<b>the module</b> chaftsingenieurwesen Logistics and Supply	, M.Sc. Wirtschaft 7 Chain Managem	sinformatik, M.Sc. 1 ent	Entrepreneurship and	l Innovation Manage-
8	Grade bonu	is compliant to §25	(2)			
9	<b>References</b> Hauschildt, Tidd/Bessan Further liter	J., Salomo, S., Schu at (2013): Managing rature will be announ	lltz. C., Kock, A. Innovation: Integ aced in the lecture	(2016): Innovatio rating Technologic	nsmanagement, 6. al, Market and Orgar	Aufl. Vahlen Verlag, nizational Change.
Coi	urses					

-	<b>Course nr.</b> 01-10-1M01-vu	<b>Course name</b> Technology and Innovation Management		
	<b>Instructor</b> Prof. Dr. Alexand	er Kock	<b>Type</b> Lecture and practice	SWS 4

Mo Intr	dule name	nnovation Manageme	ent			
<b>Mo</b>	<b>dule nr.</b> 22-2B01	Credit points	Workload 90 h	Self-study	Module duration	Module cycle
Lar Eng	<b>iguage</b> glish	0.01		Module owner Prof. Dr. Alexand	er Kock	livery bennester
1	<ul> <li>Teaching content         The lecture offers students an introduction to the topic of innovation management in companies. In times of disruptive and radical innovations, well-founded knowledge in innovation management is an elementary core competence of companies in order to stay competitive. After learning the conceptual basics, students learn about managing the different stages of the innovation process, from initiative to the adoption of an innovation. In addition, strategic aspects and the human side of innovation management will be introduced. The lecture thus forms an excellent thematic orientation and introduction for undergraduate students for the advanced courses of the master studies.     </li> </ul>					
2	<ul> <li>2 Learning objectives After the course students are able to <ul> <li>give an overview of the components of the innovation process and management.</li> <li>identify and evaluate problems that arise in the management of innovations.</li> <li>explain, evaluate and apply theories of technology and innovation management. <ul> <li>assess the basic design factors of a firm's innovation system.</li> <li>derive actions to improve innovation processes in companies.</li> <li>apply the concepts to practice-relevant questions.</li> </ul></li></ul></li></ul>					
3	<b>Recommen</b> Prerequisite Previous Kne	<b>ded prerequisites fo</b> s: none owledge: see initial s	<b>or participation</b> kills and basics in	business administr	ration	
4	Form of exa Module exa • Modul	<b>mination</b> m: e exam (Technical ex	amination, Writte	en examination, Du	ıration: 90 Min., Def	ault RS)
5	Prerequisite Passing the 1	e <b>for the award of c</b> Examination	redit points			
6	Grading Module exan • Modul	n: e exam (Technical ex	amination, Writte	en examination, We	eighting: 100 %)	
7	Usability of B.Sc. Wirtsc	<b>the module</b> haftsingenieurwesen	, B.Sc. Wirtschaft	sinformatik		
8	Grade bonu	is compliant to §25	(2)			
9	<b>References</b> Hauschildt, Tidd/Bessar	J., Salomo, S., Schult It (2013): Managing	z. C., Kock, A. (20 Innovation: Integ	016): Innovationsm rating Technologica	nanagement, 6. Aufl. al, Market and Organ	Vahlen Verlag. nizational Change.
Col	Further liter	ature will be announ	ced in the lecture			
	11303					

-	<b>Course nr.</b> 01-22-2B01-vl	<b>Course name</b> Introduction to Innovation Management		
	<b>Instructor</b> Prof. Dr. Alexand	er Kock	<b>Type</b> Lecture	<b>SWS</b> 2

Mo HIC	<b>dule name</b> GHEST lecture	e series - From the co	ncept to your own	1 company		
<b>Mo</b>	dule nr. 27-0701	Credit points	Workload	Self-study	Module duration	Module cycle
Lar Ger	nguage man	2.01	0011	Module owner Prof. Dr. rer. pol.	Carolin Bock	livery bemester
1	1 <b>Teaching content</b> The HIGHEST lecture series introduces students to the process of founding a startup. The aim of the lecture is to raise students' awareness of startup-related topics and entrepreneurial thinking. Various topics of the multi-layered start-up process are discussed and underpinned by numerous exciting examples from practice. The aim is to convey contents that are helpful for a successful founding process and enable entrepreneurial action.					
	<ul> <li>Exemplary topics are:</li> <li>writing a business plan, financing, grants and funding programs, founder skills, founder teams,</li> <li>idea generation, innovations, investors, creative techniques, marketing and sales in startups,</li> <li>ecosystems and networks, legal, social entrepreneurship and more.</li> <li>Among other things, the lecture series will address these questions:</li> <li>What is innovation, and what are the paths to commercialization?</li> <li>How does an innovation become a business idea and ultimately a company?</li> <li>How do I know I'm a founder?</li> <li>What skills and competencies does a founding team need? Who do I involve and who not?</li> <li>How do I build a business?</li> <li>How do I lead a team?</li> <li>How do I get customers?</li> <li>What (legal) measures are there to protect my idea or research result?</li> <li>What financing options, funding programs or support services are available?</li> <li>What should I look out for when approaching financiers and Venture Capitalists?</li> <li>How do I negotiate conditions skillfully?</li> <li>What are positive examples, pioneers or unicorns and what can I learn from them?</li> </ul>					
2	Learning of Through the opportunitie are supporte TU Darmsta	<b>Djectives</b> e course, students a s and challenges of th ed and motivated to p dt and know where t	re better able to ne startup process pursue their own s hey can get which	assess their own a Students know the tartups. Students k support.	bilities as founders. e individual steps of a now the network and	Students know the a startup process and d environment of the
3	Recomment The lecture	<b>ded prerequisites fo</b> series is suitable for a	or participation all students (Bach	elor/Master) and d	oes not require any	special knowledge.
4	Form of exa Module exar • Modul Supplement Oral/writter Written: exa Oral: team of	mination m: e exam (Study achie to Assessment Meth a: Type and duration m (duration 60 - 90 or individual exam (d	vement, Oral/writ ods: of exam are anno minutes) luration 15 - 20 m	ten examination, p unced by the begir inutes per participa	o/np RS) nning of the course ant)	
5	<b>Prerequisite</b> Passing the	e for the award of c examination	redit points			
6	Grading					

	<ul><li>Module exam:</li><li>Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</li></ul>						
7	Usability of the	module					
	General Catalogi	ie of the Department of Law and Economics					
8	Grade bonus co	Grade bonus compliant to §25 (2)					
9	<b>References</b> Will be announce	ed in the course.					
Co	urses						
	Course nr.Course name01-27-0Z01-vlHIGHEST lecture series - From the concept to your own company						
	InstructorTypeSWProf. Dr. rer. pol. Carolin BockLecture0						

Mo Intr	<b>dule name</b> roduction to E	Intrepreneurship							
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle			
Lan Eng	nguage	3 CP	90 h	45 n Module owner Prof. Dr. rer. pol.	Carolin Bock	Every Semester			
1	<b>Teaching content</b> The course "Grundlagen des Entrepreneurship" (Introduction to Entrepreneurship), being part of the module "Grundlagen Entrepreneurship" introduces concepts of entrepreneurship relying on basic concepts and definitions. Hereby, a global and international perspective is taken. The course includes the topics: actions of entrepreneurs, their motivations and idea generating processes, effectuation and causation, their decision-making, and en- trepreneurial failure. Concerning entrepreneurial businesses, business planning, growth models, strategic alliances of young ventures, and human and social capital of entrepreneurs are discussed, Further, special types of entrepreneurship are taught. In addition, workshops will give students an insight into practical methods such as design thinking and the implementation and identification of opportunities.								
2	<ul> <li>Learning objectives</li> <li>After the course students are able to <ul> <li>define and describe basic concepts towards entrepreneurship,</li> <li>understand the psychologically-related concepts of being an entrepreneur,</li> <li>understand and describe the evolution from small firms to multinational enterprises,</li> <li>describe special types of entrepreneurship,</li> <li>understand basic concepts of entrepreneurial thinking towards idea- and business model creation,</li> <li>realize business opportunities and build sustainable business models,</li> <li>evaluate chances and risks of national and international markets as well choosing among various market entry strategies,</li> <li>incorporate stakeholder feedback into the business model.</li> </ul> </li> </ul>								
3	Recomment Prerequisite Previous Kn	<b>ded prerequisites fo</b> s: none owledge: see initial s	<b>or participation</b> kills and basics in	business administr	ration				
4	Form of exa Module exa • Modul	<b>amination</b> m: e exam (Technical ex	amination, Writte	en examination, Du	ration: 60 Min., Def	ault RS)			
5	Prerequisite Passing the	e for the award of cr Examination	redit points						
6	Grading Module exan • Modul	m: e exam (Technical ex	amination, Writte	en examination, We	eighting: 100 %)				
7	Usability of B.Sc. Wirtsc	<b>the module</b> haftsingenjeurwesen	. B.Sc. Wirtschaft	sinformatik					
8	Grade bonu	is compliant to §25	(2)						
9	References								

Grichnik, D., Brettel, M., Koropp, C., Mauer, R. (2010) Entrepreneurship. Stuttgart: Schäffer-Poeschel Verlag Hisrich, R. D., Peters, M. P., & Shepherd, D. A. (2010). Entrepreneurship (8th ed.). New York: McGraw-Hill. Read, S., Sarasvathy, S., Dew, N., Wiltbank, R. & Ohlsson, A.-V. (2010). Effectual Entrepreneurship. New York: Routledge Chapman & Hall.

More literature will be provided within the course and distributed to the students accordingly

Co	Courses								
	<b>Course nr.</b> 01-27-1B01-vl	<b>Course name</b> Introduction to Entrepreneurship							
	<b>Instructor</b> Prof. Dr. rer. pol.	Carolin Bock	<b>Type</b> Lecture	<b>SWS</b> 3					

Mo	dule name								
Gei	rman and Inte	rnational Corporate	Law	I		1			
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle			
Lar	12-1001/4	4 Gr	120 11	Module owner	1 101111	Every Semester			
Ger	man			Prof. Dr. jur. Jani	ne Wendt				
1	1 Teaching content The lecture is divided into two parts: The first part is an introduction to commercial law. The aim is to understand the importance of contract drafting in a company and to take into account the main aspects of commercial law regulations. The second part is devoted to company law, in particular the law of commercial partnerships and corporations. It also deals with the basic issues of good corporate governance and the importance of compliance. European company law will also be introduced. Recitation: This course discusses practical cases concerning commercial law and general company law. In preparation for the exam, sample cases will be discussed.								
2	<ul> <li>Learning objectives</li> <li>After the course students are able to <ul> <li>recognise the conditions for the application of commercial law.</li> <li>distinguish between the different commercial intermediaries.</li> <li>understand the basic structures of the most important forms of partnerships and corporations as legal entities for companies.</li> <li>understand the importance of good corporate governance and the importance of compliance for companies.</li> <li>deal with different legal texts.</li> <li>understand the significance of European legal developments for German law and in particular for the protection of investors.</li> <li>understand the context of legal regulations (e.g. sales law + commercial law + company law).</li> <li>work on simple facts of the German commercial and company law, as well as the financial market law by applying a legal approach and to compile answers to simple legal questions independently.</li> <li>generally recognise, assess and respond to the possibilities and risks of liability in legal matters.</li> </ul> </li> </ul>								
3	<b>Recommen</b> Prerequisite Previous Kn	<b>ded prerequisites fo</b> s: none owledge: see initial s	<b>or participation</b> kills and contract	law					
4	Form of exa Module exa • Modul	<b>amination</b> m: e exam (Technical ex	camination, Writte	en examination, Du	ıration: 90 Min., Def	ault RS)			
5	Prerequisite Passing the	e for the award of cr Examination	redit points						
6	Grading Module exan • Modul	m: e exam (Technical ex	camination, Writte	en examination, We	eighting: 100 %)				
7	Usability of B.Sc. Wirtsc	the module haftsingenieurwesen	, B.Sc. Wirtschaft	sinformatik					
8	Grade bonu	is compliant to §25	(2)						
9	References								

	Wendt, J., Wendt Buck-Heeb, P. (20 Poelzig, D. (2017 Brox/Henssler, H Kindler, Grundku	, D. (2019): Finanzmarktrecht, 1. Aufl. De Gruyter Verlag. D17): Kapitalmarktrecht, 9. Aufl. C.F. Müller Verlag D: Kaptalmarktrecht, 1. Aufl. C.H. Beck Verlag andelsrecht rs Handels- und Gesellschaftsrecht		
	Further literature	will be announced in the lecture.		
Co	urses			
	<b>Course nr.</b> 01-42-0001-vl	<b>Course name</b> German and International Corporate Law		
	<b>Instructor</b> Prof. Dr. jur. Jani	ne Wendt	<b>Type</b> Lecture	<b>SWS</b> 2
	<b>Course nr.</b> 01-42-0001-ue	<b>Course name</b> German and International Corporate Law		·
	<b>Instructor</b> Prof. Dr. jur. Jani	ne Wendt	<b>Type</b> Practice	<b>SWS</b> 1

Mo	dule name							
Intr	Introduction to Law Module pr Credit points Workload Self study Module duration Module grate							
Mo	dule nr.	Credit points	Workload	Self-study	Module d	luration	Module cy	cle
01-	40-1033/T	3 CP	90 h	00 n	1 Ierm		Every Seme	ester
Ger	Language Module owner Corman /English Drof Dr. jur. Janine Wondt							
1	Teaching content							
-	The lecture	provides a broad ins	ight into the most	important legal fie	lds of daily	v life - e.g.:	:	
	• The la	w of sales contracts						
	<ul> <li>Tenano</li> <li>Familu</li> </ul>	cy law						
	<ul> <li>Family</li> <li>Employ</li> </ul>	vment law						
	Corpor	ate law etc.						
	These will b	e illustrated by me	ans of practical c	ases. Important po	oints of ho	w to fram	e a contract	will be
	discussed.	•						
2	Learning of	<b>yectives</b> s will acquire knowle	edge of the basic r	principles of Germa	n civil law			
3	Recommend	led prerequisites fo	or participation	incipies of define				
Ŭ	None	icu prerequisites R	n purcleipution					
4	Form of exa	mination						
	Module exar	n:						
	• Modul	e exam (Technical e	xamination, Exam	ination, Duration:	90 Min., D	efault RS)		
5	Prereauisite	e for the award of c	redit points					
	Passing the f	inal module examin	ation					
6	Grading							
	Module exam	n:	· .·	· · · · · · · · · · · · · · · · · · ·	100.0/)			
	• Modul	e exam (Technical e	xamination, Exam	ination, weighting	: 100 %)			
7	Usability of	the module						
	<b>,</b>							
8	Grade bonu	s compliant to §25	(2)					
9	References		1. 1. )					
	BGB-Gesetze	estext(z.B. Beck-Text	te im atv)					
	Materialien	zum Download auf o	ler Homepage des	Fachgebiets.				
Cou	urses							
	Course nr.	Course name						
	01-40-0000-	vl Introduction t	o Law					1
	Instructor	T 1 TAT 1.				Туре		SWS
1	Prof Dr jur Janine Wendt 2							

Mo Dig	<b>dule name</b> ital Product a	nd Service Marketing	g						
Mo	dule nr.	Credit points	Workload	Self-study	Module duration	Module cycle			
Language     Module owner       English     Prof. Dr. Dr. Ruth Stock-Homburg						Every Semester			
1	<ul> <li><b>Teaching content</b>         Digital Product and Service Marketing: Selected topics in the context of digital marketing; including micro and macro environment, digital marketing strategies, the digital marketing mix, digital relationship marketing, communication strategies and channels for digital customers, and evaluation of approaches.     </li> <li>Digital Innovation Marketing:Selected topics in the context of digital innovation marketing, including basic information about innovation, key innovation strategies; important theoretical concepts of innovation marketing in the innovation strategies; important theoretical concepts of innovation     </li> </ul>								
2	<ul> <li>2 Learning objectives</li> <li>After the course students are able to <ul> <li>recognize the role of digitization for marketing and to estimate potentials.</li> <li>evaluate approaches in the context of digital marketing.</li> <li>explain different phases and tools for digital marketing.</li> <li>explain the process and the organizational design elements of a holistic and customer-oriented innovation management.</li> <li>recognize the potential of user innovations and co-opetition</li> <li>critically reflect on ethical aspects of marketing.</li> <li>apply the concepts and instruments dealt with to practice-oriented questions using specific examples.</li> </ul> </li> </ul>								
3	Recomment Marketing Sufficient En	<b>ded prerequisites fo</b> nglish skills to follow	or participation	nglish and to unde	rstand and answer t	he English-language			
	written exar	n.							
4	Form of examination         Module exam:         • Module exam (Technical examination, Oral/written examination, Default RS)         Supplement to Assessment Methods         Oral/written: Type and duration of exam are announced by the beginning of the course         Written: exam (duration 60 - 90 minutes)         Owning the course of the course of the course								
5	<b>Prerequisite</b> Passing the 1	e <b>for the award of c</b> Examination	redit points						
6	Grading Module exan • Modul	m: e exam (Technical ex	xamination, Oral/	written examinatio	n, Weighting: 100 %	)			
7	Usability of M.Sc. Wirtso ment, M.Sc.	the module chaftsingenieurwesen Logistics and Supply	, M.Sc. Wirtschaft y Chain Managem	sinformatik, M.Sc. i ent	Entrepreneurship and	l Innovation Manage-			
8	Grade bonu	is compliant to $\S{25}$	(2)						

9	References						
	Digital Product and Service Marketing						
	Chaffey, D., & Ellis-Chadwick, F. (2019). Digital marketing: strategy, implementation & practice. Pearson UK						
	Chaffey, D., & Smith, P. R. (2017). Digital marketing excellence: planning, optimizing and integrating online marketing. Routledge.						
	Homburg, C/Stock-Homburg, R. (2011): Theoretische Perspektiven der Kundenzufriedenheit, in: Homburg, C.						
	(Hrsg.), Kundenzufriedenheit: Konzepte, Methoden, Erfahrungen, Wiesbaden, 8. Auflage.						
	Stock-Homburg, R. (2011), Der Zusammenhang zwischen Mitarbeiter- und Kundenzufriedenheit: Direkte, indirekte und moderierende Effekte, Wiesbaden, 5. Auflage.						
	Digital Innovation Markating						
	Stock-Homburg R M Heald S I Holthaus C Gillert N I & von Hinnel F (2021) Need Solution Pair						
	Recognition by Household Sector Individuals: Evidence and a Cognitive Mechanism Explanation Research						
	Policy, 50(8), 104068, Source: Trott, P. (2012), Innovation Management and New Product Development, 5th						
	edition, Harlow.						
	Hauser, J., Tellis, G. J., Griffin, A. (2006), Research on Innovation: A Review and Agenda for Marketing Science, Marketing Science, 25(6), 687-717.						
	von Hippel, E. (2005), Democratizing Innovation, Cambridge, Kapitel 9-11.						
	Garcia, R., & Calantone, R. (2002). A Critical Look at Technological Innovation Typology and Innovativeness						
	Terminology: A Literature Review. Journal of Product Innovation Management, 19(2), 110-132.						
	Leifer et al. (2000), Radical Innovation: How Mature Companies can Outsmart Upstarts, Harvard Business						
	School Press, Boston						
	Further literature will be announced in the lasture						
	Further literature will be announced in the lecture.						
Co	urses						
	Course nr. Course name						
1	01 17 0005 mm Disital Bus dust and Comiss Manhating						

Gourse III.	Course nume						
01-17-0005-vu	17-0005-vu Digital Product and Service Marketing						
Instructor	Туре	SWS					
Prof. Dr. Dr. Ruth	Lecture and practice	2					
Course nr.	Course name						
01-17-0007-vu	Digital Innovation Marketing						
Instructor		Туре	SWS				
Prof. Dr. Dr. Ruth	Lecture and practice	2					
	01-17-0005-vu Instructor Prof. Dr. Dr. Ruth Course nr. 01-17-0007-vu Instructor Prof. Dr. Dr. Ruth	01-17-0005-vu       Digital Product and Service Marketing         Instructor       Prof. Dr. Dr. Ruth Stock-Homburg         Course nr.       Course name         01-17-0007-vu       Digital Innovation Marketing         Instructor       Prof. Dr. Dr. Ruth Stock-Homburg	Ourse nil     Ourse nilline       01-17-0005-vu     Digital Product and Service Marketing       Instructor     Type       Prof. Dr. Dr. Ruth     Stock-Homburg       Course nr.     Course name       01-17-0007-vu     Digital Innovation Marketing       Instructor     Type       Prof. Dr. Dr. Ruth     Stock-Homburg				

Mo Ma	dule name							
<b>Mo</b>	<b>dule nr.</b> 01-0M05	<b>Credit points</b>	Workload	Self-study	Module du	iration	Module cyc	<b>cle</b>
Lar Ger	iguage man	0.01	100 11	Module owner	1 101111		livery benne	
1	Teaching co Specific topi	<b>ntent</b> cs in a focus area lav	v and economics o	or informations ma	nagement.			
2	<ul> <li>After the course/s the students are able to <ul> <li>identify a specific topic in the fields of business studies, economics or law or information management and elaborate it by means of scientific methods.</li> <li>research, identify and exploit relevant literature (particularly research literature in English).</li> <li>structure the topic and establish a line of arguments.</li> <li>evaluate pros and cons in a comprehensible way.</li> <li>record the results according to scientific criteria.</li> <li>present the topic to the group and discuss it.</li> </ul> </li> </ul>							
3	<ul> <li>Recommended prerequisites for participation</li> <li>Background knowledge: see initial skills and defined by individal examiner and announced in advance.</li> </ul>							
4	Form of examination         Course related exam:         • [01-01-0M01-se] (Technical examination, Presentation, Default RS)         Supplement to Assessment Methods         Written paper and presentation (participation in discusson)							
5	Prerequisite Passing the I	e for the award of c	redit points					
6	Grading Course relate • [01-01	ed exam: -0M01-se] (Technica	al examination, Pr	esentation, Weight	ing: 100 %)			
7	Usability of M.Sc. Wirtsc ment, M.Sc.	<b>the module</b> haftsingenieurwesen Logistics and Supply	, M.Sc. Wirtschaft y Chain Managem	sinformatik, M.Sc.	Entrepreneu	rship and	l Innovation N	Manage-
8	Grade bonu	s compliant to §25	(2)					
9	<ul> <li>9 References</li> <li>Bänsch, A.: Wissenschaftliches Arbeiten: Seminar- und Diplomarbeiten</li> <li>Theissen, M.R.: Wissenschaftliches Arbeiten: Technik, Methodik, Form</li> <li>Thomson, W.: A Guide for the Young Economist - Writing and Speaking Effectively about Economics</li> </ul>							
Coι	ırses							
	<b>Course nr.</b> 01-01-0M01	-se   Course name Master Semina	ar					
	Instructor				1	<b>Гуре</b> Seminar		SWS 2

Mo Pro	<b>dule name</b> ject Managen	ient							
<b>Mo</b>	<b>dule nr.</b>	Credit points	Workload	Self-study	Module duration	Module cycle			
Lan	Language     Module owner       Englich     Prof. Dr. rer. pol. Andreas Pfpür								
1	<ul> <li><b>Teaching content</b>         Project management I: Basics of planning and decision making for projects, project goals, generation of project alternatives, separation basics in configuration management, project definition, program - portfolio, stake-holder management and communication, quality management, scope and change management, human re-sources management for projects / project managers         Project management II: Strategic goals, separation and linking of projects; project portfolio planning; multi project management; organizational structures of multi project management; tools to select project alterna-tives; tools for project controlling; project management as professional service.     </li> </ul>								
2	<ul> <li>2 Learning objectives         After the course students are able to         <ul> <li>understand the strategic goals of project management, the methods of choosing realization alternatives and the methods of project controlling</li> <li>understand the various subsystems of project management (e.g. Configuration Management, Human Resource Management, Stakeholder Management, Risk Management)</li> <li>understand the principles, methods and organization of multi project management</li> </ul> </li> </ul>								
3	Recommended prerequisites for participation Prerequisites: none Previous Knowledge: see initial skills								
4	<ul> <li>Form of examination         Module exam:         <ul> <li>Module exam (Technical examination, Oral/written examination, Default RS)             Supplement to Assessment Methods             Oral/written: Type and duration of exam are announced by the beginning of the course             Written: exam (duration 60 - 90 minutes)         </li> </ul></li></ul>								
5	Prerequisite Passing the l	e <b>for the award of c</b> Examination	redit points						
6	Grading Module exar • Modul	n: e exam (Technical ex	amination, Oral/	written examinatio	n, Weighting: 100 %	)			
7	Usability of M.Sc. Wirtsc ment, M.Sc.	<b>the module</b> haftsingenieurwesen Logistics and Supply	, M.Sc. Wirtschaft ⁄ Chain Managem	sinformatik, M.Sc. I ent	Entrepreneurship and	I Innovation Manage-			
8	Grade bonu	s compliant to §25	(2)						
9	<b>References</b> Project Mana 5th Edition Further liter	agement Institute (20 ature will be announ	013): A Guide to t aced in the lecture	he Project Manage	ment Body of Knowle	edge (PMBOK Guide)			
<b>Co</b> ι	irses								

<b>Course nr.</b> 01-19-0001-vu	<b>Course name</b> Project Management I		
Instructor		<b>Type</b> Lecture and practice	<b>SWS</b> 2
<b>Course nr.</b> 01-19-0003-vu	<b>Course name</b> Project Management II		
<b>Instructor</b> Prof. Dr. Alexand	ler Kock	<b>Type</b> Lecture and practice	SWS 2

Module name						
Module nr. Credit points		Workload	Self-study	Module duration	Module cycle	
01-14-1B01 5 CF		150 h	60 h	1 Term	Every Semester	
<b>Language</b> German			<b>Module owner</b> Prof. Dr. rer. pol. Reiner Quick			
1	Teaching contentFinancial Accounting: Fundamentals of accounting and bookkeeping, inventory, balance sheet, recording of assets and debt, recording of expenses and revenues, selected transactions (sales and purchases, non-current assets, current assets, accruals, wage and salary, distribution of earnings), annual closing entry.Financial Reporting: Fundamentals of accounting based on the rules of the German Commercial Code (HGB), accounting concepts, purpose of accounting, bookkeeping, inventory, recognition and measurement of assets and liabilities, income statement, notes, management report.					
2	<ul> <li>Learning objectives</li> <li>After the course students are able to <ul> <li>understand the core principles of bookkeeping, inventory and preparation of the balance sheet</li> <li>book stocks and profit</li> <li>solve specific bookkeeping problems in the fields of sales and purchases, non-current and current assets, accruals, wage and salary, distribution of earnings</li> <li>understand of the steps prior to the preparation of annual financial statements according to the German Commercial Code (HGB)</li> <li>analyze of the recognition and measurement of assets and liabilities</li> <li>understand of Income statements, notes and management reports</li> <li>solve accounting cases in the context of the German Commercial Code (HGB)</li> </ul> </li> </ul>					
3	Recommended prerequisites for participation Prerequisites: none Previous Knowledge: see initial skills					
4	<ul> <li>Form of examination</li> <li>Module exam: <ul> <li>Module exam (Technical examination, Written examination, Duration: 90 Min., Default RS)</li> <li>Module exam (Study achievement, Oral/written examination, Duration: 45 Min., Default RS)</li> </ul> </li> <li>Supplement to Assessment Methods: <ul> <li>The academic achievement needs to be passed to take part in the module exam.</li> </ul> </li> </ul>					
5	Prerequisite for the award of credit points Passing the Examination					
6	<ul> <li>Grading</li> <li>Module exam:</li> <li>Module exam (Technical examination, Written examination, Weighting: 2)</li> <li>Module exam (Study achievement, Oral/written examination, Weighting: 1)</li> </ul>					
7	<b>Usability of the module</b> B.Sc. Wirtschaftsingenieurwesen, B.Sc. Wirtschaftsinformatik					
8	Grade bonus compliant to §25 (2)					
9	<b>References</b> Quick, R./ Wurl, HJ: Doppelte Buchführung, 2. Aufl., Wiesbaden: Gabler. Quick, R./Wolz, M.: Bilanzierung in Fällen. 4. Auflage. Schäffer Poeschel, Stuttgart Further literature will be announced in the lecture.					
Co	urses					
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	<b>Course nr.</b> 01-14-0001-vu	Course name Bookkeeping				
	Instructor Prof. Dr. rer. pol.	Reiner Quick	<b>Type</b> Lecture and practice	SWS 2		
	<b>Course nr.</b> 01-14-0003-vu	<b>Course name</b> Financial Accounting				
	Instructor Prof. Dr. rer. pol.	Reiner Quick	<b>Type</b> Lecture and practice	<b>SWS</b> 2		
	<b>Course nr.</b> 01-14-0001-tt	Course name Bookkeeping				
	Instructor Prof. Dr. rer. pol.	Reiner Quick	<b>Type</b> Tutorial	<b>SWS</b> 1		
	<b>Course nr.</b> 01-14-0003-tt	<b>Course name</b> Financial Accounting				
	Instructor Prof. Dr. rer. pol. Reiner Quick		<b>Type</b> Tutorial	<b>SWS</b> 1		

Mo	dule name	value added patrucel						
Ma	dule nr.	Credit points	Workload	Self-study	Module d	luration	Module cyc	cle
01-	12-0B02	4 CP	120 h	75 h	1 Term		Every Seme	ester
Lar Ger	n <b>guage</b> man			Module owner Prof. Dr. rer. pol.	Ralf Elbert	:		
1	Teaching co The student internationa business leve of organizat networks) a the fundam introduction	ontent s get an overview of l management will be el, strategic analysis, s ion and organization re discussed. Regard entals of planning an to simulation model	the management of covered as well as strategic managem al design (structur ing methodologic and decision-makin ling is provided to	of value-added net strategy and strate ent in multinationa al and procedural of al knowledge for th og (decision theorie the students.	works. The gy design (s ll companie organization ne manager es and deci	fundame strategy de s). Furthe n, organiza nent of va sion techn	ntals and the esign at compa rmore, fundar ation of interr lue-added ne niques) as we	ories of any and mentals national etworks, 11 as an
2	<ul> <li>After the course students are able to <ul> <li>reproduce basic knowledge on the management of value-added networks</li> <li>apply basic knowledge for the management of value-creating networks in practical situations</li> <li>apply different decision techniques in real-world examples establish links between the basic knowledge on the management of value-added networks and further courses in business economics</li> <li>reproduce the concepts of strategy design conveyed at different levels and to apply them in the context of practice</li> <li>understand and reproduce different models for structural and procedural organization</li> </ul> </li> </ul>							
3	<ul> <li>Recommended prerequisites for participation</li> <li>Prerequisites: none</li> <li>Previous Knowledge: see initial skills</li> </ul>							
4	Form of exa Module exa • Modul	<b>amination</b> m: e exam (Technical ex	xamination, Writte	en examination, Du	iration: 90	Min., Def	ault RS)	
5	<b>Prerequisit</b> Passing the	e for the award of c	redit points					
6	Grading Module exa • Modul	m: e exam (Technical ex	xamination, Writte	en examination, Wo	eighting: 10	00 %)		
7	Usability of B.Sc. Wirtsc	<b>the module</b> haftsingenieurwesen	, B.Sc. Wirtschaft	sinformatik				
8	Grade bonu	is compliant to §25	(2)					
9	<b>References</b> Further liter	ature will be annour	nced in the lecture					
Co	ırses							
	<b>Course nr.</b> 01-12-0001	vu Management o	of value-added net	tworks				
	<b>Instructor</b> Prof. Dr. rer	pol. Ralf Elbert				<b>Type</b> Lecture		SWS

Mo	Module name Human Resources Management								
<b>Mo</b> 01-	<b>dule nr.</b> 17-1036	Credit points 3 CP	Workload 90 h	Self-study 45 h	Module duration	Module cycle Every Semester			
Lar Ger	<b>iguage</b> man			Module owner Prof. Dr. Dr. Ruth Stock-Homburg					
1	Teaching co	ontent							
	<ul> <li>Basics of human resource management</li> <li>Selected approaches to the design of employee flow systems</li> <li>Selected approaches to the design of reward systems</li> <li>Embedding of personnel management in the company</li> <li>New challenges of personnel management (e.g. digital work, robots as team colleagues, boreout)</li> <li>2 Learning objectives</li> </ul>								
2	<ul> <li>Learning objectives</li> <li>After the courses the students are able to <ul> <li>understand and explain the fundamentals of human resource management.</li> <li>classify and critically evaluate selected approaches to the design of employee flow systems.</li> <li>classify and critically evaluate selected approaches to the design of reward systems.</li> <li>understand and explain new challenges in human resource management.</li> <li>classify the concepts discussed with regard to their relevance in corporate practice.</li> </ul> </li> </ul>								
3	<b>Recommend</b> Prerequisites Previous Kno	<b>led prerequisites fo</b> s: none owledge: see initial s	<b>or participation</b> kills and basics in	business administr	ration				
4	Form of exa Module exar • Module	<b>mination</b> n: e exam (Technical ex	amination, Writte	en examination, Du	ıration: 90 Min., Defa	ault RS)			
5	Prerequisite Passing the I	e for the award of c Examination	redit points						
6	Grading         Module exam:         • Module exam (Technical examination, Written examination, Weighting: 100 %)								
7	Usability of B.Sc. Wirtsc	<b>the module</b> haftsingenieurwesen	, B.Sc. Wirtschaft	sinformatik					
8	Grade bonu	s compliant to §25	(2)						
9	References								

	Compulsory Reading: Stock-Homburg, R. & Groß, M. (2019), Personalmanagement: Theorien - Konzepte - Instrumente, 4. Auflage, Wiesbaden. Kapitel: 1, 3-6, 8-9, 12-13, 15,18-19.					
	<ul> <li>Further Reading:</li> <li>Baruch, Y. (2004), Managing Careers: Theory and Practice, Harlow.</li> <li>Gmür, M., Thommen, JP. (2007), Human Resource Management: Strategien und Instrumente für Führungskräfte und das Personalmanagement, 2. Auflage, Zürich.</li> <li>Mondy, R. W. D., &amp; Martocchio, J. J. (2015). Human Resource Management, Global Edition. Pearson Education Limited.</li> <li>Junker, A. (2018). Grundkurs Arbeitsrecht (17., neu bearbeitete Auflage). Verlag C.H. Beck.</li> <li>Further literature will be announced in the lecture.</li> </ul>					
Coi	urses					
	<b>Course nr.</b> 01-17-0003-vu	Course name Human Ressources Management				
	InstructorTypeSWSProf. Dr. Dr. Ruth Stock-HomburgLecture and practice3					

Mo Sus	<b>dule name</b> stainable Man	agement						
<b>Mo</b> 01-	<b>dule nr.</b> 42-0M02/6	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module duration 1 Term	Module cycle Every Semester		
Lar Ger	<b>nguage</b> rman			<b>Module owner</b> Prof. Dr. jur. Jani	ne Wendt			
1	<ul> <li>Sustainability and corporate law - definitions and implications of sustainability: conceptualisation through the Brundtland Report as well as the Rio Earth Summit and follow-up summits; conceptual consolidation and Agenda 2030; central features of the concept of sustainability - corporate law as an obstacle or promoter of sustainability - significance of the corporate governance discussion - the shareholder value model: criticism and alternative models - corporate law promotion of sustainability: sustainability and executive remuneration; social responsibility (CSR), supply chain legislation in Germany and Europe; climate change litigation; sustainable finance and social entrepreneurship</li> <li>Sustainability Management: Sustainability and Corporate Social Responsibility: Approaches, Opportunities and Challenges for Companies - Sustainability-oriented Management Systems: Quality, Environmental and Energy Management Systems as well as Social Standards and Social Responsibility - Integrated Management Systems - Sustainability Reporting - Sustainability Supply Chain Management - Relations to Corporate Governance and Compliance Management - Implementation of Sustainability Management in Companies: Guest lectures from corporate practice</li> </ul>							
2	<ul> <li>covertaince and compliance management - implementation of sustainability management in companies. Guest lectures from corporate practice</li> <li>2 Learning objectives <ul> <li>After the course students are able to</li> <li>distinguish and derive different definitions and conceptualisations of sustainability,</li> <li>assess whether corporate law can be judged as an obstacle or a promoter of sustainability,</li> <li>present criticism and alternative models of the shareholder value model,</li> <li>present different approaches to corporate law promotion of sustainability, including regulation of executive remuneration, social responsibility (CSR) and supply chain legislation in Germany and Europe,</li> <li>discuss the main features of climate change litigation,</li> <li>classify Sustainable Finance and Social Entrepreneurship,</li> <li>understand the tasks, objectives and problems of sustainability management in companies</li> <li>assess the design, opportunities and challenges of management systems</li> <li>assess the possibilities and limitations of the different instruments of quality and environmental management</li> <li>critically analyze approaches from business practice</li> </ul> </li> </ul>							
3	<b>Recommen</b> Prerequisite Previous Kn	<b>ded prerequisites fo</b> s: none owledge: see initial s	<b>or participation</b> kills					
4	Form of exa Module exa • Modul Supplement Oral/written Written: exa Oral: team of	amination m: le exam (Technical ex to Assessment Meth n: Type and duration am (duration 60 - 90 or individual exam (d	kamination, Oral/ ods of exam are anno minutes) luration 15 - 20 m	written examinatic ounced by the begin inutes per particip	n, Default RS) nning of the course ant)			
5	Prerequisite Passing the	e for the award of c	redit points					
6	Grading							

1	Module exam:								
	• Module exam (Technical examination, Oral/written examination, Weighting: 100 %)								
7	Usability of the module M.Sc. Wirtschaftsingenieurwesen, M.Sc. Wirtschaftsinformatik, M.Sc. Entrepreneurship and Innovation Manage- ment, M.Sc. Logistics and Supply Chain Management								
8	Grade bonus co	mpliant to §25 (2)							
9	ReferencesMittwoch, Nachhaltigkeit und Unternehmensrecht (2022)Ahsen, A. von; Bradersen, U.; Loske, A.; Marczian, S. (2015): Umweltmanagementsysteme. In: Kaltschmitt, M.;Schebek, L. (Hrsg.): Umweltbewertung für Umweltingenieure, Berlin, Heidelberg, S. 359-402.Baumast, A.; Pape, J. (Hrsg.): Betriebliches Nachhaltigkeitsmanagement, 2. Aufl., Stuttgart 2022Further literature will be announced in the lecture.								
Co	urses								
	<b>Course nr.</b> 01-14-0010-vu	<b>Course name</b> Sustainability Management							
	Instructor		<b>Type</b> Lecture and practice	SWS 2					
	<b>Course nr.</b> 01-42-0006-vu	<b>Course name</b> Sustainability and Corporate Law							
	<b>Instructor</b> Prof. Dr. jur. Jani	ne Wendt	<b>Type</b> Lecture and practice	SWS 2					

## 2.10 Optional Subjects AIS-TE: Technology

Mo Mic	Module name Microelectronic Devices								
<b>Mo</b> 18-	<b>dule nr.</b> pr-1030	Credit points 4 CP	Workload 120 h	Self-study 75 h	Module duration	Module cycle Winter term			
Lar	nguage			Module owner Prof Dr rer nat	Sascha Preu				
1	Teaching co	ontent			busenu i reu				
	<ol> <li>Introduction: Semiconductor Devices &amp; Microelectronic</li> <li>Semiconductor: Materials, Physics &amp; Technology</li> <li>PN-Junction</li> <li>Metal-Oxide-Semiconductor Capacity</li> <li>Schottky Contact</li> <li>MOS-Field-Effect-Transistor (MOSFET)</li> <li>CMOS: Digital Applications</li> <li>MOS-Memory</li> <li>Bipolar- Junction-Transistor</li> <li>Outlook: Scaling Limits &amp; SET,</li> </ol> 2 Learning objectives								
2	<ul> <li>Learning objectives         Upon completion of the module, students will have developed an understanding of             <ul></ul></li></ul>								
3	<b>Recommend</b> Electrical Er Laboratory F	<b>ded prerequisites fo</b> agineering and Infor ETiT, Laboratory Elec	or participation mation Technolog tronics, Mathema	gy I, Electrical Eng tics I, Mathematics	ineering and Inform II, Physics	ation Technology II,			
4	Form of exa Module exa • Modul	mination n: e exam (Technical ex	xamination, Exam	ination, Duration:	90 Min., Default RS)				
5	Prerequisite Passing the f	e for the award of c	redit points ation						
6	Grading         Module exam:         • Module exam (Technical examination, Examination, Weighting: 100 %)								
7	<b>Usability of</b> BSc ETiT	the module							
8	<b>Grade bonu</b> Yes	s compliant to §25	(2)						
9	References								

Skript: Microelectronic devices - the Basics

- 1. Robert F. Pierret: Semiconductor Device Fundamentals, ISBN 0201543931
- 2. Roger T. How, Charles G. Sodini: Microelectronics an Integrated Approach, ISBN 0135885183
- 3. Richard C. Jaeger: Microelectronic Circuit Design, ISBN 0071143866
- 4. Y. Taur, T.H. Ning, Fundamentals of Modern VLSI Devices, ISBN 0521559596
- 5. Thomas Tille, Doris Schmidt-Landsiedel: Mikroelektronik, ISBN 3540204229
- 6. Michael Reisch: Halbleiter-Bauelemente, ISBN 3540213848

## Courses

0	11565			
	<b>Course nr.</b> 18-pr-1030-vl	Course name Microelectronic Devices		
	Instructor Prof. Dr. rer. nat. Sascha Preu		<b>Type</b> Lecture	SWS 2
	<b>Course nr.</b> 18-pr-1030-ue	<b>Course name</b> Microelectronic Devices		
	<b>Instructor</b> Prof. Dr. rer. nat.	Sascha Preu	<b>Type</b> Practice	<b>SWS</b> 1

Mo Pro	dule name	ment Methodology I						
Mo	dule nr.	Credit points	Workload	Self-study	Module	duration	Module cy	cle
18- Lar	sa-1010	8 CP	240 h	180 h Module owner	1 Term		Winter tern	n
Ger	rman			Prof. Dr. Mario Kupnik				
1	<b>Teaching co</b> Practical exp	ontent perience in the metho	ods used for the d	evelopment of tech	nical prod	ucts. Work	in a project	team.
2	After successful completion of the modul, students are able to apply development methodologies to a concrete development project in a team. They can create a schedule, analyze the state of the art, write a list of requirements, abstract a task and work out sub-problems. They can search for solutions using different solution methods, develop optimal solutions using evaluation methods and derive a reaonable overall concept. The students have learned to derive the required parameters needed by calculation and modeling. They can create manufacturing documentation with all necessary documents such as parts lists, technical drawings and circuit diagrams, carry out the construction and examination of a laboratory sample and reflect retrospectively on the development carried out.							
3	3 Recommended prerequisites for participation							
4	<ul> <li>Form of examination         Module exam:         <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)             Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.         </li> </ul> </li></ul>							
5	Prerequisite Passing the	e for the award of c	<b>redit points</b> ation					
6	Grading Module exa • Modul	m: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting:	100 %)		
7	Usability of BSc ETiT, BS	<b>the module</b> Sc WI-ETiT						
8	Grade bonu	is compliant to §25	(2)					
9	<b>References</b> Script: Deve	lopment Methodolog	gy (PEM)					
Co	urses							
	<b>Course nr.</b> 18-sa-1010-	pj <b>Course name</b> Product Develo	opment Methodol	ogy I				
	Instructor Prof. DrIng Quoc Khanh	g. Klaus Hofmann, F , Prof. Dr. Mario Kup	Prof. Ph.D. Thoma onik	as Burg, Prof. DrI	ng. Tran	<b>Type</b> Project se	eminar	SWS 4

Mo Pro	Module name Product Development Methodology II								
Мо	dule nr.	Credit points	Workload	Self-study	Module	duration	Module cyc	cle	
18-	sa-1020	5 CP	150 h	105 h	1 Term		Summer ter	rm	
<b>Lar</b> Ger	<b>iguage</b> man			Module owner Prof. DrIng. Klaus Hofmann					
1	<b>Teaching co</b> Practical exp teamwork, w team and or	ontent periences by using m erbal and written rep ganize the developm	nethodical proced presentation of res eent process indep	ures in the develog sults and the organ endently.	oment of t ization of o	echnical p developme	roducts. In a nt. Work in a	ddition project	
2	2 Learning objectives Applying the development methodology to a specific development project in a team. To do this, students can create a schedule, can analyze the state of the art, can compose a list of requirements, can abstract the task, can work out the sub-problems, can seek solutions with different methods, can work out optimal solutions using valuation methods, can set up a final concept, can derive the parameters needed by computation and modeling, can create the production documentation with all necessary documents such as bills of materials, technical drawings and circuit diagrams, can build up and investigate a laboratory prototype and can reflect their development in retrospect.								
3	3         Recommended prerequisites for participation           Product Development Methodology I								
4	<ul> <li>Form of examination Module exam:</li> <li>Module exam (Study achievement, Oral/written examination, Default RS) Beport and/or Presentation. The type of examination will be appounded in the beginning of the lecture</li> </ul>								
5	Prerequisite Passing the	e for the award of c	<b>redit points</b> ation						
6	Grading Module exan • Modul	n: e exam (Study achie	vement, Oral/writ	tten examination, V	Veighting:	100 %)			
7	Usability of B.Sc etit, B.S	<b>the module</b> Sc iST, B.Sc. WI-etit,	M.Sc MedTec						
8	Grade bonu	s compliant to §25	(2)						
9	References Script: Deve	lopment Methodolog	gy (PEM)						
Coi	ırses								
	<b>Course nr.</b> 18-sa-1020-	<b>Course name</b> pj Product Develo	opment Methodol	ogy II					
	Instructor Prof. DrIng Quoc Khanh	g. Klaus Hofmann, P , Prof. Dr. Mario Kup	Prof. Ph.D. Thoma onik	s Burg, Prof. DrI	ng. Tran	<b>Type</b> Project se	eminar	<b>SWS</b> 3	

Mo Pro	Module name Product Development Methodology III								
Мо	dule nr.	Credit points	Workload	Self-study	Module	duration	Module cyc	cle	
18-	sa-2010	5 CP	150 h	105 h	1 Term		Winter tern	n	
Lar Ger	<b>iguage</b> man			<b>Module owner</b> Prof. Ph.D. Thomas Burg					
1	<b>Teaching co</b> Practical exp teamwork, v team and or	ontent periences by using m erbal and written rep ganize the developm	nethodical proced presentation of res lent process indep	ures in the develop sults and the organ endendly.	pment of t isation of o	echnical p developme	roducts. In a nt. Work in a	ddition project	
2	2 Learning objectives Applying the development methodology to a specific development project in a team. To do this, students can create a schedule, can analyze the state of the art, can compose a list of requirements, can abstract the task, can work out the sub-problems, can seek solutions with different methods, can work out optimal solutions using valuation methods, can set up a final concept, can derive the parameters needed by computation and modeling, can create the production documentation with all necessary documents such as bills of materials, technical drawings and circuit diagrams, can build up and investigate a laboratory prototype and can reflect their development in retrospect.								
3	3 Recommended prerequisites for participation Product Development Methodology I								
4	<ul> <li>Form of examination Module exam: <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> <li>Beport and/or Presentation. The type of examination will be appounded in the beginning of the lecture</li> </ul></li></ul>								
5	<b>Prerequisite</b> Passing the f	e for the award of c	<b>redit points</b> ation						
6	Grading Module exar • Modul	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting:	100 %)			
7	<b>Usability of</b> M.Sc. etit, M	<b>the module</b> I.Sc iST, M.Sc. MedT	ec, M.Sc. WI-etit						
8	Grade bonu	s compliant to §25	(2)						
9	References Script: Deve	lopment Methodolog	gy (PEM)						
Coι	ırses								
	<b>Course nr.</b> 18-sa-2010-	<b>Course name</b> pj Product Develo	opment Methodol	ogy III					
	<b>Instructor</b> Prof. DrIng Quoc Khanh	. Klaus Hofmann, P , Prof. Dr. Mario Kup	Prof. Ph.D. Thoma onik	s Burg, Prof. DrI	ng. Tran	<b>Type</b> Project se	eminar	<b>SWS</b> 3	

Mo Pro	Module name Product Development Methodology IV								
Мо	dule nr.	Credit points	Workload	Self-study	Module	duration	Module cyc	cle	
18-	sa-2060	5 CP	150 h	105 h	1 Term		Summer ter	rm	
<b>Lar</b> Ger	n <b>guage</b> man			Module owner Prof. DrIng. Tran Quoc Khanh					
1	<b>Teaching co</b> Practical exp teamwork, v team and or	<b>ntent</b> periences by using m erbal and written rep ganize the developm	nethodical proced presentation of res lent process indep	ures in the develop sults and the organi endently.	oment of t ization of o	echnical p developme	roducts. In a nt. Work in a	ddition project	
2	2 Learning objectives Applying the development methodology to a specific development project in a team. To do this, students can create a schedule, can analyze the state of the art, can compose a list of requirements, can abstract the task, can work out the sub-problems, can seek solutions with different methods, can work out optimal solutions using valuation methods, can set up a final concept, can derive the parameters needed by computation and modeling, can create the production documentation with all necessary documents such as part lists, technical drawings and circuit diagrams, can build up and investigate a laboratory prototype and can reflect their development in retrospect.								
3	3 Recommended prerequisites for participation Product Development Methodology I								
4	<ul> <li>Form of examination         Module exam:         <ul> <li>Module exam (Study achievement, Oral/written examination, Default RS)</li> <li>Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.</li> </ul> </li> </ul>								
5	<b>Prerequisite</b> Passing the f	e <b>for the award of c</b> inal module examina	<b>redit points</b> ation						
6	<b>Grading</b> Module exar • Module	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Veighting:	100 %)			
7	<b>Usability of</b> M.Sc etit, M	<b>the module</b> Sc iST, M.Sc. MedTe	ec						
8	Grade bonu	s compliant to §25	(2)						
9	References Script: Deve	lopment Methodolog	gy (PEM)						
Coi	ırses								
	<b>Course nr.</b> 18-sa-2060-j	j Course name Product Develo	opment Methodol	ogy IV					
	18-sa-2060-pj       Product Development Methodology IV         Instructor       Type       SWS         Prof. DrIng. Klaus Hofmann, Prof. Ph.D. Thomas Burg, Prof. DrIng. Tran       Project seminar       3         Ouoc Khanh, Prof. Dr. Mario Kuppik       3       3								

Mo Fou	<b>dule name</b> ndations of P	recision Engineering						
<b>Mo</b>	<b>dule nr.</b> bu-1010	Credit points	Workload 180 h	Self-study	Module duration	Module cyc Winter terr	cle	
Lar Ger	i <b>guage</b> man			Module owner Prof. Ph.D. Thom	as Burg			
1	1 Teaching content Precision engineering enables the repeatable integration of microelectronic and mechanical components with sensors and actuators to create dense and complex electromechanical systems. The applications range from mass products such as smartphones or cars to precision prototypes in medical technology, spaceflight, and scientific instrumentation. The course introduces the principles of design and manufacturing for precision with critical dimensions in the micrometer to millimeter range. Manufacturing methods including casting, molding, sintering, 3D printing, forming, cutting, etching, and joining will be explained. The properties, composition, and modifications of materials (metals and alloys, ceramics, polymers, composites) will be discussed in the context of key manufacturing processes.							
2	<b>Learning objectives</b> To be able to classify and explain the most important maufacturing technologies, and to critically assess their respective advantages and disadvantages. To select suitable manufacturing technologies and to design for their application. To make quantitative estimates of the limitations of a given process and to evaluate the potential of new developments based on your knowledge of physical principles and materials							
3	Recommen	ded prerequisites fo	or participation					
4	Form of exa Module exam • Modul The examination less than 6 s will be annot	amination m: e exam (Technical ex ation takes place in for tudents, the examination ounced at the beginni	xamination, Oral/ form of a written e ation will be an ora ing of the course.	written examinatic xam (duration: 90 al examination (du	n, Duration: 90 Mir minutes). If enrolln ration: 30 min.). Th	n., Default RS) nent is expecte e type of exam	ed to be	
5	Prerequisite Passing the	e for the award of c	<b>redit points</b> ation					
6	Grading Module exa • Modul	m: e exam (Technical ex	xamination, Oral/	written examinatio	n, Weighting: 100 9	%)		
7	<b>Usability of</b> BSc ETiT, M	the module Sc MEC, MSc WI-ET	iT					
8	Grade bonu	is compliant to §25	(2)					
9	References Lecture note	es, Moodle course						
Coi	ırses							
	<b>Course nr.</b> 18-bu-1010-	Course namevlTechnology of	Micro- and Precis	ion Engineering			1	
	InstructorTypeSWSProf. Ph.D. Thomas Burg, M.Sc. Niko FaulLecture2					SWS		

<b>Course nr.</b> 18-bu-1010-ue	Course nr.Course name18-bu-1010-ueFoundations of Precision Engineering				
<b>Instructor</b> Prof. Ph.D. Thom	as Burg, M.Sc. Niko Faul	<b>Type</b> Practice	<b>SWS</b> 1		
Course nr.Course name18-bu-1010-prFoundations of Precision Engineering Lab			·		
Instructor Prof. Ph.D. Thom	as Burg	<b>Type</b> Internship	<b>SWS</b> 1		

Se	odule name nsor Techniqu	e						
<b>M</b> o 18	odule nr. -kn-2120	Credit points 4 CP	Workload 120 h	Self-study 75 h	Module duration 1 Term	Module cycle Winter term		
La Ge	<b>nguage</b> rman	1		<b>Module owner</b> Prof. Dr. Mario K	upnik	1		
1	<b>1 Teaching content</b> The module teaches basic principles of different sensors and the required knowledge for correct application of sensors. With regard to the measurement chain, the focus of the course is on the conversion of any, generally non-electrical quantities into electrically evaluable signals. Resistive, capacitive, inductive, piezoelectric, optical, and magnetic measurement principles are covered in the module to provide knowledge of the measurement of important quantities such as force, torque pressure, acceleration, velocity, displacement, and flow. In addition to a phenomenological description of the principles and a derived technical description, the main elements of primary and secondary electronics for each measurement principle will also be presented and understood. In addition to the measurement principles, the description of errors will be dealt with. In addition to static and dynamic errors, errors in signal processing and error consideration of the entire measurement chain will be discussed. In the exercises the method of peer instruction is utilized.							
2	Learning objectives The Students acquire knowledge of the different measuring methods and their advantages and disadvantages. They can understand error in data sheets and descriptions interpret in relation to the application and are thus able to select a suitable sensor for applications in electronics and information, as well process technology and to apply them correctly.							
3	Recomment Measuring T	<b>ded prerequisites fo</b> Technique	r participation					
4	Form of exa Module exa • Modul	amination m: le exam (Technical ex	amination, Exam	ination, Duration:	90 Min., Default RS)			
5	Prerequisite Passing the	e for the award of c final module examina	r <b>edit points</b> ation					
6	Grading Module exa • Modul	m: le exam (Technical ex	amination, Exam	ination, Weighting	: 100 %)			
7	Usability of MSc ETiT, N	<b>the module</b> ISc WI-ETiT, MSc ME	EC, MSc Medizinte	echnik				
8	Grade bonu	is compliant to §25	(2)					
9 Co	References         • Slide set of lecture         • Script of lecture         • Textbook Tränkler "Sensortechnik", Springer         • Exercise script							

Course nr.Course name18-kn-2120-vlSensor Technique			
<b>Instructor</b> Prof. Dr. Mario K	Jupnik	<b>Type</b> Lecture	<b>SWS</b> 2
<b>Course nr.</b> 18-kn-2120-ue	Course name Sensor Technique		
<b>Instructor</b> Prof. Dr. Mario Kupnik		<b>Type</b> Practice	<b>SWS</b> 1

Mo Intr	dule name	Printing and Additiv	e Manufacturing					
<b>Mo</b> 16-	<b>dule nr.</b> 17-3253	Credit points 4 CP	Workload 120 h	<b>Self-study</b> 90 h	Module dura 1 Term	ation	Module cy Every 2. Se	<b>cle</b> mester
Lar Ger	<b>iguage</b> man		1	<b>Module owner</b> Prof. Dr. Edgar D	örsam			
1	<b>Teaching co</b> Terminology, workflow and	ntent process chains, proc d data models, pote	cess types, industri ntial	al technologies, ma	terials, design	, engin	eering streng	th, data
2	<ul> <li>Learning objectives <ul> <li>On successful completion of this module, students should be able to:</li> <li>1. Explain all terms of 3D-Printing and Additive Manufacturing.</li> <li>2. Follow through with a systematic comparison of alternative production methods.</li> <li>3. Analyze the influence of the materials on the quality of products.</li> <li>4. Explain the design demands of 3D-parts.</li> <li>5. Distinguish important aspects of CAD models and voxel models.</li> <li>6. Show and discuss the potentials of Additive Manufacturing.</li> </ul> </li> </ul>							
3	<b>Recommended prerequisites for participation</b> Recommended modules are: 16-09-5010 Production Technology, 16-08-3241/5251 Material Science & Engineering I and II, 16-07-3011 Information and Communication Technology in Mechanical Engineering and 16-07-5020 Computer Aided Design.							
4	Form of exa Module exan • Module Facultative ( Will be anno etc.).	mination n: e exam (Technical e: written 90 min or or unced at the beginni	xamination, Oral/ ral exam 30 min) ng of the term dep	written examinatio ending on the circu	n, Default RS) ımstances (nu	) mber o	f students, pa	Indemic
5	<b>Prerequisite</b> Passing the e	<b>for the award of c</b> examination	redit points					
6	Grading Module exam • Module	n: e exam (Technical e:	xamination, Oral/	written examinatio	n, Weighting:	100 %	)	
7	Usability of WP Bachelor	the module MB						
8	Grade bonu	s compliant to §25	(2)					
9	References The current	lecture notes can be	downloaded from	the moodle web p	ages while the	e semes	ster is in sess	ion.
Cot	Course nr.	Course name	D Drinting and A	ditivo Monufacture	ina			
	Instructor	<sup>vi</sup>   introduction 3			Ty	pe ecture		SWS 2

Mo Ligl	<b>dule name</b> hting Technol	ogy I						
<b>Mo</b> 18-1	<b>dule nr.</b> kh-2010	Credit points 6 CP	Workload 180 h	Self-study 120 h	Module duration	Module cy Winter terr	<b>cle</b> n	
Lan Ger	<b>iguage</b> man			<b>Module owner</b> Prof. DrIng. Tra	n Quoc Khanh			
1	<b>Teaching content</b> Structure and functionality of the human eye, terms and unit in lighting technology, photometry, radiometric and photometric properties of materials, filters, physiology of vision, colour theory, lighting, light sources. Measurement of luminous flux, luminous intensity, illuminance, luminance, determination of the spectral responsivity function of the human eye, colorimetry colour rendering, colour as traffic signals, measuring of optical material characteristics. LED properties							
2	<ul> <li>2 Learning objectives On completion of the module students will have learned the following: <ul> <li>To list and connect terms, units and radiometric and photometric properties of materials in lighting technology</li> <li>to describe and understand structure and functionality of the human eye and the physiology of vision <ul> <li>to illustrate basics of lighting, measuring methods and application.</li> </ul> They are able to measure base items in lighting technology, applying knowlegde of lighting and enhance them with experiments and have developed a better understanding for light and color. </li> </ul></li></ul>							
3	<b>Recommend</b> MSc ETiT, M	<b>led prerequisites fo</b> Sc Wi-ETiT, MSc MI	or participation					
4	Form of exa Module exar • Modul	<b>mination</b> n: e exam (Technical ex	xamination, Oral e	examination, Durat	ion: 30 Min., Defa	ult RS)		
5	<b>Prerequisite</b> Passing the f	e for the award of c	<b>redit points</b> ation					
6	Grading Module exar • Modul	n: e exam (Technical e:	xamination, Oral e	examination, Weigh	nting: 100 %)			
7	<b>Usability of</b> MSc ETiT, M	<b>the module</b> Sc Wi-ETiT, MSc MF	EC					
8	Grade bonu	s compliant to §25	(2)					
9	<b>References</b> Script for lec Excersiseboo	ture: Lighting Techi k: laboratory: lighti	nology I ng technology I					
<u></u> <u> </u> <u> </u> <u> </u> Cot	ırses							
	<b>Course nr.</b> 18-kh-2010-	Course namevlLighting Techn	nology I					
	InstructorTypeSWSDrIng. Babak ZandiLecture2				SWS 2			

<b>Course nr.</b> 18-kh-2010-pr	<b>Course name</b> Lighting Technology I		
<b>Instructor</b> DrIng. Babak Za	andi	<b>Type</b> Internship	<b>SWS</b> 2

Mo Adv	<b>dule name</b> /anced Lighting	Technology						
<b>Mo</b>	dule nr. (	Credit points	Workload	Self-study	Module duration	Module cyc Summer ter	c <b>le</b> rm	
Lan Ger	nguage man		100 11	Module owner Prof. DrIng. Tra	n Quoc Khanh			
1	<b>Teaching content</b> Chosen topics in lighting technology - current developments and applications: Street lighting, Physiology: Detektion / Glare / Lighing and Health, LED - Generation of white Light / State of the Art, Modern Methods of Light Measurement, Interiour Lighting, Display Technologies, Non-visual Light Impacts,UV-Applications, Automotive Lighting, Solar Modules							
2	<b>Learning objectives</b> On completion of the module students will have learned the following: They know current developments and applications, list and connect terms, to illustrate special topics of lighting, measuring methods and application. They are able to measure base items in lighting technology, applying knowlegde of lighting and dedicated applications and further to enhance them with experiments. They have developing a better understanding for light, color, perception and lighting situations.							
3	Recommende Lighting Techr	<b>d prerequisites fo</b> ology I	or participation					
4	Form of exam Module exam: • Module e	<b>ination</b> exam (Technical e	xamination, Oral e	examination, Durat	ion: 30 Min., Defaul	t RS)		
5	<b>Prerequisite f</b> Passing the fin	<b>or the award of c</b> al module examin	r <b>edit points</b> ation					
6	Grading Module exam: • Module e	exam (Technical e	xamination, Oral e	examination, Weigh	nting: 100 %)			
7	<b>Usability of th</b> MSc ETiT, MS	i <b>e module</b> c Wi-ETiT, MSc Ml	EC					
8	Grade bonus	compliant to §25	(2)					
9	<b>References</b> Excercisebook	: laboratory: light	ing technology II					
Coi	urses							
	<b>Course nr.</b> 18-kh-2020-vl	Course name Advanced Ligi	nting Technology					
	Instructor Prof. DrIng. 7	ran Quoc Khanh			<b>Type</b> Lecture		SWS 2	
	<b>Course nr.</b> 18-kh-2020-pr	Course name Advanced Lig	nting Technology					
	Instructor Prof. DrIng. 7	ran Quoc Khanh			<b>Type</b> Internshi	p	SWS 2	

Mo Tut	<b>dule name</b> orial in 3D-Pri	nting						
<b>Mo</b> 16-	<b>dule nr.</b> 17-3264	Credit points 4 CP	Workload 120 h	Self-study 60 h	Module of 1 Term	duration	Module cyc Every Seme	<b>cle</b> ester
Lar Ger	<b>iguage</b> man			<b>Module owner</b> Prof. Dr. Edgar D	örsam			
1	Teaching con Classification realization of	ntent of 3D printing in : products; justificat	manufacturing te ion of approach ai	chnology; requiren nd chosen producti	nents; sele on process	ection; woi	kflow; indep	endent
2	<ul> <li>Learning objectives <ul> <li>On successful completion of this module, students should be able to:</li> <li>I. Identify application areas for 3D printing.</li> <li>Choose a suitable 3D printing production process to manufacture parts.</li> <li>Modify part geometry regarding the specific production process.</li> <li>Use common software from the 3D printing workflow.</li> <li>Analyze typical printing errors and modify print parameters.</li> <li>Justify the chosen approach in written form.</li> </ul> </li> </ul>							
3	Recommend Participation	ed prerequisites for of lecture "Introduc	or participation tion 3D-Printing a	and Additive Manu	facturing"			
4	Form of exam Module exam • Module	<b>nination</b> a: e exam (Technical e:	xamination, Speci	al form, Default RS	))			
5	<b>Prerequisite</b> Passing the fi	for the award of c nal module examin	<b>redit points</b> ation					
6	Grading Module exam • Module	n: e exam (Technical e:	xamination, Speci	al form, Weighting	: 100 %)			
7	Usability of	the module						
8	Grade bonus	s compliant to §25	(2)					
9	<b>References</b> Gebhardt, An Verlag GmbH	dreas. 3D-Drucken: Co KG, 2014. http	Grundlagen und A ://www.hanser-el	Anwendungen des A ibrary.com/isbn/97	Additive Ma 783446442	anufacturir 2382	ng (AM). Carl	Hanser
Co	ırses							
	<b>Course nr.</b> 16-17-3264-t	t Course name Tutorial in 3D	-Printing					
	Instructor Type SWS Tutorial 4						SWS 4	

Mo Pro	<b>dule name</b> ject Seminar S	Spintronic Devices							
<b>Mo</b>	dule nr. me-2030	Credit points	Workload	Self-study	Module d	luration	Module cyc	c <b>le</b>	
Lon	anie 2000	0.01	100 11	Modulo ouror	1 Ieiiii		livery beine		
Ger	man/English			Prof Dr rer nat	Markus M	einert			
1	1 Togehing content								
1	In the project seminar, students have the opportunity to deal with various aspects of spintronic devices. These range from the development of measurement systems for the characterization of spintronic devices, to the fabrication and characterization of functional thin film systems, to the lithographic preparation of spintronic sensor devices or memory cell (MRAM) prototypes. Students gain valuable insights into the entire chain of device fabrication from the deposition of atomically thin film systems to their basic characterization and lithography under clean room conditions.								
2	<b>Learning objectives</b> Students learn the basics of fabrication and application of spintronic devices as sensors or magnetic memory cells. Individual projects are carried out in small groups. The students deepen the material learned in the lectures in the form of a project work and learn and deepen their knowledge in the application of electronic measurement technology to answer concrete questions from research and development.								
3	Recommend	led prerequisites fo	or participation						
	<ul><li>Introdu</li><li>Materi</li></ul>	action to Spintronics als of Electrical Engi	(desirable) neering (desirable	2)					
4	Form of exa Module exar • Modul Report and/	<b>mination</b> n: e exam (Study achie or Presentation. The	vement, Oral/wri type of examinat	tten examination, l ion will be announ	Default RS) ced in the l	beginning	of the lecture	e.	
5	<b>Prerequisite</b> Passing the f	e for the award of c	<b>redit points</b> ation						
6	Grading Module exar • Modul	n: e exam (Study achie	vement, Oral/wri	tten examination, V	Weighting:	100 %)			
7	<b>Usability of</b> MSc etit, MS	<b>the module</b> Sc iCE, BSc/MSc iST,	MSc MEC						
8	Grade bonu	s compliant to §25	(2)						
9	References Lecture note	s Introduction to Spi	intronics (Meinert	), subject-specific l	iterature aı	nd publica	tions.		
<b>Co</b> ι	urses								
	<b>Course nr.</b> 18-me-2030	-pj <b>Course name</b> Project semina	ar Spintronic Devi	ces					
	<b>Instructor</b> Prof. Dr. rer	nat Markus Meiner	+			<b>Type</b> Project se	eminar	SWS	