HOCHSCHULE
RHEIN-WAAL
Rhine-Waal University
of Applied Sciences

Handbook of Modules for the Degree Programme

Infotronic Systems Engineering, B.Sc.

Faculty of Communication and Environment

Version 3.4

01.02.2021

Dokumentenhistorie

Version	Datum	Verantw.	Bemerkung
1.0			Erste eingereichte Version für die Akkreditierung
1.1			Version für die Akkreditierung nach Änderungen durch die neuen Kollegen. Anpassung Beschreibung Analog Signal Processing, Embedded Systems, Digital Signal Processing
1.2		CR	Das Pflichtmodul „Fundamentals of Business Adminstration“ wurde in Wahlpflichtmodule umgewandelt, das Modul „Introduction into Accounting and Controlling“ kann aus dem Wahlpflichtkatalog IBSS gewählt werden.
1.3		CR	Stärkung der praktischen Ausbildung durch • „Laborausbildung: Elektrotechnik“ • „Labor: Digitaltechnik und Informatik
1.4		CR	Modul „High Frequency Technology“ entfällt
1.4.1		CR	Modul „Software Engineering“ wurde ergänzt
2.0		CR	Inhaltliche Überarbeitung folgender Module: • CI_1.03 Fundamentals of Digital Technologies • CI_2.04 Computer Networks • CI_4.01 Analog and Digital Signal Processing • CI_4.02 Identification and Automation Geänderte Modulnamen: Alter Name → Neuer Name Advanced Computer Networks & Bus Systems → Computer Networks Analog Signal Processing (50%) → Signals and Systems Analog Signal Processing (50%) → Analog and Digital Signal Processing (50%) Digital Signal Processing → Analog and Digital Signal Processing (50%) Middleware Systems → Programming: Distributed Systems (50%) Programming(50%) → Object Oriented Programming Programming(50%) → Programming: Distributed Systems (50%) Anpassung der Modulnummern.
2.1		CR	Anpassung der Gruppengrößen
2.2		CR	Homogenisierung der Begriffswelten in den Modulbeschreibungen
2.3	27.11.14	TH / CR	Anpassung von Lehrinhalten

2.4	16.12.14	TH / CR	Module ergänzt
2.5	19.01.15	AR	Überschrift geändert (Degree Programm)
2.6	30.06.16	CR	Deckblatt Studiengangsname angepasst
3.0	28.05.2019	CR / SRY	Überarbeitung des Studiengangs im Rahmen der Akkreditierung, inkl. Umstrukturierung
3.1	18.07.2019	CR	Link für Type of assessment zur RPO eingefügt.
3.2	07.12.2020	CR	Anpassungen zur Auflagenerfüllung der Reeakkreditierung durchgeführt: Anpassung des Studiengangsnamen, Darstellung der überfachlichen Kompetenzen, Modul Communication Systems eingefügt, Control Engineering nun Wahlpflicht, genauere Darstellung der stochastischen Modelle, Kapitel Specification of types of assessments detaillierter ausgeführt, Kapitel zu Prüfungsabhängigkeiten eingeführt, Curriculum ausgetauscht, Nummerierung geändert
3.3	18.01.2021	CR	Curriculum: Nicht benutzte Abkürzung T aus Curriculum entfernt. Änderung: Im Wahlpflichtbereich können mit Zustimmung des Prüfungsausschusses maximal 5 CP aus dem gesamtenStudienangebot der Hochschule Rhein-Waal belegt werden (vorher 6 CP, die nicht ins Raster passen).
3.4	25.01.2021	CR	Prüfungsform

Abbreviations

min	Minutes
h	hour(s). 1h = 60 min
TU	Teaching Unit. 1TU = 45 min
SWS	Semester hours per week, describing the amount of TU per week

Specification of the types of assessment

Assessments are regulated in the “general examination regulations for Bachelor’s and Master’s degree programmes at Rhein-Waal University of Applied Science” (RPO Rahmenprüfungsordnung der Hochschule Rhein-Waal). According to RPO there are two types of assessment.

Certificate (according RPO §20) : Certificates are pass/fail without grading. The purpose of certificates is to attest, in particular, the successful completion of exercises, practical courses, laboratories or seminars. Certificates are awarded to students who have demonstrated the ability to apply their acquired knowledge and skills and their proficiency in the use of subject-specific methods. Various documents can serve as proof of completion for certificate requirements, for example experiment records, written analyses of findings, calculations, programming exercises, constructs, design concepts and sketches, oral presentations and technical discussions etc.

Examinations (according RPO §14): The purpose of course examinations is to assess whether students have become proficient in the essential content and methodology of a specific subject area and are able to autonomously and correctly apply their acquired knowledge and skills. Examinations are planned according to learning outcomes and usually take the form of written or electronic examinations (RPO §17, §17b), multiple choice examinations (RPO §17a), oral examinations (RPO §18) or assignments, term papers or projects (RPO §19). A combination thereof is also possible with approval of the Examination Board. For periods abroad considered relevant to the degree programme, a written examination may be substituted for an oral examination with approval of the Examination Board.

According to the examination regulation the Examination Board will generally specify and notify students of the type of examination, as well as of the duration in the case of written examinations, before the start of the corresponding course in consultation with the examiner(s), and in a uniform and binding manner for all participating students. The weight of grading of composite examination types is also announced at the beginning of the semester.

The following assessment scale is used for examinations (RPO §11(3)):

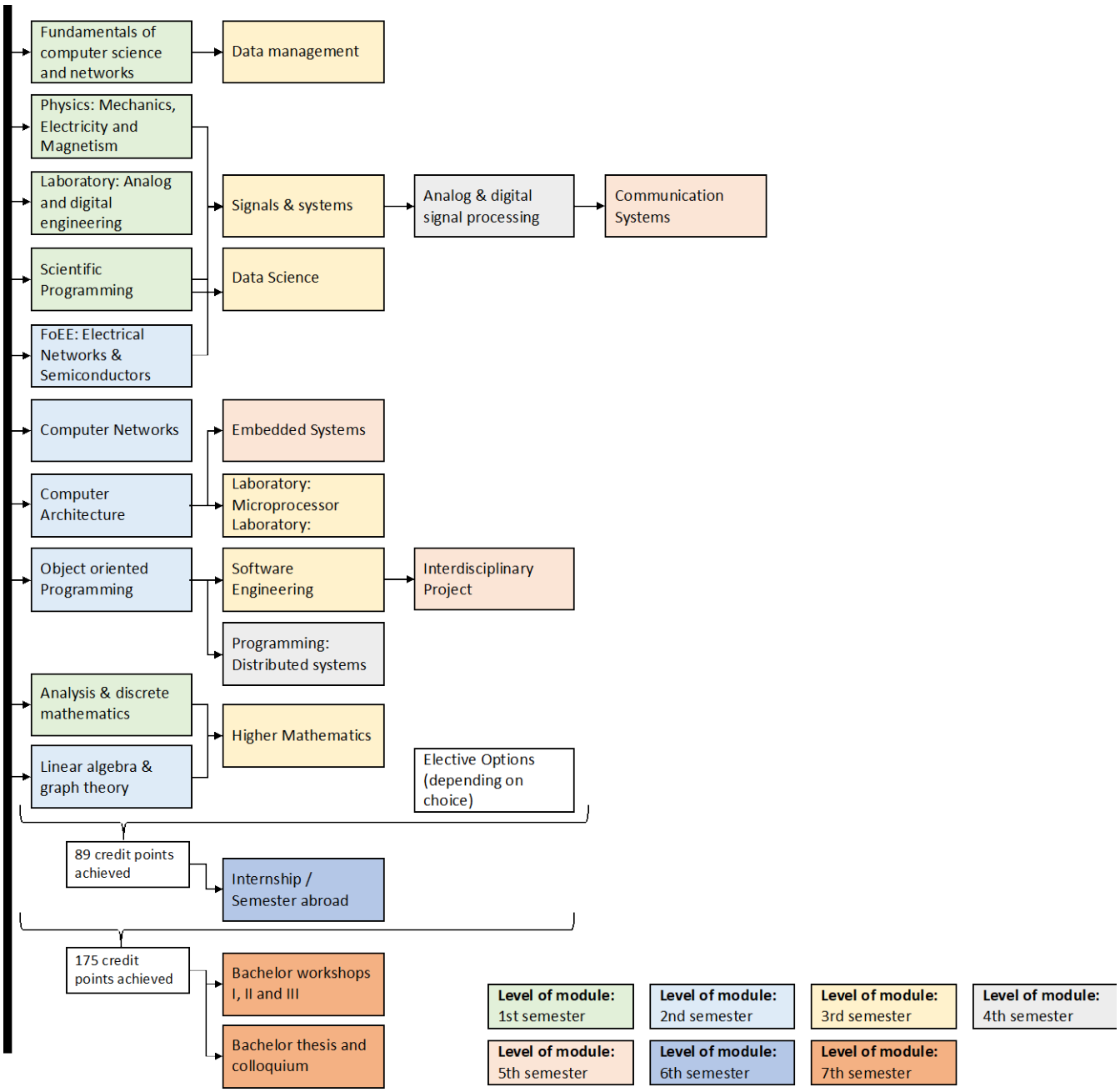
1 = Very Good	= Excellent
2 = Good	= Well above average
3 = Satisfactory	= Average
4 = Sufficient	= Meets all requirements despite shortcomings
5 = Failed	= Does not meet requirements due to significant shortcomings

Marks can be raised or lowered by 0.3 points for more precise assessment; 0.7, 4.3, 4.7 and 5.3 are not valid marks.

In the event of any discrepancy or doubt between the RPO and this document, the RPO version takes precedence.

Dependencies: Formal entry requirements of the non-elective modules

The following figure summarizes the formal dependencies of the non-elective modules according to the provided module descriptions. The dependencies describe the formal entry requirements (passed courses). Beside formal dependencies content dependencies exist, which are considered in the level of the modules.



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Curriculum of the Bachelor Degree Programme "Infotronic Systems Engineering, B.Sc."

Code No (Kennnr.)	Module	SW (SWS)	Type (Veranstaltungsart) L (V)	SL (SL)	S (S)	Ex (Ü)	PT (Pra)	Pro (Pro)	TE (Prü)	Sum CP	WS 1	SS 2	WS 3	SS 4	WS 5	SS 6	WS 7
CI_1.02	Fundamentals of computer science and networks Grundlagen der Informatik und der Computernetzwerke	4	2			2			E	5	4					CI_6.01 Internship or semester abroad (30 CP; TE: C) (Praxis- oder Auslandssemester)	CI_7.01 Workshop 1: Research Methods (Forschungsmethoden) (4 SW; 5 CP, type:S;TE:C) CI_7.02 Workshop 2: Scientific Writing (wissenschaftliches Schreiben) (4 SW; 5CP; type:S; TE: C) CI_7.03 Workshop 3: Advanced Seminar (Hauptseminar) (4 SW; 5 CP; type:S; TE: C) CI_7.04 Bachelor Thesis (Bachelorarbeit) (12 CP) and Colloquium (Kolloquium) (3 CP)
CI_1.05	Analysis & discrete mathematics Analysis und diskrete Mathematik	4	2			2			E	5	4						
CI_1.07	Physics: Mechanics, Electricity and Magnetism Physik: Mechanik, Elektrizität und Magnetismus	10	5			5			E	10	10						
CI_1.08	Laboratory: Analog and digital engineering Laborausbildung: Analoge und digitale Schaltungen	6					6		C	5	6						
CI_1.09	Scientific Programming Wissenschaftliches Programmieren	4	2			2			E	5	4						
CI_2.03	Object Oriented Programming Objektorientierte Programmierung	8	4			2	2		E	10		8					
CI_2.04	Computer Networks Computernetze	4	2				2		E	5		4					
CI_2.05	Linear algebra & graph theory Lineare Algebra und Graphentheorie	4	2			2			E	5		4					
CI_2.07	Fundamentals of Electrical Engineering: Electrical Networks & Grundlagen der Elektrotechnik: Elektrische Netze und	4	2			2			E	5		4					
CI_2.08	Computer Architecture Computerarchitektur	4	2			2			E	5		4					
CI_3.02	Signals & Systems Signale und Systeme	4	2			2			E	5			4				
CI_3.03	Data Management Datenmanagement	4	2			2			E	5			4				
CI_3.06	Higher Mathematics Höhere Mathematik	4	2			2			E	5			4				
CI_3.07	Software Engineering Software Engineering	4	2			2			E	5			4				
CI_3.08	Laboratory: Micorprocessor Laboratory Laborausbildung: Mikroprozessortechnik	4					4		C	5			4				
CI_3.09	Data Science Data Science	4	2			2			E	5			4				
CI_4.01	Analog and digital signal processing Analoge und digitale Signalverarbeitung	8	4			2	2		E	10				8			
CI_4.03	Programming: Distributed Systems Programmierung: verteilte Systeme	6	2			2	2		E	5				6			
	Elective key competences Wahlfach: Schlüsselkompetenz	4		4					C	5				4			
	Elective Option 1 Wahlpflichtkurs 1	4	2			2			E	5				4			
	Electicve Option 2 Wahlpflichtkurs 2	4	2			2			E	5				4			
CI_5.01	Embedded Systems Embedded Systems	4	2				2		E	5					4		
CI_5.02	Communication Systems Nachrichtentechnische Systeme	4	2			2			E	5					4		
CI_5.03	Interdisciplinary Project Interdisziplinäres Projekt	6						6	E	10					6		
	Elective Option 3 Wahlpflichtkurs 3	4	2			2			E	5					4		
	Elective Option 4 Wahlpflichtkurs 4	4	2			2			E	5					4		
	Semester hours per week (total)	124								150	28	24	24	26	22	30	30

SWS: 124, CP: 150 SWS: 12, CP:60

				Total	WS 1	WS 2	WS 3	WS 4	WS 5	WS 6	WS 7
				SWS: 136, CP: 210							
Allocation	CH (SWS)	total	136		28	24	24	26	22	0	12
	CP	total	210		30	30	30	30	30	30	30

Key Competences Options

Code No (Kennnr.)	Elective Key Competences Module	SW (SWS)	TE (Prü)	Sum CP
CI_K.01	Project Management Projektmanagement	4	C	5
CI_K.02	Foreign Language Fremdsprache	4	C	5

Elective Options / Wahlpflichkatalog *,**

Code No (Kennnr.)	Elective Module	SW (SWS)	TE (Prü)	Sum CP
CI_W.01	Ambient Intelligent Systems Ambient Intelligent Systems	4	E	5
CI_W.03	Communication Security Sicherheit in Kommunikationssystemen	4	E	5
CI_W.05	Advanced Modelling and Simulation Fortgeschrittene Modellierung und Simulation	4	E	5
CI_W.06	Fundamentals of Business Administration Grundlage der Betriebswirtschaft	4	E	5
CI_W.07	Parallel Programming Parallel Programming	4	E	5
CI_W.08	Innovative Technologies Innovative Technologien	4	E	5
CI_W.09	Control Engineering Steuerungs- und Regelungstechnik	4	E	5
CI_W.10	Machine Learning Machine Learning	4	E	5
CI_W.11	Drone Technology and Application Dohnentechnologie und Ihre Anwendung	4	E	5

*Im Wahlpflichtbereich können mit Zustimmung des Prüfungsausschusses maximal 5 CP aus dem gesamten Studienangebot der Hochschule Rhein-Waal belegt werden. / As elective subjects, a maximum of 5 CP can be chosen with the consent of the examination committee from any study programme at the Rhine-Waal University of Applied Sciences.

**Die Fakultät behält sich das Recht vor eine Mindestteilnehmerzahl für das Zustandekommen eines Wahlpflichtkurses festzulegen oder eine Veranstaltung organisationsbedingt zu verschieben. Die Möglichkeit des Erreichens der vorgeschriebenen Kreditpunktanzahl aus dem Wahlpflichtbereich bleibt unberührt./ The faculty reserves the right to determine a minimum number of participants for offering an elective subject and to postpone single subjects because of organisational issues. The possibility to obtain the required number of credit points remains unaffected.

CI_1.02 Fundamentals of computer science and networks

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_1.02	150 h	5 CP	1st semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 33.75 h / 3 SWS Exercises: 11.25 h / 1 SWS	45 h / 60 TU	105 h	Lectures: open Exercises: 50 students

Learning outcomes / Competences and qualifications profile

This module has introduced students to the key principles of computers and networks. Successful students have gained the ability to identify major hardware and software components of a computer system, to understand their relationship to one another and the importance of these components within the system. They are also able to convert numbers from different numeral systems, which are frequently used by computer systems, and can express conditions and causality using binary logic.

Furthermore students have gained an understanding of how computer networks work. They are able to explain the ISO/OSI reference model and IP traffic and can set up small networks independently.

In addition to the addressed computing science competencies, students have understood the importance of privacy and data protection for individual persons and society

Content

- Example for today's use of computers in different environments

- Basic principles: number systems, representation of text, combinational logic

- Hardware of a computer system, incl. CPU, motherboard, storage devices, RAID and backup systems

- Introduction to operating systems, incl. common operating systems

- Computer networks: network classifications, ISO/OSI reference model, layers of IP networks, network devices, basic security

- The importance of privacy, data protection and security

Teaching methods

Tuition in seminars, lectures and practical classes
Entry requirements None
Types of assessment Graded examination
Requirements for the award of credit points Passed examination
Use of module (in other study programs) Same module in "Communication and Information Engineering" and "Mobility and Logistics"
Weight towards final grade 3,33 %
Person in charge of module Prof. Dr. Christian Ressel
Additional information Reading: Clements, A.:Principles of COMPUTER HARDWARE, ISBN 978-0-19-927313-3, Oxford University Press, 2006 (4th edition Mafield,C.: Bebop - to the boolean boogie,ISBN 1856175073, Newnes, 2008 (3rd. edition) Tannenbaum,A.: Computer Networks, ISBN 0130661023, Prentice Hall, 2002 (4th. edition) Muller, J.-M. et al.: Handbook of Floting Point Arithmetic, ISBN 081764704X, Springer, 2009 Brent, R. P.; Zimmermann, P.: Arithmetic (Cambridge Monograph on Applied and Computational Mathematics), ISBN 0521194695, Cambridge University Press, 2010

CI_1.05 Analysis and discrete mathematics

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_1.05	150 h	5 CP	1st semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 SWS Exercises: 22.5 h / 2 SWS	45 h / 60 TU	105 h	Lectures: open Exercises: 40 students

Learning outcomes / Competences and qualifications profile

This lecture introduced students to the basics of Discrete Mathematics and fundamental topics of Analysis. Students will have learned how to use Analysis to solve practical problems linked to engineering and logistics.

With the knowledge of the mathematical methods and formulas students can solve analytical problems based on discrete or continuous functions and are able to apply their knowledge to their professional context as analysts, planners or engineers.

Additionally, students are able to develop advanced solutions to describe and optimize technological functionalities in a mathematical way by using basic trigonometric functions as well as main formulas and procedures of differential and integral calculus.

Content

- Fundamentals of set theory, sets of numbers
- Complex numbers, Cartesian coordinates, polar coordinates
- Definition and calculation of limits, rule of L'Hôpital
- Fundamental functions - polynomial -, potential -, exponential, logarithm -, and - trigonometric functions
- Properties and graphs of functions, continuity, differentiability
- One- and two-dimensional differential calculus, partial derivatives, Hessian Matrix
- Taylor series, extremal points, applications
- Integral calculus, anti-derivatives, definite and indefinite integrals

- Partial integration, integration by substitution, calculating areas and surfaces
Teaching methods Tuition in lectures and practical classes
Entry requirements None
Types of assessment Graded examination
Requirements for the award of credit points Passed examination
Use of module (in other study programs) Same module in "Communication and Information Engineering" and "Mobility and Logistics"
Weight towards final grade 3,33 %
Person in charge of module Prof. Dr. Agatha Kalhoff
Additional information Literature: Brown, Arlen, Pearcy, Carl: An Introduction to Analysis, Springer, 1995 Marco Baronti, Filippo de Mari, Robertus van der Putten, Irene Venturi: Calculus Problems, Springer, 2016 James Stewart: Calculus, Early Transcendentals, International Metric Edition, 6th Edition, BrooksCole, 2008; ISBN-13: 9780495382737 Gerald Teschl, Susanne Teschl: Mathematik für Informatiker, Bd. 2 Analysis und Statistik, 2. Auflage, Springer, 2007

CI_1.07 Physics: Mechanics, electricity and magnetism

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_1.07	300 h	10 CP	1st semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 56.25 h / 5 SWS Exercises: 56.25 h / 5 SWS	112.5 h / 150 TU	187.5 h	Lectures: open Exercises: 50 students

Learning outcomes / Competences and qualifications profile

This module has introduced students to key principles of Physics. The successful student is able to apply and use the physical concepts, laws and equations he has learned in advanced modules and in his or her professional life. After passing this module the student is able to describe simple motion mathematically, can decompose forces, and has a sound understanding of the physical concepts work, energy and power. The student has understood the principal of energy conservation and is able to solve given tasks concerning the topics mentioned above. The student is also able to describe simple harmonic oscillation/waves, calculate the natural frequency of simple oscillating systems, has a sound understanding of period and wave length and is able to solve basic tasks including superpositioning of waves. Furthermore students know fundamental principles in the topic of electricity and magnetism. Students understand simple electric circuits with passive components such as resistors, capacitors and inductors. The students are familiar with alternating current and have understood the principles of induction.

Content

- Physical quantities and units
- 1 D and 3D Motion
- Newton's laws and forces
- Friction and drag forces
- Work, energy and power
- Linear momentum and collisions
- Circular motion and angular momentum
- Oscillations and waves

- Electrical charges and Coulomb's law
- Electrostatic field, electrical flux and Gauss's law
- Electrostatic potential energy and electric potential
- Capacitance
- Electrical current, Ohm's law, resistance, electrical power
- Kirchhoff's laws
- Introduction to Network Analysis: Nodal analysis
- Magnetism and Sources of the magnetic field
- Magnetic circuits
- Induction
- Electrical RC and RL Circuits
- AC circuits: Impedences, Phasors
- Power in AC systems and power adjustment
- Transformer

Teaching methods

Lectures and practical classes

Entry requirements

None

Types of assessment

Graded examination

Requirements for the award of credit points

Passed assessment

Use of module (in other study programs)

Same module in "Environment and Energy" and "Communication and Information Engineering"

Weight towards final grade

6,67 %

Person in charge of module

Prof. Dr. Christian Ressel

Additional information

Reading:

Tipler P.A.; Mosca G. (2007): Physics for Scientists and Engineers. Enlarged 6th Edition; W.H. Freeman.

Halliday D.; Resnick R.; Walker J. (2010): Fundamentals of Physics. 9th Edition; Wiley, John & Sons.

W.D. Stanley, J.R. Hackworth, R.L. Jones: Fundamentals of electrical engineering and technology", Delmar Cangage Learning, New York, 2007.

Hambley, A.R.;Electrical Engineering: Principles and Applications; 5th Edition, Pearson.

R. Kories, H. Schmidt-Walter: Electrical Engineering -A pocket reference, Springer, Berlin,2003

CI_1.08 Laboratory: Analog and digital engineering

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_1.03	150 h	5 CP	1st semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Laboratories: 67.5 h / 6 SWS	67.5 h / 90 TU	82.5 h	Practical classes: 24 students

Learning outcomes / Competences and qualifications profile

Students are experienced in handling real electrical components and basic measurement equipment. They are able to use software to develop and test electrical circuits. They have gained fundamental mechanical skills. Furthermore Students have gained first experience in simulate circuits. They are able to read and to make use of data sheets and use digital components to realize basic functionalities. They can realize first functions by using a microcontroller based board.

Content

- Introduction to the physical concepts of current, electric potential, power
- Basic measurement techniques
- Using an Oscilloscope
- Circuit design and applications with basic logic gates and sequential logic elements
- Microcontroller basics
- Circuit design for standard I/O microcontroller interfaces
- Basics of Electronic Assembly and Packaging
- Basic characteristic diagrams of passive and active electronic components
- Circuit design with passive components
- Circuit design with active components
- Circuit design with CAD-Tools

Teaching methods

Lectures, accompanied by exercises in which case studies and problems in practice are presented
Entry requirements None
Types of assessment Certificate (Testat)
Requirements for the award of credit points Successful participation in 80 % of all lessons offered
Use of module (in other study programs) –
Weight towards final grade None (ungraded)
Person in charge of module Prof. Dr. Christian Ressel
Additional information Reading: Clements, A.: Principle of Computer Hardware, ISBN 978-0-19-927313-3, Oxford University Press (4th edition) S. Salivahanan and S. Arivazhagan: Digital Electronics, Vikas Publishing House, 2011 Hill, C. W. L. (2009): International Business. Competing in the Global Marketplace. 7th edition. New York: McGraw-Hill.

CI_1.09 Scientific programming

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_1.09	150 h	5 CP	1st semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 semester hours per week (SWS) Exercises: 22.5 h / 2 SWS	45 h / 60 TU	105 h	Lectures: open Exercises: 40 students

Learning outcomes / Competences and qualifications profile

This module introduces students to the basic principles of scientific programming. Understanding successful students the importance of programming in the engineering sciences. They are familiar with the basic principles and different programming paradigms. They have knowledge in identifying and formulating problems that need to be identified with their own software. They are able to solve simple data conversion, analysis and modeling problems and know the basic principles of digital data processing. They can apply the learned methods in different contexts.

Due to the discussions with and the continuous feedback from fellow students (and the lecturer) students have strengthen their abilities of critical self-reflection, to have a professional argument about technical approaches or scientific topics. Besides they train their presentation skills, to look at approaches from different perspectives and learn to accept critical discussions as part of the scientific process.

Content

Examples for **today's use of computers in engineering**

Introduction to programming (e.g. in Python)

- The core python language (Python shell, IPython Notebook, …)

- Simple Plots (with pylab and matplotlib)

- NumPy, SciPy

- introduction to OOP

Basic principles: number representation and errors

Solving simple numerical problems, e.g.

- linear and nonlinear equations

- numerical differentiation

- numerical integration

- curve fitting and interpolation

handling data

Teaching methods

Tuition in seminars, lectures and practical classes

Entry requirements

None

Types of assessment

Graded examination

Requirements for the award of credit points

Passed assessment

Use of module (in other study programs)

Open to students of other study programs, EE_1.05 “Fundamentals of scientific programming”

Weight towards final grade

3,33 %

Person in charge of module

Prof. Dr. Frank Zimmer

Additional information

Reading:

Chapra, S.C.; Canale, R.P.: Numerical Methods for Engineers, ISBN 978-0073397924, McGraw-Hill Education – Europe, 7th ed., 2014

Gilat, A.; Subramaniam, V.: Numerical Methods for Engineers and Scientists: An Introduction with Applications Using MATLAB, ISBN 978-1118554937, John Wiley & Sons Inc., 3rd ed., 2013

Jones, O.; Maillardet, R.; Robinson, A.: Introduction to Scientific Programming and Simulation Using R, ISBN 978-1466569997, CRC Press, Taylor & Francis Group, Boca Raton, FL, 2nd new edition, 2014

Hill, C.: Learning Scientific Programming with Python, ISBN 978-1107428225, Cambridge University Press, 2016

Langtangen, H.P.: A Primer on Scientific Programming with Python, ISBN 978-3662498866, 5th ed., Springer-Berlin, 2016

Linge, S.; Langtangen, H.P.: Programming for Computations - Python: A Gentle Introduction to Numerical Simulations with Python, ISBN 978-3319324272, Springer, Berlin, 2016

Quarteroni, A. M.; Saleri, F.; Gervasio, P.: Scientific Computing with MATLAB and Octave, ISBN 978-3642453663, 4th edition, Springer, Berlin, 2014

Turner, P.R.; Arildsen, T.; Kavanagh, K.: Applied Scientific Computing: With Python, ISBN 978-3319895741, Springer, Berlin, 2018

Wouwer, A.V.; Saucez, P.; Vilas, C.: Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications, ISBN 978-3319067896, Springer, Berlin, 2014

CI_2.03 Object oriented programming

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_2.03	300 h	10 CP	2nd semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 45 h / 4 SWS Exercises: 22.5 h / 2 SWS Practical classes: 22.5 h / 2 SWS	90 h / 120 TU	210 h	Lectures: open Exercises: 50 students Practical classes: 20 students

Learning outcomes / Competences and qualifications profile

The course has taught students to code fluently in an object-oriented style using the programming language Java. Students have learned to use standard library classes. Successful students have a sound understanding of the principles and practice of object oriented analyses and design in the construction of small robust, maintable programs. They are able to implement, compile, test and run programs, comprising more than one class to address a particular software problem. They are able to use simple data structures like collections and to make use of functionality of classes found in the standard API (such as the Math class).

Content

- IDE introduction and usage, coding styles

- Fundamental programming structures and control structures

- Data Structures including arrays, linked lists, heaps, stacks, queues (including different queuing rules FIFO, LIFO, SIRO, non-preemptive priority, preemptive priority, Round Robin)

- Objects, classes, constructors, attributes, methods, parameters

- Inheritance, polymorphism

- (Multiple) interfaces, abstract classes, adapters

- Exception handling

- Terminal I/O, file I/O

- Threads, Concurrency and related problems

- TCP/IP and UDP/IP socket programming

- Characteristics of an algorithm

- Fundamental algorithms (sorting and searching)

Teaching methods

Lectures and practical classes

Entry requirements

None

Types of assessment

Graded examination and successful participation in practical classes

Requirements for the award of credit points

Passed assessment

Use of module (in other study programs)

–

Weight towards final grade

6,67 %

Person in charge of module

N.N.

Additional information

Reading:

Liang, Y.D.: Introduction to Java programming, Pearson, 2011.

Lafore, R.: Data structures and algorithms in Java, Sams/Pearson, 2003.

Flanagan, D.: Java in a nutshell, O'Reilly, 2005.

Barnes, D.J. & Kölling, M. : Objects First with Java. A Practical Introduction Using BlueJ, Pearson, 2012

Oracle: Java Platform, Standard Edition 8. API Specification. Online available: https://docs.oracle.com/javase/8/docs/api/ (last retrieved Nov 20, 2014

CI_2.04 Computer networks

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_2.04	150 h	5 CP	2nd semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 SWS Exercises: 22.5 h / 2 SWS	45 h / 60 TU	105 h	Lectures: open Exercises: 40 students

Learning outcomes / Competences and qualifications profile

Having completed this module, students understand the architectures of computer networks and relevant factors influencing network operation. They have gained an overview of the reasons for having a variety of different types of protocols and networks. They understand distributed networking systems with focus on Internet technologies and Internet operation. Furthermore, students can analyze protocols and can independently consult standards and technical reports concerning computer networks. Students are able to select and configure network technologies that provide fast and reliable communication.

Content

- Further details on computer network architecture with layers and protocols, the Internet architecture: network of networks

- Finite state machines, message sequence charts, wireshark

- Further details on link layer: link layer services, switched local area networks: link-layer addressing and ARP, multiple access links and protocols, sliding windows, Ethernet

- A closer look on the network Layer: Comparing IPv4 and IPv6, forwarding and routing, virtual circuit and datagram networks, router/switch operation, ICMP, multicast, hierarchical routing, BGP, Autonomous System Number

- IP security issues, IP alternatives, transport protocols and congestion control

- Network management tasks and principles, SNMP, virtual private networks, virtual local area networks (VLAN)-switching, link virtualization, multiprotocol label switching (MPLS), data center networking, software defined networks, Internet-standard management framework: structure of management information: SMI, management information base: MIB, SNMP protocol operations and transport mappings, ASN.1

- Wireless links and network characteristics, 802.11 (WLAN): architecture, MAC protocol, and frames

- Multimedia and VoIP networking: SIP, RTTP, RTSP

- IP security issues

Teaching methods

Lectures and practical classes

Entry requirements

None

Types of assessment

Graded examination

Requirements for the award of credit points

Passed assessment

Use of module (in other study programs)

-

Weight towards final grade

3,33 %

Person in charge of module

N.N.

Additional information

Kurose, J.F. & Ross, K.W. (2013). Computer Networking. A Top-Down Approach, Pearson.

Chappell, L. (2013). Wireshark 101. Essential Skills for Network Analysis, Laura Chappell University.

Tannenbaum, A.S. & Wetherall, D.J. (2011). Computer Networks, Pearson.

Anderson, A. & Benedetti, R. (2009). Head First Networking, O'Reilly.

CI_2.05 Linear algebra and graph theory

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_2.05	150 h	5 CP	2nd semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 SWS Exercises: 22.5 h / 2 SWS	45 h / 60 TU	105 h	Lectures: open Excerises: 40 students

Learning outcomes / Competences and qualifications profile

This lecture has introduced students to mathematical methods of linear algebra and the basics of graph theory which are needed to solve technical and operational problems.

With these mathematical methods and procedures at hand, students are able to solve linear problems and to apply the knowledge to their professional context as analysts, planners or engineers.

Additionally, students are able to develop advanced solutions to describe and optimize networks by applying the basic rules and procedures of graph theory.

Content

Linear Algebra:
- Introduction of vectors, matrices and matrix operations

- Vectors spaces and vector subspaces

- Linear equation systems

- Methods to solve linear equation systems**:** Gaussian Algorithm, Determinants, Inverse matrix

- Eigenvalues and Eigenspaces

Graph Theory:
- Fundamentals of graph theory

- Euler cycles, Hamilton cycles, weighted graphs

- Applications: Traveling Salesman, Postman Problem, Shortest path problem

- Algorithms of Fleury and Dijkstra

Teaching methods Tuition in lectures and practical classes
Entry requirements None
Types of assessment Graded examination
Requirements for the award of credit points Passed examination
Use of module (in other study programs) Same module in "Communication and Information Engineering" and "Mobility and Logistics"
Weight towards final grade 3,33 %
Person in charge of module Prof. Dr. Agatha Kalhoff
Additional information Literature: Reinhard Diestel: Graph Theory, Springer 2017 Belkacem Said-Houari: Linear Algebra, Birkhäuser-Basel, 2017 Seymour Lipschutz 3,000 Solved Problems in Linear Algebra (Schaum's Solved Problems Series) Gerald Teschl, Susanne Teschl: Mathematik für Informatiker, Bd. 1 Diskrete Mathematik und Lineare Algebra, 3. Auflage, Springer 2009

CI_2.07 Fundamentals of electrical engineering: Networks and semiconductors

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_2.07	150 h	5 CP	3rd semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 SWS Exercises: 22.5 h / 2 SWS	45 h / 60 TU	105 h	Lectures: open Exercises: 40 students

Learning outcomes / Competences and qualifications profile

Having passed this module, students know fundamental principles in topics which serves as a basis for the understanding of advanced concepts of subsequent courses. In particular, students are capable of handling and analyzing advanced and complex circuit elements and circuits. Furthermore, students have a profound understanding of the working principles and physics of semiconducter circuit elements and are able to apply typical semiconductor circuit elements for different purposes.

Content

- Thevenin & Norton equivalent circuits
- Network analysis: further methods
- Two Port Networks
- Semiconductors
- Diodes
- Transistors
- Operational Amplifiers

Teaching methods

Tuition in seminars, lectures and practical classes

Entry requirements

None

Types of assessment

Graded examination
Requirements for the award of credit points Passed assessment
Use of module (in other study programs) -
Weight towards final grade 3,33 %
Person in charge of module Prof. Dr. Christian Ressel
Additional information Reading: Bird, J.: Electrical Circuit Theory and Technology, ISBN 0750657847, Newnes publications Alexander, C.K., Saiku, M.: "Fundamentals of electric circuits", ISBN 978-0-07-35295-4, McGraw-Hill Cathey, J: Schaum's outline series - electronic devices and circuits, ISBN 0-07-139830-9, McGraw-Hill Schwarz, Goldham:"Electrical Engineering", ISBN 13978-0-19-510585-8, Oxford University Press

CI_2.08 Computer architecture

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_2.08	150 h	5 CP	2nd semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 SWS Exercises: 22.5 h / 2 SWS	45 h / 60 TU	105 h	Lectures: open Exercises: 40 Students

Learning outcomes / Competences and qualifications profile

CI_2.02 introduces digital design with an emphasis on abstraction as the guiding design principle for mastering complex systems such as a RISC microprocessor. Students learn the principles of digital logic, beginning from transistors, via CMOS circuits and logic gates to combinational and sequential circuits. Boolean Algebra and design techniques like logic minimization, verification, and finite state machine design are covered. In the process of studying the computer architecture of a MIPS processor, participants learn assembly programming using the SPIM simulator. The course concludes with the study of a microarchitecture of the MIPS processor.

Content

- Transistors, CMOS, logic gates
- Hazards in combinational circuits
- Arithmetic circuits
- Sequential circuits, finite state machines
- Assembly programming and machine language
- Microarchitecture of a MIPS processor
- Timing Analysis

Teaching methods

Lectures, exercises, and practical lab sessions

Entry requirements

None

Types of assessment Graded examination
Requirements for the award of credit points Passed assessment
Use of module (in other study programs) –
Weight towards final grade 3,33 %
Person in charge of module Prof. Dr. Volker Strumpen
Additional information Readings: Harris D.M.; Harris S.L. (2007): Digital Design and Computer Architecture. 1st Edition; Morgan Kaufmann.

CI_3.02 Signals and systems

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_3.02	150 h	5 CP	3rd semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 SWS Exercise: 22.5 h / 2 SWS	45 h / 60 TU	105 h	Lectures: open Exercises: 40 students

Learning outcomes / Competences and qualifications profile

CI_3.02 covers the principles and concepts of signal and system analysis. The course emphasizes the distinct advantages of different representations, including block diagrams, differential and difference equations, system functions, and Fourier representations. Basic signals and LTI systems are covered in both continuous and discrete time, as well as the relationships between Fourier, Laplace, and z-transforms, poles and zeros, impulse and step response, and frequency response. Applications such as passive circuit analysis and digital signal processing connect theory with practice.

Content

- Basic signals in continuous and discrete time
- Singularity functions, complex exponentials, and series representations
- Properties of signals and systems, incl. linearity and time invariance
- Convolution sum and integral
- Laplace transform and z-transform
- Fourier representations
- System functions and system response
- Frequency Response
- Sampling and Aliasing

Teaching methods

Lectures, exercises, and practical lab sessions

Entry requirements Students have to pass CI_1.01 “Physics: Mechanics, electricity and magnetism” CI_1.04 “Scientific programming” CI_2.01 “Fundamentals of electrical engineering: Electrical networks and semiconductors” before taking this course.
Types of assessment Graded examination
Requirements for the award of credit points Passed assessment
Use of module (in other study programs) -
Weight towards final grade 3,33 %
Person in charge of module Prof. Dr. Volker Strumpen
Additional information Readings: Oppenheim A.V.; Willsky A.S. (1997): Signals and Systems. 2nd Edition; Pearson.

CI_3.03 Data management

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_3.03	150 h	5 CP	3rd semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 SWS Exercises: 22.5 h / 2 SWS	45 h / 60 TU	105 h	Lectures: open Exercises: 40 students

Learning outcomes / Competences and qualifications profile

After passing this module students are able to make use of abstraction methods in order to transform real world scenarios into database models for various applications. The students are able to select the suitable architectural design for the given model. In addition to that students are familiar with normalization methods and data consitency principles. They can independently express SQL statements to solve complex tasks of database creation, use and maintance. Students have further knownledge about contemporary extensions of traditional database management, such as semantic web, ontologies, big data, data mining and NoSQL databases.

Content

- Introduction: file systems and data base systems, migration from file system, client-server-architecture, data

  base based web-applications

- Abstraction, analysis and modelling methods

- Data models, Entity Relationship Model (ER), Enhanced Entity Relationship Model (primary key, foreign key,

  integrity constraints ...)

- Theoretical fundamentals of relational data bases: relational algebra, functional dependencies, normalization,

- Structured Query Language

- Semantical modelling and data base design, Ontologies, Semantic Web, and other alternative non-centralized storage formats

- No-SQL Databases, Big Data

- Object oriented data bases, data warehouse, data mining, information

- retrieval, search engines

Teaching methods

Lectures and practical classes

Entry requirements

Students have to pass

CI_1.02 “Fundamentals of computer science and networks”

before taking this course.

Types of assessment

Graded examination

Requirements for the award of credit points

Passed assessment

Use of module (in other study programs)

Same module in "Communication and Information Engineering" and "Mobility and Logistics"

Weight towards final grade

3,33 %

Person in charge of module

Prof. Dr. Michael Schwind

Additional information

Reading:
Elmasri, R., Navathe S.: Database Systems, ISBN 0132144980, Pearson, 6th edition, 2014

Barnes, D.J., Kölling, M.: Objects First with Java - A Practical Introduction using BlueJ, Prentice Hall, 5th edition, 2012

Vaish, G.: Getting Started with NoSQL, Packt Publishing, 2013

Robinson, I., Webber, J., Eifrem E.: Graph Databases, O’Reilly, 2nd edition, 2015

CI_3.06 Higher mathematics

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_3.06	150 h	5 CP	3rd semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 SWS Exercises: 22.5 h / 2 SWS	45 h / 60 TU	105 h	Lectures: open Exercises: 40 students

Learning outcomes / Competences and qualifications profile

Students are enabled to use advanced mathematical methods such as fundamental knowledge of vector analysis, complex analysis, Fourier analysis and Laplace transform in given engineering contexts. They are also used to express engineering problems in the language of mathematics and to solve them by using modern calculation and simulation tools such as MATLAB/Octave, R or Python.

Content

Vector Calculus

- Vector differential calculus (grad, div, curl)
- Vector integral calculus (integral theorems)
- Line Integrals
- Surface Integrals
- Gauss's Theorem
- Stokes's Theorem

Coordinate Systems

Distributions

Integral Transforms

- Complex Analysis
- Fourier Analysis

- Discrete Signals

- Discrete Fourier transform in 2D

- Laplace Transform

- z-Transform

Introduction to Differential Equations

- Ordinary differential equations (first order ODEs, second order ODEs, higher order ODEs), using built-in Solvers

- Aspects of partial differential equations

Numerical Analysis

- Fundamental numerical concepts

- Numerics for ODEs and PDEs

Aspects of probability and statistics

Teaching methods

Lectures and practical classes

Entry requirements

Students have to pass

CI_1.05 “Mathematics: Analysis and discrete mathematics”

CI_2.05 “Mathematics: Linear algebra and graph theory”

before taking this course.

Students are expected to have basic knowledge of a modern programming language.

Types of assessment

Graded examination

Requirements for the award of credit points

Passed assessment

Use of module (in other study programs)

Open to students of other study programs

Weight towards final grade

3,33 %
Person in charge of module Prof. Dr. Frank Zimmer
Additional information Reading: Chapra, S.C.; Canale, R.P.: Numerical Methods for Engineers, ISBN 978-0073397924, McGraw-Hill Education – Europe, 7th ed., 2014 Gilat, A.; Subramaniam, V.: Numerical Methods for Engineers and Scientists: An Introduction with Applications Using MATLAB, ISBN 978-1118554937, John Wiley & Sons Inc., 3rd ed., 2013 Kreyszig, E.: Advanced Engineering Mathematics, ISBN 978-8126554232, John Wiley & Sons, 10th ed., 2015 Hill, C.: Learning Scientific Programming with Python, ISBN 978-1107428225, Cambridge University Press, 2016 Quarteroni, A. M.; Saleri, F.; Gervasio, P.: Scientific Computing with MATLAB and Octave, ISBN 978-3642453663, 4th edition, Springer, Berlin, 2014 Stroud, K.A.; Booth, D.J: Engineering Mathematics, ISBN 978-1137031204, Red Globe Press, 7th ed., 2013 Stroud, K.A.; Booth, D.J: Advanced Engineering Mathematics, ISBN 978-0230275485, Red Globe Press, 5th ed., 2011 Turner, P.R.; Arildsen, T.; Kavanagh, K.: Applied Scientific Computing: With Python, ISBN 978-3319895741, Springer, Berlin, 2018

CI_3.07 Software engineering

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_3.07	150 h	5 CP	3rd semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 SWS Exercises: 22.5 h / 2 SWS	45 h / 60 TU	105 h	Lectures: open Exercises: 40 students

Learning outcomes / Competences and qualifications profile

Students have gained an overview of the ten knowledge areas of software engineering as defined by the ACM/IEEE Computer Society Software Engineering Body of Knowledge (IEEE 2013) and have been introduced to selected methods. Students are able to decide which software engineering methods should be applied in different situations. Students are able to evaluate the appropriateness of specific methods in the context of specific organizational setting and software product requirements.

Besides they have discussed and understood the direct and indirect responsibility and effects that comes with the leap of faith provided by society to engineers, computer scientists and technical development.

Content

- Ethical aspects of software engineering, software engineering as a professional discipline and the influence on society.
- Software processes: OMG SPEM, Eclipse Process Framework Composer
- Agile software development: TDD, Scrum
- Requirements engineering
- System modeling, architectural design: UML, Enterprise Architect
- Design Patterns
- Configuration Management, build, continous integrationsoftware factories
- Software testing

Teaching methods

Lectures and practical classes

Entry requirements

Students have to pass

CI_2.04 “Object oriented programming”

before taking this course.

Types of assessment

Graded examination

Requirements for the award of credit points

Passed assessment

Use of module (in other study programs)

-

Weight towards final grade

3,33 %

Person in charge of module

N.N.

Additional information

Reading:

- IEEE Computer Society (2013): Software Engineering Body of Knowledge (SWEBOK V3).

- Sommerville, I. (2011): Software Engineering, Addison-Wesley

- de Marco, T. (2009): Software Engineering: An Idea Whose Time Has Come and Gone?. IEEE Software, July/August 2009.

- ISO/IEC 12207:2008: Systems and software engineering - Software life cycle processes.

- Brooks, F. (1995): The Mythical Man-Month. Addison-Wesley.

CI_3.08 Laboratory: Microprocessor laboratory

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_3.08	150 h	5 CP	3rd semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Laboratories: 45 h / 4 SWS	45 h / 60 TU	105 h	Practical laboratories: 25 students

Learning outcomes / Competences and qualifications profile

CI_3.04 offers an opportunity to practice digital design with hardware description languages (HDL) and field-programmable gate arrays (FPGA). Building upon CI_2.02, students learn to use logic-level simulation for design and verfication of combinational and sequential circuits. The course emphasizes modularization as a the guiding design principle to cope with the complexity of large designs, leading up to the design and synthesis of a microprocessor.

Content

- Hardware description languages (SystemVerilog)
- Simulation, Testing, and Verification
- Combinational circuits
- Arithmetic circuits
- Sequential circuits, finite state machines
- Logic-level description of a microprocessor
- Synthesis for FPGAs
- Timing Analysis

Teaching methods

Practical lab sessions

Entry requirements

Students have to pass

CI_2.02 “Computer architecture”

before taking this course.
Types of assessment Graded examination
Requirements for the award of credit points Passed assessment
Use of module (in other study programs) -
Weight towards final grade None (ungraded)
Person in charge of module Prof. Dr. Volker Strumpen
Additional information Readings: Harris D.M.; Harris S.L. (2013): Digital Design and Computer Architecture. 2nd Edition; Morgan Kaufmann.

CI_3.09 Data science

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_3.09	150 h	5 CP	3rd semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 SWS Exercises: 22.5 h / 2 SWS	45 h / 60TU	105 h	Lectures: open Exercises: 40 students

Learning outcomes / Competences and qualifications profile

Students are familiar with a programming language (e.g. Python or R) and they can write well-structured programs and modules for data analysis using the libraries covered. Students can get an overview of data and describe its properties. They are trained in basic mathematical and statistical concepts and methods in the context of data science and can apply them in different areas. They are able to find meaningful numerical representations for different data sets and to manipulate them compactly and efficiently. They can apply the learned methods in different contexts.

Content

Introduction and Motivation

Data Science as an **Interdisciplinary Scientific Field**

Mathematical and Statistical Foundations

- Probability, Descriptive Statistics, Correlation Analysis, Statistical Analysis (Statistical Distributions, Sampling, Significance, Permutation Tests and P-values, Bayesian Reasoning, …)

- Logarithm, Linear Algebra

- Mathematical Models, Modelling of stochastic dependencies (like Queueing theory, Markov chain etc.)

Data Handling

- Collecting and Loading Data

- Cleaning and Manipulating Data

-Visualizing and Describing Data

Methods and Tools **Big Data** **Data Science and Machine Learning**
Teaching methods Tuition in seminars, lectures and practical classes
Entry requirements Students have to pass CI_1.04 “Scientific programming” before taking this course.
Types of assessment Graded examination
Requirements for the award of credit points Passed assessments
Use of module (in other study programs) Open to students of other study programs
Weight towards final grade 3,33 %
Person in charge of module Prof. Dr. Frank Zimmer
Additional information Reading: Bruce, P.; Bruce A.: Statistics for Data Scientists: 50 Essential Concepts, ISBN 978-1491952962, O’Reilly UK Ltd., 2017 Cady, F.: The Data Science Handbook, ISBN 978-1119092940, John Wiley & Sons Inc., 2017 Cielen, D.; Meysman A.D.B.: Introducing Data Science, ISBN 978-1633430037, Manning, 2016

Dinu, J.: Foundations of Data Science: A Practical Introduction to Data Science with Python, ISBN 978-0134398808, Addison Wesley, 2018

Godsey, B.: Think Like a Data Scientist, ISBN 978-1633430273, Manning, 2017

Hill, C.: Learning Scientific Programming with Python, ISBN 978-1107428225, Cambridge University Press, 2016

McKinney, W.: Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython, ISBN 978-1491957660, O'Reilly UK Ltd, 2nd ed., 2017

Skiena, S.S.: The Data Science Design Manual, ISBN 978-3319554433, Springer, Berlin, 2017

VanderPlas, J.: Python Data Science Handbook: Essential Tools for working with Data, ISBN 978-1491912058, O'Reilly UK Ltd., 2016

Wickham, H.; Grolemund, G.: R for Data Science, ISBN 978-1491910399, O'Reilly UK Ltd, 2017

CI_4.01 Analog and digital signal processing

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_4.01	300 h	10 CP	4th semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 45 h / 4 SWS Exercises: 22.5 h / 2 SWS Laboratories: 22.5 h / 2 SWS	90 h / 120 TU	210 h	Lectures: open Exercises: 50 students Laboratories: 25 students

Learning outcomes / Competences and qualifications profile

This module introduces basic concepts and fundamentals of analog and digital signal processing and system characterization. Students learn to represent analog and digital signals in the time and frequency domains, and to apply Fourier, Laplace, and z-transforms to study analog and digital signals and systems. The lectures and emphasize the similarities and differences between the discrete and continuous time domains. The course then focuses on practical filter design, including passive and active analog filters as well as finite and infinite impulse response digital filters. The laboratory complements the theory with hands-on software and hardware design and characterization of filters. The course concludes with the topics of sampling, interpolation, and modulation.

Content

- Signal representations in CT and DT
- LTI systems in CT and DT
- Convolution in CT and DT
- Fourier series and transforms in CT and DT
- Laplace transform and z-transform
- Analog Filter Design, incl. passive and active LC-ladders and Butterworth filters
- Digital FIR and IIR filters
- Sampling and Interpolation
- Modulation in CT and DT

Teaching methods Lectures, exercises, and practical lab sessions
Entry requirements Students have to pass CI_3.02 “Signals and systems” before taking this course.
Types of assessment Graded examination
Requirements for the award of credit points Passed assessments
Use of module (in other study programs) -
Weight towards final grade 6,67 %
Person in charge of module Prof. Dr. Volker Strumpen
Additional information Readings: Oppenheim A.V.; Willsky A.S. (1997): Signals and Systems. 2nd Edition; Pearson. Oppenheim A.V.; Schafer R.W. (2010): Discrete-Time Signal Processing. 3rd Edition; Pearson.

CI_4.03 Programming: Distributed systems

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_4.03	150 h	5 CP	4th semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 SWS Exercises: 22.5 h / 2 SWS Practical Training: 22.5 h / 2 SWS	67.5 h / 90 TU	82.5 h	Lectures: open Exercises: 40 students Practicals: 25 students

Learning outcomes / Competences and qualifications profile

Students have learned to develop complex software systems in Java which are distributed on networked computers. They are skilled in using eclipse or netbeans as integrated development environments. They have experience in using communication middleware systems and in integrating as well as testing of distributed systems. They know architectural patterns for distributed systems and can choose suitable architectural approaches according to environmental requirements. They are familiar with the typical challenges caused by the heterogeneity of enterprise application environments. Middleware systems of various technologies and categories have been practically utilized during exercises.

Content

- JavaDoc, external libraries
- Representation of data (XML, JSON), parsing (SAX)
- Java on Android (anatomy of a simple app)
- Multi-tier architectures
- Classification of middleware: typical requirements and categories
- Enterprise Application Integration (EAI)- Distributed objects (Java RMI), de-/serialization
- Indirect communication (JGroups, Publish Subscribe, Message Queues)
- Enterprise Java Beans, application servers
- Workflow management: process oriented EAI

- Service-oriented architectures

- Web services

- Service orchestration

Teaching methods

Lectures and practical classes

Entry requirements

Students have to pass

CI_2.04 “Object oriented programming”

before taking this course.

Types of assessment

Graded examination

Requirements for the award of credit points

Passed assessment

Use of module (in other study programs)

-

Weight towards final grade

3,33 %

Person in charge of module

N.N.

Additional information

Tanenbaum, A.S. & van Steen, M. (2007). Distributed Systems: Principles and Paradigms, Pearson

Coulouris, G., Dollimore,J., Kindberg, T., & Blair, G. (2012). Distributed Systems: Concepts and Design, Pearson

Papazoglou, M. (2012): Web Services and SOA: Principles and Technology. Pearson

Erl, T. (2007): SOA Principles of Service Design. Prentice Hall International

Fowler, M. (2002). Patterns of Enterprise Application Architecture. Addison-Wesley

Gamma, E. et al. (1994). Design Patterns. Elements of Reusable Object-Oriented Software. Addison-Wesley

CI_5.01 Embedded systems

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_5.01	150 h	5 CP	5th semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 SWS Practical classes: 22.5 h / 2 SWS	45 h / 60 TU	105 h	Lectures: open Practicals: 25 students

Learning outcomes / Competences and qualifications profile

Having passed this module students know fundamental principles of embedded systems with emphasis on microcontrollers (MC). They have been introduced to the programming of MCs and their electrical interfacing in practical classes. Interactions of MCs with the user and the environment have been realized, as well as solutions for the machine-to-machine communication. The students are familiar with common development environments and can solve practical problems of moderate complexity. This introductory course equips students with the basic skills necessary for further acquisition of more sophisticated problems.

Content

- Classification of embedded hardware and typical applications: microcontroller, digital signal processor, field programmable gate array, system on chip, embedded computer

- Embedded systems on a programmable chip using FPGAs

- Internal devices: GPIO, ADC, DAC, Timer, Counter, PWM, DMA

- Digital interfaces: UART , I2C, SPI, 1Wire

- Multi-tasking: interrupt handler, scheduler, real-time kernel, operating system

- Programming in C

- In system debugging

Teaching methods

Tuition in seminars, lectures and practical classes

Entry requirements

Students have to pass

CI_2.02 “Computer architecture” before taking this course. It is expected that students have knowledge of the principle components of a programming language.
Types of assessment Graded examination
Requirements for the award of credit points Passed assessment
Use of module (in other study programs) -
Weight towards final grade 3,33 %
Person in charge of module Prof. Dr. Volker Strumpen
Additional information Reading: Noergaard, T.:"Embedded Architecture", ISBN: 978-0-382196-6, Oxford, Newnes, 2013.

CI_5.02 Communication Systems

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_5.02	150 h	5 CP	5th semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 SWS Exercise: 22.5 h / 2 SWS	45 h / 90 TU	105 h	Lectures: open Exercises: 40 students

Learning outcomes / Competences and qualifications profile

This module introduces communication systems by implementing a complete software defined radio. Students focus on a specific communication system, a pulse-amplitude modulated digital radio, rather than being confronted with an encyclopedic catalog of possible methods employed in communication systems. However, the course covers a complete radio from start to finish, providing students with much of the fundamental knowledge needed to understand modern communications systems in general. The radio is implemented in Matlab/Octave, and challenges students to cope with real world imperfections such as channel noise, multipath interference, phase jitter, frequency inaccuracies, clock errors, etc.

Content

- Software Defined Radio
- Modulation, IF Mixing, Sampling, and Interpolation
- Digital Filter Design
- Information and Entropy
- Source and Channel Coding
- Pulse Shaping and Matched Filters
- Adaptive Methods and Automatic Gain Control
- Carrier Recovery
- Timing Recovery
- Linear Equilization

Teaching methods Tuition in seminars, lectures and exercises
Entry requirements Students have to pass CI_4.01 “Analog and digital signal processing” before taking this course.
Types of assessment Graded examination
Requirements for the award of credit points Passed assessment
Use of module (in other study programs) -
Weight towards final grade 3,33 %
Person in charge of module Prof. Dr. Volker Strumpen
Additional information Readings: Johnson, Jr. C.R.; Sethares W.A., Klein Andrew G. (2011): Software Receiver Design, Cambridge University Press.

CI_5.03 Interdisciplinary project

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_5.03	300 h	10 CP	5th semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Contact time: 67.5h / 6 SWS	67.5 h / 90 TU	232.5 h	open

Learning outcomes / Competences and qualifications profile

In this module students have expanded and deepened the knowledge and skills they have acquired in previous project and modules. The interdisciplinary character of the project encourages students to discover new topics and gather practical experiences in different fields. Having completed this module, students are able to work on questions of theory or praxis in an international and interdisciplinary team. Students of a team have to organize and manage their tasks and results independently. As identified relevant competences - students will train their: communication skills, time and team management skills, structural abilities, reflective abilities, conflict abilities, presentation skills. Besides students get the opportunity to be confronted with and to work on socially relevant topics. They are able to work scientifically and to produce convincing results in their teams

Content

The content differs between projects, depending on the study programs which are involved and the teaching staff's background. Depending on students' knowledge, lectures and workshops concerning different topics will be included so that students can attend different lectures of other degree programmes.

Teaching methods

Sessions for basic information about the project options; project coordination; project counseling provided by teaching staff or project partner from a company; accompanying lectures depending on projects' topics and demand; presentation of results to an interested audience consisting of university staff and students as well as external project partners.

Entry requirements

Students have to pass

CI_3.04 “Software Engineering”

before taking this course.

Types of assessment

Graded examination (depending on topic e.g. project report as well as presentation of results performed in team work.)
Requirements for the award of credit points Project report and presentation of results delivered. Both have to meet quality criteria to pass the module.
Use of module (in other study programs) Same module for all Bachelor study programs of the faculty
Weight towards final grade 6,67 %
Person in charge of module All professors of the faculty
Additional information -

CI_6.01 Internship / Semester abroad

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_6.01	900 h	30 CP	6th semester	Summer or winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
		900 h	open

Learning outcomes / Competences and qualifications profile

The internship has been done in a company, an agency or a research institute in a field related to the degree programme. Students have applied their classroom knowledge in a real world professional environment. They have gained insights into a company and into specific practical fields. During their stays as interns they have worked on different tasks in the companies and have taken on responsibility for certain topics. A descriptions of the projects and of the lessons learned in the internship has to be presented in a scientific report. The internship also offers opportunities to increase knowledge, specialise in a certain field, gain additional qualifications, network, and career management.

Students who opted for a semester abroad have gained intercultural competencies. They have improved their foreign language skills or have even studied a new foreign language, have learned how to get along in a foreign educational system and have worked with other students and teaching staff of different nationalities. Semester abroad reports have to meet criteria of scientific reports. This means that the report also includes areflection on a topic related to the degree programme with a special focus on country-specific features. The topic has to be arranged in advanced and needs to be approved by the supervisor.

Content

Depending on internship company or university abroad. Topics will be discussed beforehand with teaching staff of Rhine-Waal University of Applied Sciences.

Teaching methods

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Entry requirements

89 credit points achieved

Types of assessment

Certificate (Testat)

Requirements for the award of credit points The required 20 weeks of internship have to be completed as a whole. An interruption is not allowed. Students have to hand in an internship report which meets scientific quality criteria. In case of a semester abroad at least 15 ECTS have to be earned at the foreign university which is located in a non-German speaking country. Exceptions can be made in cases in which the success of the semester abroad is defined differently. Besides students have to hand in a report according to scientific quality standards (with minimum of 10 pages). The specific topic must be agreed in advance with the supervising teacher at the Rhein-Waal University of Applied Sciences. Furthermore, students will have to present their topic in a faculty public presentation.
Use of module (in other study programs) Same module in "International Business and Social Sciences", "Communication and Information Engineering", "Information and Communication Design", "Environment and Energy", and "Mobility and Logistics"
Weight towards final grade None (ungraded)
Person in charge of module All professors of the faculty
Additional information -

CI_7.01 Bachelor workshop I: Research methods

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_7.01	150 h	5 CP	7th semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Seminaristic lectures: 45 h / 4 SWS	45 h / 60 TU	105 h	50 students

Learning outcomes / Competences and qualifications profile

Having completed this course, students are able to decide which research method is suitable to answer the research question they have chosen for their thesis. Regarding the specific requirements of scientific work students gain the competence to develop a hypothesis, to use an appropriate study setup for the verification or falsification of the hypothesis, to collect and evaluate data, to consider data quality, to discuss own work in the context of other findings and to present results in articles and contributions to conferences.

Due to the discussions during the course students have strengthen their abilities of critical self-reflection and strengthen their abilities to evaluate methods and approaches and to participate in scientific discussions.

Content

Lectures and exercises on

- the challenge of finding the appropriate research question
- observational versus experimental methods
- objectivity and repeatability•hypotheses and theories
- correlation versus causality
- the experimental setup suitable to verify or falsify a hypothesis
- evaluation of nominal, ordinal, interval and ratio data
- descriptive statistics, algorithms and models
- presentation of data in tables and figures
- developing and validating models
- writing an extended abstract

- oral presentations at conferences - the sources of information (scientific papers, norms, legislation)
Teaching methods Seminaristic lectures which will include discussions as well as student tasks
Entry requirements 175 credits points achieved (including internship or semester abroad)
Types of assessment Certificate (Testat)
Requirements for the award of credit points Successful participation reflected by the total of submitted assignments
Use of module (in other study programs) This module is open to students of other Bachelor courses of the Communication and Environment faculty.
Weight towards final grade None (ungraded)
Person in charge of module Prof. Dr. Ute Hansen
Additional information Reading: Field, A., Hole, G. (2003): How to Design and Report Experiments, SAGE Publications Sullivan, M. (2014) Fundamentals of Statistics, Pearson

CI_7.02 Bachelor workshop II: Scientific writing

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_7.02	150 h	5 CP	7th semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Seminaristic lectures: 45 h / 4 SWS	45 h / 60 TU	105 h	35 students

Learning outcomes / Competences and qualifications profile

Students are able to communicate their results of scientific working in an appropriate written form. They have learned how to write effectively, concisely, and clearly. By practicing the discussed writing techniques they have gained an understanding of and experience in creating a scientific manuscript.

Content

- Writing style
- Writing techniques
- Structure, outline, and first draft
- Organizing the writing process
- How to present methods and results effectively
- Discussing the results
- Putting the fragements together
- Abstract and Introduction
- Rewriting the manuscript
- Editing and publishing the text

Teaching methods

Workshop including seminaristic lectures and many writing exercises. Students discuss their results and support each other.

Entry requirements

175 credits points achieved (including internship or semester abroad)

Types of assessment Certificate (Testat)
Requirements for the award of credit points Successful participation reflected by the total of submitted assignments
Use of module (in other study programs) Same module in "International Business and Social Sciences", "Communication and Information Engineering", "E-Government", "Environment and Energy", "Media Communication and Computer Sciences" and "Mobility and Logistics"
Weight towards final grade None (ungraded)
Person in charge of module Prof. Dr. Kai Tiedemann
Additional information Reading: Cargill, M. / O'Connor, P. (2009): Writing Scientific Research Articles. Strategy and Steps. Chichester: Wiley-Blackwell. Glasman-Deal, H. (2010): Science Research Writing for Non-Native Speakers of English. A Guide for Non-Native Speakers of English. London: Imperial College Press. Hofmann, A. H. (2010): Scientific Writing and Communication: Papers, Proposals, and Presentations. Oxford: Oxford University Press. Russey, W. E. / Ebel, H. F. / Bliefert, C. (2006): How to Write a Successful Science Thesis. The Concise Guide for Students. Weinheim: Wiley-VCH.

CI_7.03 Bachelor workshop III: Colloquium

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_7.03	150 h	5 CP	7th semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Seminaristic lectures: 45 h / 4 SWS	45 h / 60 TU	105 h	35 students or small groups supervised by different professors

Learning outcomes / Competences and qualifications profile

Students have received feedback, advice and guidance for their bachelor thesis. Each student has presented his or her own thesis in a short presentation (20-30 minutes). Together with other students, he/she has discussed the current state of research findings, methodology etc. In that way students have learned to present their research in a convincing way, to professionally defend their research and to accept feedback or criticism from their peers. At the same time students have learned to give feedback, provide ideas and advice for the work of others and formulate criticism in a fair way.

Content

- How to present research findings in a professional way
- How to comment and criticize the research of others
- How to moderate a group discussion
- Students´ presentations of their own findings followed by an open group discussion

Teaching methods

Students present their own research. Group discussions about the findings and methods applied.

Entry requirements

175 credits points achieved (including internship or semester abroad)

Types of assessment

Certificate (Testat)

Requirements for the award of credit points Individual student´s presentation of his/her own research findings.
Use of module (in other study programs) Same module in "International Business and Social Sciences", "Communication and Information Engineering", "Environment and Energy", and "Mobility and Logistics"
Weight towards final grade None (ungraded)
Person in charge of module All professors of the faculty
Additional information -

CI_7.04 Bachelor thesis and colloquium

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_7.04	450 h	15 CP	7th semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Bachelor Thesis: 12 CP Colloquium: 3 CP	Depends on need and demand		

Learning outcomes / Competences and qualifications profile

Students have conducted their own studies examining a research question from their scientific discipline, developing an appropriate methodological approach, and reflecting their research design and findings critically.

During the disputation students have proven their competencies in evaluating the topic and reflecting on its impact on real-life problems.

Content

- Depends on the topic; inter alia:
- Researching and evaluating literature
- Developing a research question and deriving hypotheses
- Operationalizing constructs
- Analyzing methodological strengths and weaknesses of different research approaches
- Developing research designs
- Conducting the studies
- Evaluating the results / Implementation
- Writing the thesis
- Presenting and defending the findings

Teaching methods

Individual supervision and support

Entry requirements 175 credits points achieved (including internship or semester abroad)
Types of assessment Written Bachelor thesis and oral disputation
Requirements for the award of credit points Passed Bachelor thesis and disputation as well as successful completion of all other modules of the curriculum
Use of module (in other study programs) -
Weight towards final grade 10 %
Person in charge of module All professors of the faculty
Additional information -

CI_W.01 Ambient intelligent systems

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_W.01	150 h	5 CP	4th or 5th semester	Once a year	1 semester

Courses	Teaching time	Self-study	Planned group size
Seminar-like lectures: 22.5 h / 2 SWS Practical exercises: 22.5 h / 2 SWS	45 h / 60 TU	105 h	25 students

Learning outcomes / Competences and qualifications profile

Ambient Intelligence envisions a world where people are surrounded by sensors and intelligent, intuitive interfaces embedded in the everyday objects around them. This enables the environment to identify individuals or objects and to response to their presence and behaviour in an appropriate and perhaps personalized way.

In this module the students have been introduced to the vision of ambient intelligent systems. They have gained a sound understanding of enabling technologies and they got an overview of applications and understood how articficial intelligence enables these applications. The application field Ambient Assisted Living (AAL) has been discussed in detail. The students have learned how new technology can be used to improve care processes and to increase the personal mobility and comfort of elderly people. They also got a brief idea of other socio-cultural impacts. At the end of this course students are able to come up with new ideas and to start innovative projects in this area.

Content

Vision, history and predecessor technologies/visions

-Working with the user: human centered design

- Architectures of Ambient Intelligent Systems (including service oriented architecture and frameworks like OSGi)

- From sensor data to context: modelling, automatic detection and recognition

- Knowledge-based systems

- Action Planning Algorithms

- Adaptive systems

- Ideas and current research in the area of AmI and AAL

- Privacy and data protection in smart environments

- Ethical and social impacts

Teaching methods

Tuition in seminars, lectures and practical classes

Entry requirements

Students have to pass

CI_1.02 “Fundamentals of computer science and networks”

CI_2.04 “Object oriented programming”

before taking this course.

Types of assessment

Graded examination

Requirements for the award of credit points

Passed assessment

Use of module (in other study programs)

Open to students of other study programs

Weight towards final grade

3.33 % (Elective course)

Person in charge of module

Prof. Dr. Christian Ressel

Additional information

Reading:

Corchado,J.M. et al: 3rd Symposium of Ubiquitous Computing and Ambient Intelligence 2008. ISBN 978-3-540-85866-9, Berlin, Springer, 2008

Corchado,J.M. et al: Ambient Intelligence and Future Trends -: International Symposium on Ambient Intelligence 2010. ISBN 3642132677, Berlin, Springer 2010

Omatu, S. et al: Distributed Computing, Artificial Intelligence, Bioinformatics, Soft Computing, and Ambient Assisted Living: 10th International Work-Conference. ISBN 3642024807, Berlin, Springer, 2009

Verhaegh, W.; Aarts,E.; Korst,J.: Algorithms in ambient intelligence. ISBN 978-1402017575,Springer Netherlands, 2004.

Bravo, J. et al: Ambient Assisted Living: Third International Workshop, IWAAL 2011. ISBN 3642213022, Berlin, Springer, 2011.

Vasilakos,A.; Pedrycz, W.: Ambient intelligence, wireless networking, and ubiquitous computing. ISBN 1-580-53963-7,Boston, Artech House Inc, 2006

CI_W.03 Communication security

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_W.03	150 h	5 CP	4th semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 SWS Exercises: 22.5 h / 2 SWS	45 h / 60 TU	105 h	Lectures: open Exercises: 40 students

Learning outcomes / Competences and qualifications profile

Students have gained fundamental knowledge of security terms and concepts, such as threats, vulnerabilities, protection and incident handling. The purpose of the course is to provide the student with an overview of the field of communication / information security and respective implementation issues for communication systems. The students will be exposed to the spectrum of security activities, its methods, methodologies and mechanisms.

Coverage will include cryptographic functions, inspection and protection of assets, detection of and reaction to threats to communication systems, and analysis of incident procedures. Another focus will be set on security related organizational structures and product / system certification with respect to standardized security evaluation crietria.

Content

- Legal, Ethical, and Professional Issues in Information Security
- Cryptography
- Operating System Vulnerabilities and Resolutions
- Communication Security, Tunneling
- Cryptographic Protocols
- Malware, Anti-Virus
- Firewalls and (virtual) Private Networks
- IDS and Access Control
- Trustworthy Hardware
- Physical Security

- Cryptographic Protocols

- Audits

- Implementing Security

- Security Certification

- Information Security Management

Teaching methods

Lectures and practical classes

Entry requirements

Students have to pass

CI_1.02 “Fundamentals of computer science and networks”

CI_2.03 “Computer networks”

before taking this course. It is expected that students have knowledge of a programming language and of the fundamentals of operating systems.

Types of assessment

Graded examination

Requirements for the award of credit points

Passed assessment

Use of module (in other study programs)

Open to students of other study programs

Weight towards final grade

3.33 % (Elective course)

Person in charge of module

Prof. Dr. Ulrich Greveler

Additional information

Reading:

Paar, C. (2010): Understanding Cryptography, Berlin-Heidelberg, Springer-Verlag

Schneier, B. (1996): Applied Cryptography, Canada, John Wiley & Son, Inc.

Anderson, R.J. (2008): Security Engineering, Canada, Wiley Publisching, Inc.

CI_W.05 Advanced modelling and simulation

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_W.05	150 h	5 CP	4th or 5th semester	Winter or summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lecture: 22.5 h / 2 SWS Exercise: 22.5 h / 2 SWS	45 h / 90 TU	105 h	Lecture: open Exercise: 40 students

Learning outcomes / Competences and qualifications profile

This course enables students to create models of technical systems and to analyze them via simulations. In detail, the students learn to model complex technical problems, to describe them mathematically and to find solutions. They know the appropriate use of models and simulations and their limits and understand the steps of the simulation process. Students are familiar with modern modelling and simulation techniques as well as common tools and they can apply the learned methods to different problems in practice, for example to make predictions, to find general rules and to raise new questions. They understand modeling and simulation techniques as a useful tool for understanding technical systems and they can apply them in different contexts.

Content

Introduction: to modelling and simulation, motivation, meaning of modelling and simulation in the context of technical systems, practical examples from everyday life, typical questions, different categories of simulations, steps of the simulation process

Continuous simulations

- e.g. Growth processes (exponential, logistic), predator-prey relationships, stepwise extension (e.g. by intraspecific competition, different predator or prey species),

- Introduction of dimensionless variables

- Implementation e.g. with Octave/Matlab, Scilab/Xcos, R or Python

- Transfer of the learned methods to other situations and technical systems

- Modelling of stochastic dependencies (like Queueing theory, Hidden Markov Model)

- Fundamentals of numerical methods in the context of differential equations:

- Ordinary differential equations (ODE): discretization, Euler method, Runge-Kutta method and subsequent implementation of examples, stability of methods, built-in solvers in modern tools

- Partial differential equations (e.g. heat conduction equation via FEM or FDM, solution of the one-dimensional advection-diffusion equation via FDM)

Discrete and Stochastic Simulations

- e.g. Monte Carlo simulations (e.g. radioactive decay)

Modelling and simulations in **data science** and **machine learning**

Teaching methods

Tuition in seminars, lectures and practical classes

Entry requirements

Students have to pass

CI_1.04 “Scientific programming”

CI_3.06 “Higher mathematics”

before taking this course. Students are expected to have basic knowledge of a modern programming language.

Types of assessment

Graded examination

Requirements for the award of credit points

Passed assessment

Use of module (in other study programs)

Open to students of other study programs

Weight towards final grade

None (ungraded)

Person in charge of module

Prof. Dr. Frank Zimmer

Additional information

Reading:

Campbell, S.L.; Chancelier, J.-P.; Nikoukhah, R.: Modeling and Simulation in Scilab/Scicos with ScicosLab 4.4, ISBN 978-1441955265, Springer, Berlin, 2nd ed., 2009

Chapra, S.C.; Canale, R.P.: Numerical Methods for Engineers, ISBN 978-0073397924, McGraw-Hill Education – Europe, 7th ed., 2014

Gilat, A.; Subramaniam, V.: Numerical Methods for Engineers and Scientists: An Introduction with Applications Using MATLAB, ISBN 978-1118554937, John Wiley & Sons Inc., 3rd ed., 2013

Kreyszig, E.: Advanced Engineering Mathematics, ISBN 978-8126554232, John Wiley & Sons, 10th ed., 2015

Jones, O.; Maillardet, R.; Robinson, A.: Introduction to Scientific Programming and Simulation Using R, ISBN 978-1466569997, CRC Press, Taylor & Francis Group, Boca Raton, FL, 2nd new edition, 2014

Hill, C.: Learning Scientific Programming with Python, ISBN 978-1107428225, Cambridge University Press, 2016

Quarteroni, A. M.; Saleri, F.; Gervasio, P.: Scientific Computing with MATLAB and Octave, ISBN 978-3642453663, 4th edition, Springer, Berlin, 2014

Stroud, K.A.; Booth, D.J: Engineering Mathematics, ISBN 978-1137031204, Red Globe Press, 7th ed., 2013

Stroud, K.A.; Booth, D.J: Advanced Engineering Mathematics, ISBN 978-0230275485, Red Globe Press, 5th ed., 2011

Turner, P.R.; Arildsen, T.; Kavanagh, K.: Applied Scientific Computing: With Python, ISBN 978-3319895741, Springer, Berlin, 2018

Tyagi, A.K.: MATLAB and Simulink for Engineers, ISBN 978-0198072447, Oxford Univ Pr, Pap/Cdr, 2011

Wouwer, A.V.; Saucez, P.; Vilas, C.: Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications, ISBN 978-3319067896, Springer, Berlin, 2014

CI_W.06 Fundamentals of business administration

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_W.06	150 h	5 CP	4th or 5th semester	Winter or summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 SWS Exercises: 22.5 h / 2 SWS	45 h / 60 TU	105 h	Lectures: open Exercises: 40 students

Learning outcomes / Competences and qualifications profile

Students have gained an understanding of fundamental concepts of business administration and the basic functions of organizations. They have a good grasp of important terms, concepts, and methods and are able to apply them to real-life problems. They have discussed the impacts of globalization and can describe its influence on business processes.

Content

- An organization and its goals
- Corporate organization and organizational structure
- Principles of strategic management and planning
- The operations function: the process of production, costs and planning, production logistics
- Fundamentals of marketing: the marketing mix
- Principles of finance
- The controlling function
- Fundamentals of human resource management and leadership

Teaching methods

Lectures, accompanied by exercises in which case studies and problems in practice are presented

Entry requirements

None

Types of assessment Graded examination
Requirements for the award of credit points Passed assessment
Use of module (in other study programs) Same module in "Communication and Information Engineering", "International Business and Social Sciences" and "Mobility and Logistics"
Weight towards final grade 3.33 % (Elective course)
Person in charge of module Prof. Dr. Daniel H. Scheible
Additional information Reading: Gamble, J. E. / Thompson, A. A. (2011): Essentials of Strategic Management. The Quest for Competitive Advantage. 2nd edition. New York: McGraw-Hill. Hill, C. W. L. (2009): International Business. Competing in the Global Marketplace. 7th edition. New York: McGraw-Hill. Kotler, P. / Armstrong, G. (2010): Principles of Marketing. 13th edition. Upper Saddle River: Pearson Prentice Hall. Luthans, F. / Doh, J. P. (2009): International Management. Culture, Strategy, and Behavior. 7th edition. New York: McGraw-Hill. Robbins, Stephen P. / DeCenzo, David A. / Coulter, Mary (2011): Fundamentals of Management. Essential Concepts and Applications. 7th edition. Upper Saddle River: Pearson Prentice Hall. Slack, N. / Chambers, S. / Johnston, R. (2010): Operations Management. 6th edition. Harlow: Pearson Prentice Hall.

CI_W.07 Parallel programming

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_W.07	150 h	5 CP	4th or 5th semester	Once a year	1 semester

Courses	Teaching time	Self-study	Planned group size
Seminar-like lectures: 22.5 h / 2 SWS Practical exercises: 22.5 h / 2 SWS	45 h / 60 TU	105 h	25 students

Learning outcomes / Competences and qualifications profile

Multicore processors are today's standard computer architecture ranging from embedded processors, laptops, desktops, to supercomputers. This module introduces the principles and practice of parallel programming on these shared-memory architectures, including data and task parallelism. The course focuses on methods for high-performance engineering such as leaf coarsening and cache oblivious algorithms. Students learn to make effective use of the features provided by OpenMP.

Content

- Data parallelism
- Task parallelism
- Multithreaded algorithms
- Specification of parallelism with OpenMP
- Performance engineering

Teaching methods

Lectures, exercises, and practical programming labs

Entry requirements

Students have to pass

CI_2.02 "Computer architecture"

before taking this course.

Types of assessment

Graded examination
Requirements for the award of credit points Passed assessment
Use of module (in other study programs) -
Weight towards final grade 3.33 % (Elective course)
Person in charge of module Prof. Dr. Volker Strumpen
Additional information Readings: OpenMP Application Programming Interface, Version 5.0, 2018. Cormen T.H., Leiserson C.E., Rivest R.L., Stein C. (2013), Introduction to Algorithms, 3rd ed; MIT Press.

CI_W.08 Innovative technologies

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_W.08	150 h	5 CP	4th or 5th semester	irregular	1 semester

Courses	Teaching time	Self-study	Planned group size
Seminar-like lectures: 22.5 h / 2 SWS Practical exercises: 22.5 h / 2 SWS	45 h / 90 TU	105 h	40 students

Learning outcomes / Competences and qualifications profile

The students are familiar with trends and innovative approaches in computer science or engineering. They know current frameworks and methods and can apply them.

Content

Examples:

- Current approaches in development of mobile Applications
- Technologies and software development in the domain of industry 4.0
- Development of cyber physical systems
- digital forensics

Teaching methods

Tuition in seminars, lectures and practical classes

Entry requirements

Students have to pass

CI_3.02 “Signals and systems”

before taking this course.

Types of assessment

Graded examination

Requirements for the award of credit points

Passed assessment

Use of module (in other study programs) Open to students of other study programs
Weight towards final grade 3.33 % (Elective course)
Person in charge of module Prof. Dr. Christian Ressel
Additional information Reading: depends on thematic focal points

CI_W.09 Control engineering

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_5.02	150 h	5 CP	4th or 5th semester	Once a year	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 SWS Exercise: 22.5 h / 2 SWS	45 h / 90 TU	105 h	Lectures: open Exercises: 40 students

Learning outcomes / Competences and qualifications profile

After finishing this module, students have gained fundamental knowledge and skills to describe and analyse technical systems. They are familiar with basics of control systems, such as closed-loop control, time and frequency domains analysis, Bode and Nyquist plots, as well as PID control. Students have worked with common simulation and modelling software and are furthermore able to implement simple controllers in software and hardware. Special attention is given to real-life examples and applications of control systems. Students have gained enough skills to recognize and conceptualize elements of more complex control systems.

Content

- Mathematical modelling of technical systems
- Functionality and basic structure of control circuits
- Description of linear continuous systems
- Stability of linear continuous control systems

Teaching methods

Tuition in seminars, lectures and practical classes

Entry requirements

Students have to pass

CI_3.02 “Signals and systems”

before taking this course.

Types of assessment

Graded examination
Requirements for the award of credit points Passed assessment
Use of module (in other study programs) -
Weight towards final grade 3,33 % (Elective Course)
Person in charge of module Prof. Dr. Rolf Becker
Additional information Reading: Nise, N. (2011). Control systems engineering. New York, N.Y.: John Wiley & Sons. Okuyama, Y. (2014). Discrete Control Systems. London: Springer-Verlag.

CI_W.10 Machine learning

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_W.10	150 h	5 CP	5th semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Seminar-like lectures: 22.5 h / 2 SWS Practical exercises: 22.5 h / 2 SWS	45 h / 60 TU	105 h	40 students

Learning outcomes / Competences and qualifications profile

Machine Learning is a key to develop intelligent systems and analyze data in science and engineering. This course provides an introduction to the fundamental methods at the core of machine learning. It covers theoretical foundations including supervised and unsupervised learning. The theory is beeing introduced by examples from the ambient intellegience domain (and others) including learning as an approach to relize adaptive systems. The implementation of programs in this domain is also part of the course. Having passed this module students are aware of the challenges of machine learning. They have gained basic understanding not just of algorithms but also critical reflection, which allows them to perform problem oriented feature engineering, to find appropriate models.

Content

- Introduction and motivation
- Adaptive systems
- statistical learning theory
- local methods, like: nearest neighbor, k-nearest neighbor, parzen windows, high dimensions
- Bias variance and cross validation
- Regularized least squares and classification
- Regularization Networks
- Kernal based methods and support Vector Machines
- Dimensionality reduction and variable selection
- Clustering algorithms

- Neural Networks

- Bayesian learning

Teaching methods

Tuition in seminars, lectures and practical classes

Entry requirements

Students have to pass CI_3.06 “Higher mathematics” before taking this course.

Types of assessment

Graded examination

Requirements for the award of credit points

Passed assessment

Use of module (in other study programs)

Open to students of other study programs

Weight towards final grade

3.33 % (Elective course)

Person in charge of module

Prof. Dr. Christian Ressel

Additional information

Reading:

Hastie, Tibshirani and Friedman: "Elements of statistical learning", ISBN: 9678-038784857-0 , Springer, 2017

Harrington:" Machine learning in action", ISBN: 978-1-617-29018-3, Shelter Island, Manning, 2012

Mendelson (Hrsg): "Advanced lectures on machine learning", ISBN: 3-540-00529-3, Berlin, Springer, 2003

Alpaydin:"Introduction to machine learning", ISBN: 978-0-262-01243-0, Cambridge, MIT Press, 2010

CI_W.11 Drone technology and application

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_W.12	150 h	5 CP	5th semester	Winter semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Seminar-like lectures: 22.5 h / 2 SWS Practical exercises: 22.5 h / 2 SWS	45 h / 60 TU	105 h	25 students

Learning outcomes / Competences and qualifications profile

Unmanned Aircraft Systems (UAS) for very low level (VLL) airspace are established cost effective systems enabling novel applications and business cases. The operation of such drones touches several fields such as the complex technology of the UAS itself but also payloads for specific applications, flight control, mission planning, air traffic control and legal regulation. Real world case studies in this domain are ideal for problem based learning.

UAS technology by itself is extremely broad. It comprises e.g. embedded systems (flight controllers), control engineering, sensors, power electronics, remote control, telemetry as well as computer vision for navigation and machine learning.

In fact a drone is a component in a larger distributed system. Application specific payloads open further universes of interesting challenges, be them imaging systems such as RGB, hyperspectral or thermal cameras, radars, laser scanners or actuators for physical interactions, to name a few. Application examples are remote sensing for earth observation, structural health monitoring, surveillance, precision agriculture or transport of cargo and passengers.

Having passed this module students are aware of the significance of UAS. They are able to assess technology and applications. They know the fundamental principles and components of a drone. They are able to integrate simple systems and to operate them. They have shaped their skills in embedded systems, control engineering and application development.

Content

Flight controllers (FC) as control systems

Remote control and communication protocols

Mission planning and automated flight

Companion computer (CC) and on-board computing

Sensor integration and computer vision Remote sensing and application development
Teaching methods Seminar-like lecture and practical exercises
Entry requirements Students have to pass CI_3.02 “Signals and systems” before taking this course.
Types of assessment Graded examination
Requirements for the award of credit points Passed assessment
Use of module (in other study programs) -
Weight towards final grade 3.33 % (Elective course)
Person in charge of module Prof. Dr. Rolf Becker
Additional information -

CI_K.01 Project management

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_K.01	150 h	5 CP	4th semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
Lectures: 22.5 h / 2 SWS Exercise: 22.5 h / 2 SWS	45 h 90 TU	105 h	Lectures: open Exercises: 40 students

Learning outcomes / Competences and qualifications profile

Having passed this module students are able to plan and carry out projects. They are familiar with methodological tools used in project planning, realisation, monitoring and completion in fields like personnel, costs, deadlines and quality. They are able to present project results appropriately.

Students have experienced the dynamics and pitfalls of teamwork and are sensitized for different cultures and the cooperation with people from different cultural background. Besides due to the interaction during the course students have strengthen their communication skills, their reflective abilities and conflict abilities. During the practical parts they train their structural competencies, time and team management skills.

Content

- Defining the project and its scope

- Developping the project plan (defining work packages, setting milestones, developing flow charts and network plans)

- Scheduling the project

- Creating, leading, and managing a project team (esp. teams with participants from different nations/cultures)

- Managing resources and monitoring project performance , Controlling the project and managing risk

- International projects, cooperation with customers/project partners from foreign countries and different cultures (intercultural competences)

- Project closure, documentation and presenting to an audience

- Developing the presentation (developing the material, structuring the presentation, use of presentation software, preparation)

- Presentation techniques and visual aids

Teaching methods

Lectures, accompanied by exercises in which students conduct their own projects (case studies) and present their results

Entry requirements

None

Types of assessment

Certificate (Testat)

Requirements for the award of credit points

Participation in a project (case study), final presentation and report

Use of module (in other study programs)

Same module in "Environment and Energy", "Communication and Information Engineering", "Information and Communication Design", "International Business and Social Sciences" and "Mobility and Logistics"

Weight towards final grade

None (ungraded)

Person in charge of module

Prof. Dr. Daniel H. Scheible

Additional information

Reading:

Heerkens, G. R. (2002): Project Management. New York: McGraw-Hill.

Hillson, D. (2009): Managing Risk in Projects. Farnham; Burlington: Gower.

Larson, E. W. / Gray, C. F. (2011): Project Management. The Managerial Process. 5th edition. New York: McGraw-Hill.

Raynolds, G. (2008): Presentation Zen. Simple Ideas on Presentation Design and Delivery. Berkeley: New Riders.

Stanton, N. (2009): Mastering Communication. 5th edition. Basingstoke; New York: Palgrave Macmillian.

CI_K.02 Foreign language

Code	Workload	Credits	Level of module	Frequency of offer	Duration
CI_K.02	150 h	5 CP	4th semester	Summer semester	1 semester

Courses	Teaching time	Self-study	Planned group size
45 h / 4 SWS	45 h 60 TU	105 h	Lecture: open Exercise: 40 students

Learning outcomes / Competences and qualifications profile

At the beginning of the course, students define the language level to be achieved based on their current language skills. The improvement of the language level will be defined in a learning agreement.

Students who are not German-native speakers have to take German courses unless they have reached language level C1. Other students are allowed to take any course offered by the Language Center of the HSRW (except courses in their native language).

After successful completion of the module, the language skills of students have been approved according to the learning agreement.

Content

Is defined in the course description of the language center of HSRW

Teaching methods

Is defined in the course description of the language center of HSRW

Entry requirements

Is defined in the course description of the language center of HSRW

Types of assessment

Certificate (Testat)

Requirements for the award of credit points

Is defined in the course description of the language center of HSRW

Use of module (in other study programs)

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Weight towards final grade None (ungraded)
Person in charge of module Prof. Dr. Christian Ressel
Additional information Reading: Is defined in the course description of the language center of HSRW