

Joint International Master's Programme

Information Technology

Course Handbook

Vers. 4-3, 1.02.2010



Halmstad University
School of Information Science,
Computer and Electrical
Engineering
Halmstad, Sweden



Wrocław
University
of Technology

Faculty of Computer Science and
Management
Wrocław, Poland

Hochschule Ostwestfalen-Lippe
University of Applied Sciences

Department of Electrical
Engineering and Computer Science
Lemgo, Germany



Department of
Computer Science and Engineering
Esbjerg, Denmark

This handbook provides a guide to the course units of the joint Master's programme (Master of Science - MSc) in Information Technology between

- **HU:** School of Information Science, Computer and Electrical Engineering, Halmstad University, Halmstad, Sweden
- **WRUT:** Faculty of Computer Science and Management, Wroclaw University of Technology, Wroclaw, Poland
- **OWL-UAS:** Department of Electrical Engineering and Computer Science, Ostwestfalen-Lippe University of Applied Sciences, Lemgo, Germany,
- **AUE:** Department of Computer Science and Engineering, Aalborg University Esbjerg, Esbjerg, Denmark

Revision History

Version	Date	Who	Changes
1.0	18.07.2003	Meier	Original Issue
1.1	06.11.2003	Meier	<i>Random Processes</i> substitutes <i>Stochastic Processes</i>
2.0	10.05.2005	Meier	New style for accreditation in Lemgo 2005
2.1	16.06.2005	Meier	<i>Signals and Systems</i> substitutes <i>Methods and Writing in Scientific Work</i> Course abbreviations <i>Halmstad</i> added <i>Wireless Communications</i> : Literature update
3.0	25.01.2007	Meier	Complete update with <i>Wroclaw University of Technology</i> as new partner
3.1	23.03.2007	Meier	<i>Information Fusion</i> in Lemgo added
3.2	3.05.2008	Meier	New university and department name Lemgo, new logo Update <i>Wireless Communications</i> Update <i>Network Security</i> Update <i>Communication for Distributed Systems</i> Update <i>Intelligent Sensors</i>
3.3	2.06.2008	Meier	Update <i>Communication for Distributed Systems</i> Update <i>Web Services</i>
3.4	22.08.2008	Carlsson	Update Halmstad courses, semester 1 and 2.
4.0	06.06.2009	Meier	New Lemgo: <i>System Modeling and Simulation</i> New Lemgo: <i>Software Engineering for Web Services</i> New Wroclaw: <i>Theory of Information and Signals</i> New Wroclaw: <i>Project Work</i>
4.1	12.06.2009	Meier	Update Lemgo: <i>Information Fusion</i> Update Lemgo: <i>Signal Processing Algorithms</i> Update Lemgo: <i>Network Security</i>
4.2	22.12.2009	Meier	New Lemgo: <i>Project Work</i> New Lemgo: <i>Scientific Methods and Writing</i> New Lemgo: <i>Seminar</i>
4.3	1.02.2010	Meier	New Lemgo: <i>Innovation and Development Strategies</i>

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1 Courses from Halmstad (1st Semester)

Note: The official course plans are those published at the Halmstad University web site. In the case of any difference between these and the present document, the official course plans should be used.

Degree programme:	Information Technology (Master)
Course name:	ALGORITHMS AND DATA STRUCTURES
Abbreviation or number:	
Semester:	First semester
Responsible lecturer:	Dr. Veronica Gaspes, senior lecturer in Computer science.
Lecturers:	Dr. Veronica Gaspes, senior lecturer in Computer science.
Language:	English
Relation to curriculum:	Compulsory.
Teaching type / hours:	Instruction entails lectures and laboratory works.
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	A basic course in programming.
Goals:	<p>The course aims at providing knowledge on algorithm complexity, algorithm design and classical data structures. The aim of the course is also to improve programming abilities in a modern programming language, currently Java.</p> <p>The course builds on basic programming knowledge and practice and prepares the student to participate in larger programming projects. It introduces currently-accepted techniques to solve frequently occurring problems and prepares the student to make informed choices from several alternative solutions. The course also illustrates how some more advanced programming language constructs can be used.</p> <p>On completion of the course the student shall be able to</p> <ul style="list-style-type: none"> • explain how to estimate the execution time of programs • recognize techniques for algorithm design such as divide and conquer, recursion, dynamic programming • recognize data structures and algorithms for search and sorting, such as quick sort, binary search trees, hash tables • identify the need and use data structures as modules to solve larger problems • use techniques for algorithm design in solving larger problems • judge how suitable a program is given its execution time • choose adequate implementations of data structures from program libraries
Contents:	<p>Abstract data types, basic data structures, recursion, divide and conquer, asymptotic analysis of execution time, algorithms for sorting and searching, data structures for searching, graph algorithms. Examples of advanced data structures: Binary Decision Diagrams. Examples of advanced algorithm design techniques: dynamic programming.</p>
Examination:	Examination consists of two elements: written examination of the theory, and project results presented both in writing and oral.
Teaching media:	
Literature:	Weiss, M. (2005). Data Structures and Problem Solving using Java. (3rd edition) Addison Wesley.

Degree programme:	Information Technology (Master)
Course name:	EMBEDDED SYSTEMS PROGRAMMING
Abbreviation or number:	
Semester:	First semester
Responsible lecturer:	Dr. Veronica Gaspes, senior lecturer in Computer science.
Lecturers:	Dr. Veronica Gaspes, senior lecturer in Computer science.
Language:	English
Relation to curriculum:	Optional in the first semester
Teaching type / hours:	Concepts, methods, problems and solutions are presented in a series of lectures. Lectures are complemented with supervised short computer based exercises. Three bigger laborations with several supervision occasions allow the students to formulate their own designs and implementations.
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	The course Algorithms and data structures 7.5 credits.
Goals:	<p>The course introduces programming techniques suitable for embedded systems. The course addresses mainly techniques for concurrency, real-time and reactivity. The course also addresses programming language support for concurrency, real-time and reactivity.</p> <p>The course is based on knowledge and experience in sequential programming. On completion of the course students will have acquired experience in programming embedded systems that execute on one or several processors, that comply with time constraints and that can interact with the physical environment.</p> <p>On completion of the course students will be able to</p> <ul style="list-style-type: none"> • program embedded applications • program and use a kernel to support concurrency, real-time and reactivity • design, structure and analyze programs for embedded systems • explain different mechanisms for communication and synchronization between processes • explain characteristics of real-time systems and constructions to deal with them in programs • compare, select and apply programming language constructs designed for concurrency and real-time
Contents:	<p>Programming close to hardware. Programs that react to events. Concurrent programming: programs organized as concurrent threads, a kernel supporting threads, programming language support; problems with threads that share memory, protecting data with encapsulation, object orientation. Reactive programming: a programming discipline for organizing concurrent programs using reactive objects that cooperate via synchronous and asynchronous method calls; programming language support. Real-time programming: specification of and support for real time; deadlines, baselines, periodic processes and event controlled processes.</p>
Examination:	The course is examined by means of laborations for which written or spoken reports should be passed and a graded written exam. To pass the laborative part of the course all laborations should be passed.
Teaching media:	

Literature:	Lecture notes, exercises and laborations can be found under the website for the course.
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Degree programme:	Information Technology (Master)
Course name:	IMAGE ANALYSIS
Abbreviation or number:	
Semester:	First semester
Responsible lecturer:	Dr. Josef Bigun, Professor of Signal analysis
Lecturers:	Dr. Josef Bigun, Professor of Signal analysis
Language:	English
Relation to curriculum:	Optional in the first semester
Teaching type / hours:	Instruction consists of lectures and computer exercises. The latter must be documented by reports written in english. Presence at and active participation in the lectures and exercises are compulsory.
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	Knowledge in mathematics, programming and computer systems from a bachelor of science programme.
Goals:	The student shall acquire knowledge and practical experience of digital image analysis, of primarily 2D images. After completing the course, the student shall be able to <ul style="list-style-type: none"> • describe the fundamental concepts in image analysis, primarily color, texture and shape • use these fundamental concepts to describe and solve practical problems • describe real image analysis problems mathematically.
Contents:	The following elements are included in the course: image representation, sampling and quantization, geometric transformation and interpolation, linear and non-linear filtering, local orientation and scale, shape, texture.
Examination:	For the grade "Passed" presence at computer exercise sessions and approvals of 2/3'rd of these are required. Higher grades require further exercises to be completed.
Teaching media:	
Literature:	Bigun, J. (2006). <i>Vision with Direction</i> . (1) Heidelberg: Springer-Verlag Berlin and Heidelberg GmbH & Co.

Degree programme:	Information Technology (Master)
Course name:	MULTIVARIABLE CALCULUS
Abbreviation or number:	
Semester:	First semester
Responsible lecturer:	Dr. Per-Sverre Svendsen, senior lecturer in Mathematics/Theoretical physics
Lecturers:	Dr. Per-Sverre Svendsen, senior lecturer in Mathematics/Theoretical physics
Language:	English
Relation to curriculum:	Optional in the first semester
Teaching type / hours:	Instruction is organised into lectures, exercises, and (optional) home assignments..
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	Basic knowledge of linear algebra and single-variable analysis at bachelor level.
Goals:	<p>The course aims to provide insight and skills in real multi-variable analysis - in particular within areas of relevance to applications in technology and the physical sciences.</p> <p>The course is set to provide the necessary background knowledge for advanced level Mathematics courses as well as application-oriented courses, e.g., Image analysis and Learning and self-organizing systems.</p> <p>Upon completion of the course the student shall be able to:</p> <ul style="list-style-type: none"> • account for both the formal definition and the practical meaning/application of typical concepts, e.g., limits, extremal values, and double/triple integrals. • solve given problems - both more extensive assignments with access to reference material and computer programs, and more limited paper-and-pen-only-problems. • demonstrate a critical appraisal of the value/answer obtained from solving a problem. • weigh the merits and appropriateness of different solution methods. • demonstrate a basic skill in phrasing a computational problem in mathematical terms and, decide whether the problems can be solved exactly or if approximate methods must be used
Contents:	Real-valued functions of several variables. Limits and continuity. Partial derivatives, differentiability, chain-rule, gradient, and directional derivative. Taylor's formula and local extrema. Optimization on compact and non-compact sets with and without constraints. Double- and triple integrals. Basic vector calculus. Curve- and surface integrals. Greens formula. Potential fields.
Examination:	Examination is in the form of a written exam.
Teaching media:	
Literature:	C. H Edwards, D. E Penney <i>Multivariable Calculus</i> , Prentice Hall, 2002. ISBN 0130339679.

Degree programme:	Information Technology (Master)
Course name:	OPTICS, VISION AND CAMERAS
Abbreviation or number:	
Semester:	First semester
Responsible lecturer:	Dr. Jörgen Carlsson, senior lecturer in Physics
Lecturers:	Dr. Jörgen Carlsson, senior lecturer in Physics
Language:	English
Relation to curriculum:	Optional in the first semester
Teaching type / hours:	Instruction consists of lectures, exercises, home assignments and laboratory works. Participation in laboratory works is compulsory.
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	-
Goals:	<p>The course aims at providing an overview of how images are formed and recorded. The course is particularly directed towards practical use of optical components and cameras with the purpose of giving a basis for work with development of image recording and other measurements techniques based on using light and cameras.</p> <p>Upon completion of the course the student shall be able to:</p> <ul style="list-style-type: none"> • describe the design and function of optical and image forming systems • describe, in a general manner, light and other types of electromagnetic radiation and optical components and their use • manage optical and image forming equipment
Contents:	Classical optics. Optical instruments and image forming systems such as the eye, camera, telescope and microscope. The wave properties of light. Interference and diffraction. CCD-cameras and other forms for electronic image capturing.
Examination:	Examination is by written exam and approved laboratory works.
Teaching media:	
Literature:	Lee, H-C. (2005). <i>Introduction to Color Imaging Science</i> . Cambridge: Cambridge University Press.

Degree programme:	Information Technology (Master)
Course name:	RANDOM PROCESSES
Abbreviation or number:	
Semester:	First semester
Responsible lecturer:	Dr. Eric Järpe, senior lecturer in Mathematics
Lecturers:	Dr. Eric Järpe, senior lecturer in Mathematics
Language:	English
Relation to curriculum:	Optional in the first semester
Teaching type / hours:	ITeaching consists of lectures, exercises at which theoretical problems are solved using methods presented at the lectures as well as laborations.
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	Mathematical analysis, linear algebra and a basic course in probability theory and statistical theory.
Goals:	The course aims at giving basic knowledge about random processes, mainly stationary. Upon completion of the course the student shall be able to: <ul style="list-style-type: none"> • identify properties of different random processes • simulate some processes • estimate expectation and covariance function • filter noise from signal • predict the continued path of some processes
Contents:	Random processes, Poisson process and stationary processes. Something about generalised functions and Stiltjes integrals. Covariance function, spectral density function and sampling. Gaussian processes, Filtration, AR and MA processes. Inference for stationary processes. Signal adjusted filter, Wiender filter.
Examination:	Examination is by written exam and approved laboratory experiments.
Teaching media:	Transparencies/Powerpoint presentations, exercises, computer based exercises.
Literature:	Georg Lindgren and Holger Rootzén: <i>Random Processes</i> .

Degree programme:	Information Technology (Master)
Course name:	SIGNAL ANALYSIS AND REPRESENTATION
Abbreviation or number:	-
Semester:	First semester
Responsible lecturer:	Dr Kenneth Nilsson, Senior lecturer.
Lecturers:	Dr Kenneth Nilsson, Senior lecturer.
Language:	English
Relation to curriculum:	Compulsory.
Teaching type / hours:	Instruction is in the form of lectures, exercises, and home assignments. Home assignments shall be approved to receive a grade for the course.
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	The course requires a course in Electrical Circuits and Transform Theory or equivalent knowledge.
Goals:	<p>The course gives basic knowledge of how signals and systems are characterized and analysed. Only systems that are linear and time invariant (LTI-systems) are considered in this course.</p> <p>Upon completion of the course the student should be able to</p> <ul style="list-style-type: none"> • describe sampling and reconstruction (the sampling theorem) • use z-and fourier transform for characterization and analysis of digital signals and LTI-systems • perform digital filtering using convolution and Discrete Fourier Transform (DFT) • use DFT and window function to do frequency analysis • design digital filters given a specification • use software for signal processing
Contents:	Sampling and reconstruction. Mathematic models in the time domain: difference equation and convolution sum. Transforms in discrete time: z-transform, poles and zeros, fourier transform and discrete fourier transform. Window functions. Digital filters: FIR and IIR filters. Design of digital filters.
Examination:	Examination is through approved laboratory exercises and a written exam.
Teaching media:	
Literature:	Proakis J. G., ManolakisD. G. (2007). <i>Digital Signal Processing, Principles, Algorithms and Applications</i> , 4th edition. Pearson/Prentice Hall. ISBN 0-13-187374-1.

2 Courses from Wroclaw (1st Semester)

Degree programme:	Information Technology (Master)
Course name:	Advanced Algorithms and Data Structures
Abbreviation or number:	WRUT1_02
Semester:	First semester
Responsible lecturer:	Dr. Dariusz Konieczny
Lecturers:	Dr. Dariusz Konieczny
Language:	English
Relation to curriculum:	Mandatory in the first semester.
Teaching type / hours:	Lectures - 30h, classes - 15h, laboratory - 15h
Students' workload:	The equivalent of five weeks full time work. This includes approximately 75 hours of teacher led education. Plus 105 hours additional student individual work/homework.
ECTS credits:	6 ECTS credits
Prerequisites:	Algorithms and Data Structures
Goals:	Knowledge of advanced algorithms and skills and its implementation
Contents:	<ul style="list-style-type: none"> - Asymptotic order notation. - Data structures: lists, priority queues, hashing tables, trees (BST, Black-Red-Tree, B-Tree, heap, set), graphs. - Design strategies: divide and conquer, dynamic programming, greedy algorithms, backtracking. - Problems: sorting, searching, adding and deleting, Huffman codes, knapsack problem, problems for computational geometry, algorithms for number theory, minimum spanning tree, shortest paths, matching in graph, network flow, string matching. - Approximation algorithms, probabilistic and randomized algorithms. - NP-complexity.
Examination:	One test at the end of lectures and classes
Teaching media:	Transparencies/Powerpoint presentations, computer based exercises.
Literature:	<p>Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, "Introduction in algorithms". The MIT Press; 2 edition (September 1, 2001), 1184 pages</p> <p>Kenneth A. Berman, Jerome L. Paul, "Algorithms: Sequential, Parallel, and Distributed", Course Technology; 1 edition (October 11, 2004), 992 pages.</p>

Degree programme:	Information Technology (Master)
Course name:	Advanced Databases
Abbreviation or number:	WRUT3_03
Semester:	Third semester
Responsible lecturer:	Dr. Lech Tuzinkiewicz
Lecturers:	Dr. Lech Tuzinkiewicz
Language:	English
Relation to curriculum:	Optional
Teaching type / hours:	Lectures 15, Project 30, Seminar 15
Students' workload:	The equivalent of three weeks full time work. This includes approximately 45 hours of teacher led education. Plus 135 hours additional student individual work/homework.
ECTS credits:	6 ECTS credits
Prerequisites:	The basics (fundamentals) of database
Goals:	This course will provide practical guidelines for applying the design rules. Students will proceed through each of the phases of the database design process to achieve a good understanding of its key aspects. Course participants are expected to create a database design for a selected fragment of reality and implement a corresponding relational database in a selected database management system
Contents:	The following main topics are in the scope of the subject: <ul style="list-style-type: none"> - The role and importance of databases, basic characteristics, an overview of the database design methodology, project documentation, - Analyzing a selected part of reality. Creating business use case model, - Modeling use cases. Scenarios, threads, actors, - Tracing requirements, assessing the consistency of models, - Analysis models, class diagrams, - Logical model. Rules for mapping class diagrams onto relational models, - Rules for specification of the relational database model. The SQL 2003 standard, - Physical model, verification criteria, - Transactions, locks and isolation levels, and - Rules for improving database performance.
Examination:	Lecture: passing final test grade. Project: completing the project according to the schedule, including the implementation of the database design in a selected DBMS
Teaching media:	Elearning
Literature:	Kifer M., Bernstein A., Lewis P., Database Systems. An Application-Oriented Approach. 2nd Edition, Addison-Wesley 2006 Elmasri R., Navathe S., Fundamentals of Database Systems, 4 th Edition, Addison-Wesley 2004

Degree programme:	Information Technology (Master)
Course name:	Advanced Topics in Artificial Intelligence
Abbreviation or number:	WRUT3_04
Semester:	Third semester
Responsible lecturer:	Prof. Halina Kwasnicka
Lecturers:	Prof. Halina Kwasnicka
Language:	English
Relation to curriculum:	Optional
Teaching type / hours:	Lecture - 30h, project - 30h
Students' workload:	The equivalent of five weeks full time work. This includes approximately 75 hours of teacher led education. Plus 105 hours additional student individual work/homework.
ECTS credits:	6 ECTS credits
Prerequisites:	Programming skills, course Advances Algorithms and Data Structures
Goals:	To acquaint students with machine learning concept and methods. Knowledge Discovery from data – methods, usefulness.
Contents:	Introduction to machine learning, deduction versus induction. Presentation of selected induction methods – decision tree generation, rules induction. Nature based methods – evolutionary algorithms, neural networks, artificial immune systems, ant colony systems: idea, properties and usefulness. Complex methods – ensembles of classifiers. Knowledge Discovery from data – phases, useful methods.
Examination:	Test / exam (50%) and completion of an assignment project (50%)
Teaching media:	Transparencies / Powerpoint presentations, computer based exercises
Literature:	Mitchell Tom M., <i>Machine Learning</i> . McGraw-Hill companies, Inc., 1997. Alex A. Freitas: <i>Data mining and knowledge discovery with evolutionary algorithms</i> . Springer Verlag, 2002. Jiawei Han: <i>Data mining : concepts and techniques</i> . Morgan Kaufmann Publishers, 2000. Dorian Pyle: <i>Data preparation for data mining</i> . Morgan Kaufmann Publishers Inc., 1999. Marco Dorigo: <i>Ant colony optimization</i> , MIT Press, 2004. James Kennedy, Russell C. Eberhart: <i>Swarm Intelligence</i> . Morgan Kaufmann. 2001.

Degree programme:	Information Technology (Master)
Course name:	Digital Image Processing
Abbreviation or number:	WRUT1_06
Semester:	First semester
Responsible lecturer:	Dr. Kazimierz Choroś
Lecturers:	Dr. Kazimierz Choroś
Language:	English
Relation to curriculum:	Optional
Teaching type / hours:	Lectures – 30h, Laboratory – 30h
Students' workload:	The equivalent of five weeks full time work. This includes approximately 75 hours of teacher led education. 105 hours additional student individual work/homework.
ECTS credits:	6 ECTS credits
Prerequisites:	---
Goals:	Presentation of structures and formats of digital images, techniques of image digitalisation in scanners and digital photo cameras, methods and algorithms of image processing and compression as well as techniques of non-linear digital video editing.
Contents:	Digital image classification. Raster of printed images. Format conversion. Image digitalization. Software for digital image processing. Digital image transformation. Digital image compression. Special effects and filters. Scanners Construction. Scanning Techniques. 3D Scanners. Image deformations during digitalisation process. Image correction techniques. Mora effects. Digital photo cameras. Digital movie cameras. Mpeg and other video formats. Codecs. Computer animations. Technology DVD. Rules of non-linear digital video editing. Virtual reality. Cyberspace.
Examination:	Exam writing or test
Teaching media:	Computer Software such as: Corel, WinMorph, TMPGEnc, Adobe Premiere, Avid.
Literature:	<ul style="list-style-type: none"> - Bovik A. (Ed.): <i>Handbook of Image and Video Processing</i>. Amsterdam, Elsevier, 2005. - Foley J. D., ..., <i>Computer Graphics, Principles and Practice</i>, Addison-Wesley 1995. - Gonzalez R. C., Woods R. E., <i>Digital Image Processing</i>, Delhi : Pearson Education, 2004. - Guan L., Kung S-Y., Larsen J., <i>Multimedia image and video processing</i>, Boca Raton : CRC Press 2001. - Law M.S. (Ed.), <i>Principles of Visual Information Retrieval</i>. London: Springer-Verlag 2001. - Richardson I.: <i>H.264 and MPEG-4 Video Compression: Video Coding for Next-Generation Multimedia</i>. Chichester, John Wiley & Sons, 2005.

Degree programme:	Information Technology (Master)
Course name:	Expert Systems
Abbreviation or number:	WRUT1_07
Semester:	First semester
Responsible lecturer:	Dr. Donat Orski
Lecturers:	Dr. Donat Orski
Language:	English
Relation to curriculum:	Optional
Teaching type / hours:	Lecture - 30h, Laboratory – 30h
Students' workload:	The equivalent of five weeks full time work. This includes approximately 75 hours of teacher led education. 105 hours additional student individual work/homework.
ECTS credits:	6 ECTS credits
Prerequisites:	Algebra, logics, set theory
Goals:	To provide students with the review of basic problems and methods related to application and design of expert systems, especially, of problems and methods developed in our research group.
Contents:	<p>History, application areas and perspectives of automated reasoning and expert systems.</p> <p>Typical components and structure of expert systems.</p> <p>Main tasks corresponding to the roles of: a user, a designer, an expert, a knowledge engineer, a programmer.</p> <p>Expert systems based on relational knowledge representation.</p> <p>Expert systems based on logical knowledge representation (propositional logic).</p> <p>Expert systems based on predicate calculus.</p> <p>Application of other logics (fuzzy, modal) and hybrid approaches.</p>
Examination:	Written. Answers to 3 out of 15 questions within the scope of the lecture.
Teaching media:	Blackboard
Literature:	<p>Z. Bubnicki "Analysis and Decision Making in Uncertain Systems", Springer Verlag, 2004</p> <p>Z. Bubnicki "Modern Control Theory", Springer Verlag, 2005</p>

Degree programme:	Information Technology (Master)
Course name:	Multimedia Information Systems
Abbreviation or number:	WRUT1_05
Semester:	First semester
Responsible lecturer:	Dr. Janusz Sobecki
Lecturers:	Dr. Janusz Sobecki
Language:	English
Relation to curriculum:	Optional
Teaching type / hours:	Lecture - 30h, laboratory - 30h
Students' workload:	Lecture: 30h – participation in lectures, 30h – self training Laboratory: 30h - participation, 90h - homework
ECTS credits:	6 ECTS credits
Prerequisites:	It is assumed that the course participants are familiar with computer graphics basics, discrete mathematics, computer architectures, and have elementary programming experiences in C++ or Java. Necessary courses: Computer Architectures, Algorithms and Data Structures, Object Oriented Programming and Design
Goals:	The main aim of the course is delivering the knowledge in the field of Multimedia Information Systems, its development problems and basic theories. The matter is discussed from different points of views: psychological, anthropological and technological. Also problems of managing a multimedia production, a storyboard development, a prototype development, a final multimedia title authoring and its evaluation methods are covered by this course.
Contents:	<p>Lecture contents: Introduction to the multimedia systems. Psychological aspects of multimedia systems. Multimedia systems applications. Multimedia platforms and its technologies. Multimedia systems design. Multimedia title storyboarding.</p> <p>Multimedia authoring tools. Multimedia Web Applications. Multimedia Web Applications tools and technologies. Macromedia Director. Macromedia Flash basics. Multimedia usage in Macromedia Flash. Prototyping and evaluation of multimedia information systems. Hypermedia, definitions, applications and methodologies. Cyberspace, virtual worlds on-line, VRML and CULT 3D.</p> <p>Laboratory: Multimedia on-line applications evaluation, multimedia off-line applications evaluation, multimedia application storyboard writing, evaluation of multimedia applications that resembles chosen subject, the application authoring in Macromedia Director or Flash based on the storyboard</p>
Examination:	Examination is in the form of a single-choice test. To pass the course, all laboratory works, and the written exam, must be completed and approved.
Teaching media:	Transparencies / Powerpoint presentations, computer based exercises

Literature:	<p>Newman W.M., Lamming M.G., <i>Interactive System Design</i>. Harlow: Addison-Wesley 1996.</p> <p>J. Sobecki, <i>Interactive Multimedia Information Systems Planning</i>, in T. Valiharju (ed.), <i>Digital Media in Networks</i> Tampere University 2000.</p> <p>Nigel Chapman, Jenny Chapman, <i>Digital Multimedia</i>. John Wiley & Sons, Ltd Chichester 2004.</p> <p>Thomson R., Thomson B., <i>PC Hardware in a Nutshell</i>. O'Really 2004.</p> <p>Craig Knuckles, David Yven, <i>Web Applications. Concepts & Real World Design</i>. Willey & Sons 2005.</p>
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Degree programme:	Information Technology (Master)
Course name:	Operations Research in Computer Science
Abbreviation or number:	WRUT1_08
Semester:	First semester
Responsible lecturer:	Prof. Jerzy Józefczyk
Lecturers:	Prof. Jerzy Józefczyk
Language:	English
Relation to curriculum:	Optional
Teaching type / hours:	Lectures - 30, classes - 30
Students' workload:	The equivalent of five weeks full time work. This includes approximately 75 hours of teacher led education. 105 hours additional student individual work/homework.
ECTS credits:	6 ECTS credits
Prerequisites:	---
Goals:	A student should receive necessary knowledge and abilities to apply operations research methods for solving selected basic problems from the area of computer systems and networks, e.g. allocation, scheduling, transportation and flow problems.
Contents:	Description of basic decision making problems for complex operation systems. Allocation of resources and tasks for independent and dependent operations with time models. Selected decision making problems for complex operations with uncertainty. Introduction to scheduling problems (basic methods and algorithms). Computational complexity of decision and optimisation problems. NP-problems. Maximum flow problem and transportation problem. New trends in scheduling theory and its applications to computer systems and networks.
Examination:	Final test
Teaching media:	Transparencies / Powerpoint presentations, computer based exercises
Literature:	Taha H.A., Operations Research, An Introduction, 5 th Edition, Prentice Hall Inc., 1995. Bubnicki Z., Modern Control Theory, Springer Verlag, 2005. Krajewski L.J., Ritzman L.P., Operations Management, processes and value chains. 7 th edition, Prentice Hall Inc, 2005.

Degree programme:	Information Technology (Master)
Course name:	Parallel Computer Architecture
Abbreviation or number:	WRUT1_03
Semester:	First semester
Responsible lecturer:	Dr. Jan Kwiatkowski
Lecturers:	Dr. Jan Kwiatkowski
Language:	English
Relation to curriculum:	Optional
Teaching type / hours:	Lectures - 30h, seminar - 15h, laboratory - 15h
Students' workload:	The equivalent of five weeks full time work. This includes approximately 75 hours of teacher led education. 105 hours additional student individual work/homework.
ECTS credits:	6 ECTS credits
Prerequisites:	It is assumed that the course participants are familiar with basic computer organisation, computer architecture and computer programming.
Goals:	The aim of the course is to present to students different parallel computer architectures with respect to different parallelism models.
Contents:	The material presented during lectures is supported by laboratory work and a seminar part. The course contents: Taxonomy of parallel computer architectures (Flynn and others) - shared memory, distributed memory and distributed shared memory computers. Static and dynamic interconnection networks, typical topologies, different routing strategy. Pipeline, vector and array processors, multiprocessor systems (bus based and switching systems). Methods for increasing speed: higher clock frequency, architectural improvements, more functional blocks, and system scalability. Memory models, utilisation of cache memory. Superscalar architectures - identification of conflicts and it's avoiding, branch prediction algorithms, automatic reordering of program execution. Non-conventional way of processing - dataflow systems, reduction computers, systolic and neuronal architectures.
Examination:	Examination is in the form of a written exam.
Teaching media:	Transparencies/Powerpoint presentations, computer based exercises.
Literature:	Zomaya, A.Y.H. (ed); (1996). Parallel and Distributed Computing Handbook, McGraw-Hill J.L. Hennessy, D.A. Patterson, Computer Architecture – a quantitative approach”, Morgan Kaufmann Pub., San Francisco 2003 D.E. Culler, J.P. Singh, "Parallel Computer Architecture - a hardware/ software approach", Morgan Kaufmann Pub., San Francisco 1999

Degree programme:	Information Technology (Master)
Course name:	System Modeling and Analysis
Abbreviation or number:	WRUT1_01
Semester:	First semester
Responsible lecturer:	Prof. Jerzy Swiatek
Lecturers:	Prof. Jerzy Swiatek
Language:	English
Relation to curriculum:	Mandatory in the first semester.
Teaching type / hours:	Lectures - 30h, classes - 15h, seminar - 15h
Students' workload:	The equivalent of five weeks full time work. This includes approximately 75 hours of teacher led education. Plus 105 hours additional student individual work/homework.
ECTS credits:	6 ECTS credits
Prerequisites:	Knowledge of mathematics from a bachelor of science program.
Goals:	The course aims to provide insight and skills in system modeling and analysis.
Contents:	<p>The material presented during lectures is supported by class work and a seminar part. The course contents:</p> <ul style="list-style-type: none"> - Models in systems research (model classification, typical problem of analysis, design, optimization, and control) - Description and some characteristics of physical signals (random description, Fourier, Z and Laplace' transformations) - Typical plant descriptions (static and dynamic models, state equations, differential and difference equations, transfer function, time and frequency analysis) - Network models, elements of queuing problems - Fundamental identification problems (identification of static plant – deterministic and probabilistic case, identification of dynamic models) - Selected problems of modeling of complex systems. - Systems described by the relation
Examination:	Examination is in the form of a written exam.
Teaching media:	Transparencies/Powerpoint presentations, computer based exercises.

Literature:	<p>Zdzisław Bubnicki, Identification of Control Plants, Warszawa: PWN, 1980.</p> <p>Lennart Ljung, System identification: theory for the user, Upper Saddle River, Prentice Hall PTR,. 1999.</p> <p>Oliver Nelles, Nonlinear system identification: from classical approaches to neural networks and fuzzy models, Berlin: Springer-Verlag, 2001.</p> <p>Robert Haber, Laszlo Keviczky, Nonlinear system identification: input-output modeling approach.Vol. 1, Nonlinear system parameter identification, Dordrecht :Kluwer Academic Publishers, 1999.</p> <p>Robert Haber, Laszlo Keviczky, Nonlinear system identification: input-output modeling approach.Vol. 1, Nonlinear system structure identification, Dordrecht :Kluwer Academic Publishers, 1999.</p> <p>Burns S. Roland, Advanced Control Engineering, Butterworth-Heineman, 2001</p> <p>Ljung L., System Identification: Theory for the User, Prentice Hall PTR, 1998</p> <p>Ikonen E., Najim K., Advanced identification and control, CRC Press LLC, 2002</p>
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Degree programme:	Information Technology (Master)
Course name:	Theory of Information and Signals
Abbreviation or number:	INZ0019
Semester:	First semester
Responsible lecturer:	Prof. Adam Grzech
Lecturers:	Prof. Adam Grzech
Language:	English
Relation to curriculum:	Mandatory at first semester (WRUT)
Teaching type / hours:	Lectures - 30h, classes - 30h
Students' workload:	The equivalent of five weeks full time work. This includes approximately 75 hours of teacher led education.
ECTS credits:	6 ECTS credits
Prerequisites:	No
Goals:	The aim of this course is to introduce some concepts of signal transmission in various transmission media using different methods of modulation, coding, multiplexing, protection as well as different organization of transmission and transmission systems.
Contents:	<ol style="list-style-type: none"> 1. Information theories and statistical theory of information; their application in signals transmission and receiving systems. 2. Information model of transmission channel models and theorem of optimal coding 3. Information systems models (general- and specific-purposes systems) 4. Transmission channels and their organization for information transmission purposes 5. Fourier transformation and their features in transmission systems analysis and design 6. Amplitude, frequency and phase modulation 7. Amplitude, frequency and phase shift keying 8. Linear and non-linear pulse-code modulation and delta modulation (sampling, quantization and coding) 9. Discrete signal transmission 10. Time- and frequency-domain multiplexing 11. Signal compression 12. Quality of communication – detection and correction coding and applications (example) 13. Quality of communication – automatic request of retransmission and applications (example) 14. Organization of teletraffic in various topological structures (bus, ring, star) 15. Standards in digital signal transmission systems (digital hierarchies)
Examination:	Exam at the end of semester
Teaching media:	Transparencies/Powerpoint presentations, computer based exercises.
Literature:	<ol style="list-style-type: none"> 1. Bruen, "Cryptography, information theory, and error-correction : a handbook for the 21st century" 2. S. Roman, „Introduction to coding and information theory" 3. Glover, „Digital communications. Advanced topics in Shannon sampling and interpolation theory" 4. M. J. Ucher, „Information theory for information technologists" 5. R. Hamming, „Coding and information theory"

3 Courses from Halmstad (2nd Semester)

Note: The official course plans are those published at the Halmstad University web site. In the case of any difference between these and the present document, the official course plans should be used.

Degree programme:	Information Technology (Master)
Course name:	AUTONOMOUS MECHATRONICAL SYSTEMS
Abbreviation or number:	
Semester:	Second semester
Responsible lecturer:	
Lecturers:	
Language:	English
Relation to curriculum:	Optional in the second semester.
Teaching type / hours:	Instruction entails lectures and laboratory works.
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	Knowledge equivalent to the courses Signal analysis and representation 7.5 credits, Digital control theory 7.5 credits, Embedded systems programming 7.5 credits, cooperating Intelligent Systems 7.5 hp, and Intelligent vehicles 7.5 credits. Programming in C is also required.
Goals:	<p>The goal of the course is for students to gain knowledge on how to integrate sensors and actuators in an autonomous mechatronical system.</p> <p>Upon completion of the course the student shall be able to:</p> <ul style="list-style-type: none"> • apply, appraise and explain sensors like colour cameras, basic image processing algorithm and some sensors for data acquisition • describe how to control a DC-motor in torque and how to integrate a gearbox with a DC-motor • develop an autonomous system navigated by a camera and other methods for navigate a robot
Contents:	<p>The lectures present methods for designing autonomous mechatronical systems with focus on signal processing of sensor values, basic image processing, and some principals of different controls of actuators.</p> <p>In the project part the students will build and program a mobile autonomous robot. The programmed robot shall solve a predefined task. The project contains different parts that have to be solved with for example image processing algorithms or navigation. The robots are constructed with Lego parts, sensors, actuators, colour camera and DSP-processor. The students work in group of 2 or 3 students per project.</p>
Examination:	Examination is to show that the robot solves the predefined task and some written report.
Teaching media:	.
Literature:	A compendium available from the course home page and recommended scientific papers available through the University library.

Degree programme:	Information Technology (Master)
Course name:	CHANNEL CODING AND DIGITAL COMMUNICATIONS
Abbreviation or number:	---
Semester:	Second semester
Responsible lecturer:	Dr. Elisabeth Uhlemann, Assistant Professor in Wireless Real-Time Communications
Lecturers:	Dr. Elisabeth Uhlemann
Language:	English
Relation to curriculum:	Optional in the second semester.
Teaching type / hours:	Instruction entails lectures and laboratory works.
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	The course Signal analysis and representation 7.5 credits. Note that courses in mathematical statistics, digital signal processing and programming will facilitate the task of assimilating the course content.
Goals:	<p>The course aims at giving a general understanding of digital communication and how to efficiently transmit information from a source to a destination.</p> <p>Upon completion of the course the student shall be able to</p> <ul style="list-style-type: none"> • analyze and evaluate digital communication systems and elaborate on trade-offs between various parameters, such as bandwidth and signal power, based on system requirements, design limitations and requested error performance • construct optimal detectors • describe some channel codes • apply and estimate the performance of the most common decoding algorithms
Contents:	An introduction on how to evaluate the quality of the received information is provided, as well as what factors limit and determine the performance of a communication system. Review of signals and random processes. Sampling and quantisation. Description of some modulation and demodulation methods. Definition of some noise and channel models. Matched filter and optimum detection. Overview of channel capacity and channel coding. Linear block and convolutional codes, code properties and error performance. Modulation and coding trade-offs.
Examination:	Examination is made in the form of requirements on completed and approved written reports from the home assignments as well as a written exam.
Teaching media:	
Literature:	Bernard Sklar, <i>Digital Communications: Fundamentals and Applications</i> , Prentice Hall, 2001. ISBN 0-13-084788-7.

Degree programme:	Information Technology (Master)
Course name:	COMPUTER LANGUAGES
Abbreviation or number:	
Semester:	Second semester
Responsible lecturer:	Dr. Veronica Gaspes, senior lecturer in Computer science.
Lecturers:	Dr. Veronica Gaspes
Language:	English
Relation to curriculum:	Optional in the second semester.
Teaching type / hours:	A series of lectures introduces concepts, tools and programming techniques, including data structures. The lectures are complemented with short supervised computer based exercises that provide experience in the use of tools and programming techniques. Supervision is also provided for a project where students build a compiler for a small programming language.
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	Knowledge equivalent to the courses Applied mathematics for computer science and engineering 7.5 credits and Embedded systems programming 7.5 credits.
Goals:	<p>The course serves as an introduction to how computer languages are described and processed, with a certain focus on programming languages. The course introduces techniques used to describe the syntax and implementation of computer languages. After completing the course, the student should be able to design and implement simple computer languages.</p> <p>The course makes use of the students' experience with computer languages and their understanding of computer organization and provides insights that will allow them to learn new computer languages and to participate in the implementation of small computer languages. Students will be able to take advanced courses in compiler techniques and on concepts of programming languages.</p> <p>On completion of the course the student shall be able to</p> <ul style="list-style-type: none"> • explain how the syntax of computer languages is described using grammars and how syntactic wellformedness can be checked • explain relevant semantic restrictions such as scope and welltypedness, as well as how they can be checked • explain how programming languages can be translated for execution • use tools for parser generation • organize and implement a small compiler • learn new languages and contribute to the development of new languages • compare computer languages based on fundamental concepts such as type system and parameter passing conventions • judge the suitability of different computer languages for different purposes

Contents:	<p>Regular expressions, finite state automata, lexer generators, lexicographic analysis of computer languages.</p> <p>Context free grammars, push-down automata, parse trees, abstract syntax, parser generators, syntactical analysis of computer languages.</p> <p>Context analysis, bindings, environments, scope, types.</p> <p>Compilation of programming languages, intermediate representation, code generation.</p> <p>The course features discussion of scientific literature with focus on, for example, domainspecific languages, functional languages or languages for distributed applications.</p>
Examination:	An oral exam based on the project is used to evaluate the students.
Teaching media:	.
Literature:	Appel, A., Palsberg, J., <i>Modern Compiler Implementation in Java</i> , 2 nd edition, Cambridge University Press, 2002.

Degree programme:	Information Technology (Master)
Course name:	DIGITAL CONTROL
Abbreviation or number:	---
Semester:	Second semester
Responsible lecturer:	Dr. Ulf Holmerg, professor of automatic control
Lecturers:	Dr. Elisabeth Uhlemann
Language:	English
Relation to curriculum:	Optional in the second semester.
Teaching type / hours:	The teaching is by lectures and computer exercises.
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	Basic course in automatic control and the course Signal Analysis and Representation 7.5 credits or the course Signals and Systems 7.5 Credits, or equivalent.
Goals:	<p>The student should get an understanding for discrete-time control systems, how to analyze, design and implement digital controllers.</p> <p>Upon completion of the course the student shall be able to:</p> <ul style="list-style-type: none"> • exemplify and analyze control systems described by difference equations • show how a process model can be estimated from measurement data • use a model-based design method for controller synthesis and implementation of a controller • evaluate the influence of model uncertainty
Contents:	The course is focusing on control systems described by difference equations and how such models can be estimated and used in model-based control design. Special emphasis is put on practical design criteria where model uncertainties are taken into account. Moreover, an implementation structure for constrained controller actuation is considered. Also, optimal reference tracking and disturbance rejection is studied.
Examination:	The examination is oral after passed computer exercises.
Teaching media:	.
Literature:	Holmberg, U. (2007). <i>Digital control</i> .

Degree programme:	Information Technology (Master)
Course name:	DISTRIBUTED REAL-TIME SYSTEMS
Abbreviation or number:	
Semester:	Second semester
Responsible lecturer:	Dr. Tony Larsson, Professor of Embedded Systems.
Lecturers:	Dr. Tony Larsson, Professor of Embedded Systems.
Language:	English
Relation to curriculum:	Optional in the second semester.
Teaching type / hours:	Teaching is divided into lectures, seminars and projects. The student reads and prepares scientific journal articles in the area for presentation and discussion in seminar form. In laboratory work/project the student designs and evaluates alternative models for scheduling, partitioning, distribution or communication in a real time system with one or more processors. Final project results are documented in scientific style reports or papers and orally with support of overhead presentations material in seminar form.
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	Courses in Discrete Mathematics and Computer Systems including basic knowledge in programming and operating systems.
Goals:	Upon completion of the course the student shall be able to: <ul style="list-style-type: none"> • describe basic terminology, concepts and principles in the area of distributed real time systems • categorize, describe, analyze and apply methods for scheduling of tasks allocated to one computer • describe and apply methods for allocation and distribution of real time tasks in a distributed computer system • discuss the effect of limited communication resources • carry out experimental evaluations and present and discuss relevant problems, solutions, discoveries and results from such experiments and relate these to others described in scientific journals
Contents:	The course treats basic functions in real time operating system kernels; prioritization, load rejection, and scheduling, partitioning, allocation and distribution of tasks over single and multiple processors; synchronization and communication between distributed tasks; architecture and design principles for real-time embedded and distributed systems.
Examination:	Examination is based on a weighted average of seminar participation and presentations, project results and their documentation and presentation, and a final written examination..
Teaching media:	
Literature:	Selected journal articles, technical reports and scientific conference proceedings etc. Kopetz, Hermann. <i>Real-Time Systems - Design Principles for Distributed Embedded Applications</i> . Kluwer Academic Publishers, Boston, Massachusetts, 1997.

Degree programme:	Information Technology (Master)
Course name:	EMBEDDED PARALLEL COMPUTING
Abbreviation or number:	---
Semester:	Second semester
Responsible lecturer:	Dr. Bertil Svensson, Professor of Computer systems engineering
Lecturers:	Dr. Bertil Svensson, Professor of Computer systems engineering
Language:	English
Relation to curriculum:	Optional in the second semester.
Teaching type / hours:	<p>Instruction is in the form of lectures, laboratory sessions, project tutoring and seminars. The latter are given by the students based on literature studies and discussions on subjects determined in consultation with the course instructor.</p> <p>All participants in a seminar prepare themselves by reading an introductory text for the topic, while those responsible for the seminar search additional information and make presentation of this as a background for further discussion.</p> <p>The project and the seminars shall be documented in short reports. The laboratory sessions are mandatory, and also leading at least one seminar.</p>
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	The courses Cooperating Intelligent Systems 7.5 credits, Embedded Systems Programming 7.5 credits, and Applied Mathematics for Computer Science and Engineering 7.5 credits, or equivalent. Basic and continuation courses in computer organization, digital logic design, and computer programming from Bachelor programme.
Goals:	<p>The course is intended to provide knowledge of how parallel computing can be used as a way to meet application demands in embedded systems, such as performance and power efficiency. Further, it is intended to give a general insight into current research and development in regard to parallel architectures and computation models. Parallelism of various types exists in all modern computer architectures, and knowledge about how to apply parallelism is necessary, in particular, when designing embedded computer systems.</p> <p>Upon completion of the course, the student shall be able to:</p> <ul style="list-style-type: none"> • describe and explain the most important parallel architecture models, as well as parallel programming models, and discuss their respective pros, cons, and application opportunities, • practically demonstrate her understanding of parallel architectures and programming models by programming parallel computer systems intended for embedded applications, • judge, evaluate and discuss how the choice of programming model and method influences, e.g., execution time and required resources, • relate the state of the art in the area to the current research and development, in particular such research and development that is important for the design of embedded systems, • read and understand scientific articles in the area, to review and discuss them and to make summaries and presentations, and • find relevant research publications and research groups in the area and have acquired an ability to continuously follow the development

	through journals and conference publications.
Contents:	<p>The course is divided into a lecture part, a laboratory part including a small project, and a seminar part.</p> <p>The lecture part initially gives a motivation for parallelism, based on demands on embedded computing (such as performance and power efficiency) and applications that require parallelism. Then it presents the fundamentals of parallel architectures (forms of parallelism, SIMD, MIMD, dataflow, reconfigurable architectures, interconnection networks, etc.) and parallel programming models (shared memory, message passing, stream programming, communicating sequential processes, process networks, etc.). Example architectures and programming techniques are presented and discussed.</p> <p>The laboratory part provides hands-on experience of embedded parallel computing, primarily based on manycore processors on a chip and their available programming tools.</p> <p>In the seminar part of the course, course participants make detailed studies of various sub-areas or specific architectures and lead seminars in these. The university's research projects are included in these special studies.</p>
Examination:	Examination of the lecture part of the course is by written exam at the end of the course. Bonus points for the written exam may be earned through participation in the seminars and providing correct answers on the written quizzes. The quality of the specific seminar or seminars that the student is responsible for is also weighed into the final grade.
Teaching media:	.
Literature:	<p>A suitable textbook (see below) is used for the lecture part. The textbook may be complemented with additional journal papers. An electronic compendium with introductory texts is used for the seminars, to which the students find additional material available in the scientific publication databases that the University has access to.</p> <p>These are examples of books for use in the lecture part:</p> <p>Wolf, W., <i>High-performance Embedded Computing: Architectures, Applications, and Methodologies</i>, Morgan Kaufmann, 2007.</p> <p>Hennessy, J.L. and D.A. Patterson, <i>Computer Architecture: A Quantitative Approach</i>, Fourth Edition, Morgan Kaufmann, 2006.</p> <p>Almasi, G.S. and A. Gottlieb, <i>Highly Parallel Computing</i>, 2nd Edition, Benjamin/Cummings, 1994.</p> <p>Zomaya, A.Y.H. (ed), <i>Parallel and Distributed Computing Handbook</i>, McGraw-Hill, 1996</p>

Degree programme:	Information Technology (Master)
Course name:	INTELLIGENT VEHICLES
Abbreviation or number:	---
Semester:	Second semester
Responsible lecturer:	
Lecturers:	
Language:	English
Relation to curriculum:	Optional in the second semester.
Teaching type / hours:	Instruction is by lectures, weekly discussions on scientific papers and exercises. The exercises is documented by a written report.
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	The courses Applied mathematics for computer science and engineering 7.5 credits, Signal analysis and representation 7.5 credits, Cooperating Intelligent Systems, and Control theory 7.5 credits or equivalent are prerequisites for the course. It is also recommended that the student has basic knowledge of mathematical statistics..
Goals:	<p>The goal of the course is to provide advanced knowledge for being able to develop intelligent vehicles and mobile robots with the emphasis on sensor systems, signal processing and control and regulation. The course focuses on sensor fusion, i.e. how information from several sensors should best be combined.</p> <p>Upon completion of the course the student shall be able to:</p> <ul style="list-style-type: none"> • apply, appraise and explain fundamental models for dead-reckoning and kinematic models and methods for combining information from several sensors • describe and compare different navigation systems for indoor and outdoor navigation • explain how basic GPS- systems work
Contents:	The course addresses: Dead-reckoning and kinematics models, indoor navigation systems, outdoor navigation systems (e.g. GPS-based systems), sensor fusion (with a focus on the Kalman filter and the Extended Kalman filter), path-planning, vehicle control and obstacle avoidance, human-machine interaction..
Examination:	Examination is in the form of a written or oral exam and exercises.
Teaching media:	.
Literature:	Siegwart, R. & Nourbakhsh, I. R. (2004). <i>Introduction to Autonomous Mobile Robots</i> . Massachusetts: the MIT Press. ISBN 0-262-19502-X. Scientific papers available at the University Library.

Degree programme:	Information Technology (Master)
Course name:	LEARNING SYSTEMS
Abbreviation or number:	
Semester:	Second semester
Responsible lecturer:	Dr. Nicholas Wickström, Senior lecturer in Information technology.
Lecturers:	Dr. Nicholas Wickström, Senior lecturer in Information technology.
Language:	English
Relation to curriculum:	Optional in the second semester.
Teaching type / hours:	Instruction consists of lectures, seminars and practical projects. In seminars, scientific literature/articles are addressed and presented by the student. In the project the student solves a practical problem using machine learning methods. This project is concluded with a written report and oral presentation at a seminar. Attendance at seminars is obligatory..
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	The courses Cooperating Intelligent Systems 7.5 credits, Signal analysis and representation 7.5 credits and Applied mathematics for computer science and engineering 7.5 credits, or equivalent.
Goals:	<p>The course aims at providing an overview of the field machine learning; learning and self-organizing systems for classification and prediction.</p> <p>.</p> <p>Upon completion of the course, the student shall be able to</p> <ul style="list-style-type: none"> • judge when the methods introduced in the course is applicable • read and comprehend scientific material in the area • apply the methods on real world problems • assimilate and present scientific results in the learning systems area
Contents:	Overview of learning systems. Overview of classification and regression. Overview of products on the market and common application areas for learning systems. Important aspects and standard methods in learning systems. The most common techniques and models for learning systems will be introduced e.g., artificial neural networks and self-organizing maps..
Examination:	Examination is by approved projects, seminar presentations, and an oral or written exam.
Teaching media:	
Literature:	R.O. Duda, P.E. Hart, D.G. Stork, <i>Pattern Classification</i> , New York: John Wiley & Sons, 2001, pp. xx + 654, ISBN: 0-471-05669-3

Degree programme:	Information Technology (Master)
Course name:	MODERN COMMUNICATION SYSTEMS AND NETWORKS
Abbreviation or number:	
Semester:	Second semester
Responsible lecturer:	Dr. Magnus Jonsson, Professor of Real-time computer systems
Lecturers:	Dr. Magnus Jonsson, Professor of Real-time computer systems
Language:	English
Relation to curriculum:	Optional in the second semester.
Teaching type / hours:	The teaching consists of lectures, a larger project exercise (or paper writing) and project seminars.
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	The course Data communication I 7.5 credits or equivalent.
Goals:	<p>The course shall give understanding of important methods, architectures, and implementations of modern communication systems and networks. The aim of the course is to give experiences in obtaining information from advanced-level literature and scientific papers, and of critical examination of scientific results from fields that involves communication in the Internet, LAN, and other networks.</p> <p>Upon completion of the course the student shall be able to</p> <ul style="list-style-type: none"> • explain how methods, protocols, and architectures treated in the course works, which limitations they have, and in what situations they can be used • gather information from scientific papers and critically examine scientific results in the field • obtain deeper knowledge in a specific subfield, including research results, and be able to present such knowledge.
Contents:	<p>Selected subjects will be treated in form of lectures and seminars. The focus is put on currently important fields, which means that the seminar subjects will be adapted for the actual course start. Although, possible subjects to be penetrated can be mentioned: routing in large internet networks (e.g., BGP4), multimedia communications, traffic models, VLAN, switch and router architectures, active networks, TCP details, application protocols, multicasting, protocols for optical networks, networks in parallel and distributed systems, system area networks (e.g. Infiniband), admission control, Internet QoS (RSVP, DiffServ, RTP etc), and IP telephony. Each student shall, in group, do a larger project exercise or write a paper (investigation, simulation, experiment or similar) to get deeper understanding of a specific subfield.</p>
Examination:	Examination is done in form of quizzes in connection with some of the lectures, written exam, project reports and presentations.
Teaching media:	
Literature:	Scientific papers available through the University library, slide copies from the lectures. The course literature will be updated for the actual course start to, e.g., reflect for recent advances in the field.

Degree programme:	Information Technology (Master)
Course name:	REAL-TIME NETWORKING
Abbreviation or number:	---
Semester:	Second semester
Responsible lecturer:	Dr. Magnus Jonsson, Professor of Real-time computer systems
Lecturers:	Dr. Magnus Jonsson, Professor of Real-time computer systems
Language:	English
Relation to curriculum:	Optional in the second semester.
Teaching type / hours:	The teaching consists of lectures and a larger project exercise.
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	The courses Cooperating Intelligent Systems 7.5 credits, Embedded Systems Programming 7.5 credits, and Applied Mathematics for Computer Science and Engineering 7.5 credits, the course Data Communication I, or equivalent.
Goals:	<p>The goal of the course is to give understanding and knowledge of communication and networks in embedded systems and essential concepts and methods used in such systems. Especially, the course shall give understanding of performance and real-time analysis of the communication systems and networks used in networked embedded systems. Furthermore, the course shall give examples from state-of-the-art research within the field.</p> <p>Upon completion of the course, the student shall be able to</p> <ul style="list-style-type: none"> • describe terminology, methods, protocols, and architectures for networked embedded systems • describe how methods etc can be used in a larger context, and be able to apply gathered knowledge in new situations • show abilities in simulation and performance evaluation of communication principles for networked embedded systems
Contents:	<p>Introduction to embedded networking and temporal control of communication. Processor and network scheduling. Static and dynamic scheduling. Preemptive and non-preemptive scheduling. Time-driven scheduling. Resource constraints. Precedence constraints. Priority inversion. Jitter handling. Holistic scheduling. Complexity analysis. Real-time analysis for distributed systems. Real-time networks and protocols (Industrial Ethernet, field buses etc). Networks for safety-critical applications (e.g., FlexRay, TTP, AFDX). Real-time analysis of field bus communication. Real-time analysis of switched networks. Wireless real-time communication including sensor networks. Performance evaluation and simulation.</p> <p>Each student shall, in group, do a larger project exercise where a specific protocol, communication scheduling method or similar is simulated and evaluated.</p>
Examination:	Examination is done in form of written assignments, written exam and project report.
Teaching media:	.
Literature:	Scientific papers available at the University library, slide copies from the lectures. The course literature will be updated for the actual course start to, e.g., reflect for recent advances in the field.

Degree programme:	Information Technology (Master)
Course name:	WIRELESS COMMUNICATION SYSTEMS
Abbreviation or number:	
Semester:	Second semester
Responsible lecturer:	
Lecturers:	
Language:	English
Relation to curriculum:	Optional in the second semester.
Teaching type / hours:	Teaching includes lectures and an individual assignment. The course includes a theoretical component of 5 credits and a project component of 2.5 credits.
Students' workload:	The equivalent of five weeks full time work. This includes approximately 60 hours of teacher led education.
ECTS credits:	7.5 ECTS credits
Prerequisites:	A course in data communication.
Goals:	<p>The objective of the course is to give a basic understanding and knowledge of wireless communication systems, to be able to analytically rate different technologies for wireless applications.</p> <p>Upon completion of the course the student shall be able to</p> <ul style="list-style-type: none"> • explain how factors can be interpreted that impact upon and limit the performance of different wireless communication systems • describe methods that are used in wireless communication systems • synthesize these methods into a wireless communication system for a specific application scenario. • describe existing standards at a comprehensive level • enter deeply into a partial area and critically judge and compare techniques related to wireless communication
Contents:	<p>Part I Basic radio technology Antennae, wave propagation, fading, channel coding, modulation multiplexing, spread spectrum.</p> <p>Part II Application areas Satellite communication, cellular systems, short range wireless systems.</p> <p>Part III Student project Each student conducts an individual project (investigation, implementation, simulation) to gain a deeper knowledge in a specific area within the subject of wireless communication.</p>
Examination:	The examination of theory part is conducted by written exam; the grades of fail together with the pass grades of 3, 4 and 5 will be awarded for this part of the course. The examination of the individual assignment is conducted by means of a written report; grades of fail or pass will be awarded for this part of the course.
Teaching media:	.
Literature:	Stallings, W. (2002). <i>Wireless Communications and Networks</i> . New Jersey: Prentice Hall.

4 Courses from Lemgo (2nd Semester)

Degree programme:	Information Technology (Master)
Course name:	Communication for Distributed Systems
Abbreviation / number	CDS / 5900
Semester:	2nd Semester, summer
Responsible lecturer:	Prof. Dr. Stefan Witte, Prof. Dr. Jürgen Jasperneite
Lecturers:	Prof. Dr. Stefan Witte, Prof. Dr. Jürgen Jasperneite
Language:	English
Relation to curriculum:	Optional course
Teaching type / hours:	Lecture / 3 hours per week, Lab / 2 hours per week
Students' workload:	180 hours = 75 hours confrontation time (lectures, exercises, and labs) plus 105 hours additional student individual work/homework time
ECTS credits:	6 CR
Prerequisites:	---
Goals:	The course is intended to provide knowledge about distributed real-time systems, Performance Evaluation and Protocol engineering of communication networks
Contents:	<p>Lecture:</p> <ol style="list-style-type: none"> 1) Introduction to distributed systems: What are distributed Systems, Requirements for distributed Real-time systems , Communication approaches, 2) System theory and technologies: Basic communication concepts, Service and Protocols, Layered Communications System, Reference Models (OSI), Technologies used at different layers, Synchronisation and clocks 3) Performance Evaluation of Communication Systems: Network Simulation: Basic Simulation Modeling, OPNET Modeler - A Tool for Discrete Event Simulation, Recap: Probabilities and Statistics, Create Models and Validation, Review of Basic Probabilities and Statistics, Analysis of Simulation Results <p>Lab:</p> <ol style="list-style-type: none"> 1) Exercises related to lectures 2) Communication Protocol Engineering with Telelogics TAU 3) Measurements at physical layers and layer 2 investigations. 4) Socket programming and evaluation 5) Performance Evaluation of a Communication Network with OPNET Simulator
Examination:	Written examination (3 hours). Bonus points of project work will be included. The course grade equals the grade of the written examination.

Teaching media:	Blackboard, Overhead/Beamer, Computer simulations
Literature:	<p>Andrew S. Tanenbaum: Computer Networks, 4th Edition, Prentice Hall, 2003</p> <p>Andrew S. Tanenbaum, Maarten van Steen; Distributed Systems-Principles and Paradigms - , Prentice Hall</p> <p>George Coulouris, Jean Dollimore, Tim Kindberg, "Distributed Systems, Concepts and Design", Addison-Wesley</p> <p>Averill M. Law, W. David Kelton, "Simulation Modeling and Analysis", Mc Graw Hill, 2000</p> <p>R. Jain, "The Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation, and Modeling", Wiley- Interscience, New York, NY, April 1991</p> <p>Miroslav Popovic, Communication Protocol Engineering, CRC, 2006</p>

Degree programme:	Information Technology (Master)
Course name:	Information Fusion
Abbreviation / number	IFU / 5907
Semester:	2nd semester, summer
Responsible lecturer:	Prof. Dr. Volker Lohweg
Lecturer:	Prof. Dr. Volker Lohweg
Language:	English
Relation to curriculum:	Optional course
Teaching type / hours:	Lecture / 3 hours per week, Lab / 2 hours
Students' workload:	180 hours = 75 hours confrontation time (lectures, exercises, and labs) plus 105 hours additional student individual work/homework time
ECTS credits:	6 CR
Prerequisites:	Mathematics for undergraduates, Signals and Systems or System Modeling and Analysis, Image Analysis or Digital Image Processing
Goals:	Information Fusion identifies the concept of combining data from different information sources, such as sensors or human experts. The conceptual strategy is based on obtaining new or more certain information by data combination. In numerous applications it is not possible to capture all necessary information or features by a single sensor source. In such cases more sensors and additive expert's know-how can generate more precise data regarding different real world systems, e.g. robots, machines and equipment, data experts systems, cognitive systems and so on.
Contents:	The following topics are highlighted: Sensory Signal Representation Fusion Models Human-centric Models Fusion Methods Statistical Concepts Dempster-Shafer-Theory (Evidence Theory) Fuzzy Concepts Multi-Sensor-Fusion Real World Examples
Examination:	programming project with presentation (30 min), graded
Teaching media:	Beamer, blackboard, charts, script
Literature:	Bosse, Eloi; <i>Concepts, Models, and Tools for Information Fusion</i> , Artech House Publishers, Boston, MA, USA 2007. Fuzzy Models and Algorithms for Pattern Recognition and Image Processing, James C. Bezdek (Editor), James Keller, Raghu Krishnapuram, Nikhil Pal, 1999. Shafer, Glenn; <i>A Mathematical Theory of Evidence</i> , Princeton University Press, 1976. Campos, Fabio; <i>Decision Making in Uncertain Situations: An Extension to the Mathematical Theory of Evidence</i> , dissertation.com, Boca Raton, FL, USA 2006.

Degree programme:	Information Technology (Master)
Course name:	Innovation and Development Strategies
Abbreviation / number	IDS / 5912
Semester:	2nd semester, summer
Responsible lecturer:	Prof. Dr.-Ing. Volker Lohweg
Lecturers:	Prof. Dr. Reinhard Doleschal, Prof. Dr. Volker Lohweg, Visiting lecturers: Dipl.-Ing. Roland Bent, Dipl.-Ing. ETH Johannes Schaede
Language:	English
Relation to curriculum:	Compulsory course
Teaching type / hours:	lectures, exercises, project work students also spend time using/applying materials from lectures to perform semester group projects / 5 hours per week
Students' workload:	180 hours = approx. 50 hours confrontation time (lectures, exercises, presentations) plus 130 hours additional student individual work/homework time and/or group work time, depending on selection of themes
ECTS credits:	6 CR
Prerequisites:	Elementary management skills
Goals:	The student obtains knowledge about fundamental principles and methods for innovation and development processes based on intercultural R&D strategies, knowledge management, portfolio analysis, risk management, and patent strategies for international companies.
Contents:	<ul style="list-style-type: none"> ▪ Intercultural management <ul style="list-style-type: none"> ○ What is culture? ○ Cultural behaviour ○ International R&D teams ▪ Knowledge management <ul style="list-style-type: none"> ○ What is company knowledge? ○ How to handle knowledge? ○ Knowledge distribution strategies ▪ Development processes <ul style="list-style-type: none"> ○ Portfolio analysis ○ Risk analysis, FMEA ○ Processes for mass products ○ Processes for single products ▪ Patent management <ul style="list-style-type: none"> ○ What are patents, patents applications, trademarks? ○ How to read patents? ○ Patent processing
Examination:	Oral examination and written report
Teaching media:	Beamer projector, whiteboard/chalkboard, papers

Literature:

- Jacob, N.: Intercultural Management: MBA Masterclass, Kogan Page, 2003.
- Rapaille, C.: The Culture Code, Random House, 2006.
- Davenport, Th. H.; Prusak, L.: Working Knowledge: How Organizations Manage What They Know. Harvard Business School Press, Boston/Massachusetts 1997.
- Nonaka, I.; Takeuchi, H.: The Knowledge-Creating Company: How Japanese companies create the dynamics of innovation. Oxford University Press, New York 1995.
- North, K.: Wissensorientierte Unternehmensführung, Wertschöpfung durch Wissen. Gabler, Wiesbaden 1998.
- Kerth/ Püttmann (2007): Die besten Strategietools in der Praxis, 2. Aufl.
- Oetinger von, B. (2000): Das Boston-Consulting-Group-Strategie-Buch: die wichtigsten Managementkonzepte für Praktiker, 8. Aufl., Düsseldorf 2000.
- Vose, D.: Risk Analysis: A Quantitative Guide, John Wiley & Sons, 3. ed., 2008.
- Eversheim, W. (Ed.): Innovation Management for Technical Products: Systematic and integrated product development and production planning, RWTH Edition, Springer, Berlin, 2008.
- Stim, R.: Patent, Copyright & Trademark (Patent, Copyright & Trademark: A Desk Reference to Intellectual Property Law), Nolo PR, 2009.
- Lecture Slides

Degree programme:	Information Technology (Master)
Course name:	Intelligent Sensors
Abbreviation / number	INS / 5901
Semester:	2nd Semester, summer
Responsible lecturer:	NN
Lecturers:	NN
Language:	English
Relation to curriculum:	Compulsory course
Teaching type / hours:	--- / 5 hours per Week
Students' workload:	180 hours = 75 hours confrontation time (lectures, exercises, and labs) plus 105 hours additional student individual work/homework time
ECTS credits:	6 CR
Prerequisites:	---
Goals:	---
Contents:	---
Examination:	---
Teaching media:	---
Literature:	---

Degree programme:	Information Technolgy (Master)
Course name:	Network Security
Abbreviation / number	NWS / 5908
Semester:	2nd semester, summer
Responsible lecturer:	Prof. Dr. Stefan Heiss
Lecturers:	Prof. Dr. Stefan Heiss
Language:	English
Relation to curriculum:	Optional course
Teaching type / hours:	Lecture / 3 hours per week, Lab / 2 hours
Students' workload:	180 hours = 75 hours confrontation time (lectures, exercises, and labs) plus 105 hours additional student individual work/homework time
ECTS credits:	6 CR
Prerequisites:	Basic knowledge of networking and IP related protocols
Goals:	<p>The students acquire a solid knowledge about threads to security and privacy in networked and distributed systems. Different security mechanisms specified in current network protocols are known and can be rated with respect to their applicability.</p> <p>Necessary background from the field of applied cryptography is provided in the lecture.</p> <p>The students carry out a detailed study of some selected security related protocol or recently published attack (project work).</p>
Contents:	<p>Networking applications and protocols and their vulnerabilities, IT Security (Aims, Threads, Secure Programming), Applied cryptography (basic mechanisms, selected algorithms and their applications), Public key infrastructures (PKI), Security and privacy in networked and distributed systems: Data link layer security (IEEE 802.11, Bluetooth), network layer security (IPsec), and transport and application layer security mechanisms (TLS).</p> <p>Selected protocols and recent attacks are studied in depth (project work).</p>
Examination:	<p>Successful completion of lab exercises and project work.</p> <p>Written examination.</p> <p>The course grade equals the grade of the written examination.</p>
Teaching media:	<p>Lectures: computer presentations, blackboard, handouts</p> <p>Labs: LAN/WLAN traffic and packet analysis, sniffing and spoofing tools, securing networks (PKI and VPN configurations)</p>
Literature:	<p>R. Anderson: Security Engineering, Wiley, 2008</p> <p>C. Kaufman, R. Perlman, M. Speciner: Network security, Prentice Hall, 2002</p> <p>A. J. Menezes, P. van Oorschot, S. A. Vanstone, Handbook of Applied Cryptography, CRC-Press 1996</p> <p>W. Stallings, Cryptography and Network Security: Principles and Practice, Prentice Hall 2006</p> <p>J. C. Snader: VPNs Illustrated. Tunnels, VPNs, and IPsec, Addison-Wesley Longman 2005</p>

Degree programme:	Information Technology (Master)
Course name:	Signal Processing Algorithms
Abbreviation / number	SPA / 5902
Semester:	2nd semester, summer
Responsible lecturer:	Prof. Dr.-Ing. Volker Lohweg
Lecturers:	Prof. Dr.-Ing. Volker Lohweg
Language:	English
Relation to curriculum:	Optional course
Teaching type / hours:	Lecture / 3 hours per week, Exercise / 2 hours
Students' workload:	180 hours = 75 hours confrontation time (lectures, exercises, and labs) plus 105 hours additional student individual work/homework time
ECTS credits:	6 CR
Prerequisites:	Mathematics for undergraduates, Signals and Systems, Digital Design
Goals:	The course shall provide knowledge in the field of linear and nonlinear digital signal processing algorithms and their hardware implementations. Especially nonlinear concepts in digital signal processing are of actual interest in a wide area of signal, bio-systems, image and multimedia processing applications. After the course the student is able to analyze and map algorithms onto different hardware platforms, such as DSPs and ASICs (FPGAs).
Contents:	<p>One keypoint is the implementation of algorithms in DSPs and FPGAs or ASICs with the help of linear systolic arrays (LSAs). The theory and practical aspects of systolic designs, optimal array scheduling, Cut-Set-Retiming procedures and the design of processing elements (PEs) as well as hardware-software co-design will be highlighted.</p> <p>Different LSA-implementations for hardware accelerators will be discussed:</p> <ul style="list-style-type: none"> Correlation and Convolution FIR filters Wavelets Spectral transforms 1D- and 2D- position invariant transforms (PIT)
Examination:	Project with presentation (30 min), graded
Teaching media:	Beamer, blackboard, charts, script Signal Processing Algorithms
Literature:	<p>Megson, G. M.: An Introduction to Systolic Algorithm Design, Clarendon Press, Oxford 1992.</p> <p>Kung, S. Y.: VLSI Array Processors, Prentice Hall, New Jersey 1988.</p> <p>Horn, R. A.; Johnson, C.R.: Topics in Matrix Algebra, Cambridge University Press 1994 (reprint 1999)</p> <p>Poularikas, A. D. (Ed.): The Transforms and Applications Handbook, 2. Edition, CRC Press and IEEE Press, 2000</p>

Degree program:	Information Technology (Master)
Course name:	System Modeling and Simulation
Abbreviation / number	SYM / 5609
Semester:	2nd semester, summer
Responsible lecturer:	Prof. Dr. Oliver Niggemann
Lecturers:	Prof. Dr. Oliver Niggemann
Language:	English
Relation to curriculum:	Optional course
Teaching type / hours:	Lecture / 3 hours per week, Lab / 2 hours
Students' workload:	180 hours = 75 hours confrontation time (lectures, exercises, and labs) plus 105 hours additional student individual work/homework time
ECTS credits:	6 CR
Prerequisites:	Basic knowledge of computer languages, software development and control engineering.
Goals:	Enable students to model and simulate embedded and real time systems. Those models can then be used i) to improve the design and implementation process, ii) to improve the system's documentation and maintainability, iii) to support the system diagnosis, and iv) to serve as a basis for the testing of the system both using PC-based simulations and Hardware-in-the-Loop Tests.
Contents:	<p>Block I: Advantages of System Models</p> <p>Block II: Overall System Models: System components, Classification of system components, Examples: SysML, Non-functional system features, Domain Specific Languages</p> <p>Block III: SW Structure Models: SW Components, Example: AUTOSAR, Service-oriented models</p> <p>Block IV: SW Behavior Models: Automatas, Continuous controller models (e.g. SL), Code generation from behavior models, Simulation of automatas and continuous controller models</p> <p>Block V: Plant Models: Discreet models, ODE-based models, physical, DAE-based and hybrid models (e.g. Modelica), Simulation of these models, Probabilistic models, Realtime topics</p>
Examination:	Successful completion of lab exercises and project work. Written examination. The course grade equals the grade of the written examination.
Teaching media:	Lectures: computer presentations, blackboard, handouts Labs: Usage of typical modeling environments
Literature:	<p>Francois E. Cellier and Ernesto Kofman. Continuous system simulation. Springer, 2006</p> <p>T. Weilkiens. Systems Engineering with SysML/UML: Modeling, Analysis, Design. Morgan Kaufmann, 2008.</p>

Degree programme:	Information Technology (Master)
Course name:	Software Engineering for Web Services
Abbreviation / number	SWE / 5903
Semester:	2nd semester, summer
Responsible lecturer:	Prof. Dr.-Ing. Thomas Korte
Lecturers:	Prof. Dr.-Ing. Thomas Korte
Language:	English
Relation to curriculum:	Optional course
Teaching type / hours:	Lecture / 1 hour per week, Lab / 4 hours
Students' workload:	180 hours = 75 hours confrontation time (lectures, exercises, and labs) plus 105 hours additional student individual work/homework time
ECTS credits:	6 CR
Prerequisites:	<ul style="list-style-type: none"> - familiarity with Object Oriented Programming - some advances in Java programming - networking fundamentals - algorithms and data structures
Goals:	This course exposes students to state of the art WWW technologies for building business to business applications. Extensive lab time is provided for the development of simple client/server applications using Web Services.
Contents:	Web Services are services offered via the Web. These services are requested by clients using the http protocol. They are part of a modern, service oriented software architecture (SOA). Typical Web services are employed by E-commerce applications like online-shops or business-to-business applications. This course teaches and practises the development of Web Services based on Java using several software technologies. After an introduction to these specific technologies the major part of the course consists of a Web Service development project.
Examination:	Exercise problems, written examination The course grade equals the grade of the written examination.
Teaching media:	Beamer / charts, computer, tools for Software development
Literature:	Script and programming problems are available for downloading. G. Alonso, F. Castsati, H. Kuno, V. Machiiraju: Web Services – Concepts, Architectures and Applications. Springer-Verlag Berlin Heidelberg New York, 2004.

Degree programme:	Information Technology (Master)
Course name:	Wireless Communications
Abbreviation / number	WLC / 5904
Semester:	2nd semester, summer
Responsible lecturer:	Prof. Dr.-Ing. Uwe Meier
Lecturers:	Prof. Dr.-Ing. Uwe Meier
Language:	English
Relation to curriculum:	Optional course
Teaching type / hours:	Lecture / 3 hours per week, Exercise / 1 hour, Lab / 1 hour
Students' workload:	180 hours = 75 hours confrontation time (lectures, exercises, and labs) plus 105 hours additional student individual work/homework time
ECTS credits:	6 CR
Prerequisites:	Signals and linear systems, basics of modulation, basics of random processes
Goals:	<p>Students acquire system theoretical knowledge of the physical and MAC layer of modern radio systems.</p> <p>They are able to determine and to model real propagation channel characteristics. They can assess the performance limits of wireless systems including modulation and channel coding.</p> <p>They learn how to use appropriate simulation and network planning tools in order to predict the quality and the limitations of wireless radio systems.</p>
Contents:	<p>Mobile radio channels (multipath propagation, DOPPLER effects, BELLO functions, channel measurements and characterization, channel modeling)</p> <p>Advanced modulation methods (theoretical limitations, spread spectrum systems, multicarrier systems, ultra wide band radio)</p> <p>Channel coding including space-time codes, MIMO (multiple input multiple output) systems</p> <p>Further topics: software defined radio (SDR), cognitive radio systems</p>
Examination:	<p>Project work (2 students per group) with presentation, lab reports, written examination.</p> <p>Bonus points from project work and lab reports will be considered in written examination. The course grade equals the grade of the written examination.</p>
Teaching media:	Beamer / charts, blackboard, lab equipment, simulation software
Literature:	<p>Script, exercise problems and lab tasks for downloading</p> <p>Simon Haykin, Michael Moher: Modern Wireless Communications; Pearson Prentice Hall; 2005</p> <p>T.S. Rappaport: Wireless Communications, Principles and Practice. Prentice Hall PTR; 2001</p> <p>K. Pahlavan, A.H. Levesque: Wireless Information Networks; John Wiley & Sons; New York 1995</p> <p>A. Paulraj, R. Nabar, D. Gore: Introduction to Space-Time Wireless Communications; Cambridge University Press; 2003</p>

5 Courses from Esbjerg (3rd Semester)

Degree programme:	Information Technology (Master)
Course name:	Computer Vision
Abbreviation or number:	CV
Semester:	Fall Semester
Responsible lecturer:	Jens Arnspang
Lecturers:	Jens Arnspang
Language:	English
Relation to curriculum:	compulsory for students choosing Computer Vision semester theme, optional for those choosing other themes
Teaching type / hours:	lectures, exercises/labs students also spend time using/applying materials from lectures to perform semester group project
Students' workload	55 hours confrontation time (lectures, exercises, and labs) plus 35 hours additional student individual work/homework time and/or group work time, depending on selection of semester theme
ECTS credits:	3 ECTS
Prerequisites:	Programming, algorithms and data structures, image analysis
Goals:	That the student obtains knowledge about fundamental theories, methods, and techniques for computer based manipulation and analysis of video pictures, visualization with computer graphics, and virtual reality.
Contents:	The duality between computer manipulation and analysis of video pictures and computer generation of synthetic pictures (computer graphics and virtual reality) is the main theme of the course. Methods and techniques for visualization and picture manipulation and interpretation as well as the use of computer vision systems for robot navigation and virtual reality are covered.
Examination:	oral examination, pass/fail grade, or examined as part of the project exam (with marks assigned) for those students choosing Computer Vision as semester theme
Teaching media:	slide projector, whiteboard/chalkboard
Literature:	Margaret W. Matlin & Hugh J. Foley: Sensation and Perception, 4th Edition Berthold K. P. Horn: Robot Vision

Degree programme:	Information Technology (Master)
Course name:	Control Theory
Abbreviation or number:	CT
Semester:	Fall Semester
Responsible lecturer:	Youmin Zhang
Lecturers:	Youmin Zhang
Language:	English
Relation to curriculum:	compulsory for students choosing Control Theory semester theme, optional for those choosing other themes
Teaching type / hours:	lectures, exercises/labs students also spend time using/applying materials from lectures to perform semester group project
Students' workload	55 hours confrontation time (lectures, exercises, and labs) plus 35 hours additional student individual work/homework time and/or group work time, depending on selection of semester theme
ECTS credits:	3 ECTS
Prerequisites:	general mathematics and physics, elementary matrix algebra, Laplace- and Z-transforms
Goals:	That the student obtains knowledge about fundamental principles and methods of conventional and modern control theories and their industrial applications.
Contents:	Dynamic system models and response, feedback control, root-locus method, frequency-response analysis and design, PID control, state-space analysis and design, digital control systems, multivariable control, kalman filters, basic nonlinear control, Matlab/Simulink, case studies.
Examination:	oral examination, pass/fail grade, or examined as part of the project exam (with marks assigned) for those students choosing Control Theory as semester theme
Teaching media:	slide projector, whiteboard/chalkboard
Literature:	R. C. Dorf and R. H. Bishop, <i>Modern Control Systems</i> , 9th Edition, Addison Wesley, 2001 (ISBN: 0-13-030660-6).

Degree programme:	Information Technology (Master)
Course name:	Database Systems
Abbreviation or number:	DBS
Semester:	Fall Semester
Responsible lecturer:	Nasrullah Memon
Lecturers:	Nasrullah Memon
Language:	English
Relation to curriculum:	optional
Teaching type / hours:	lectures, exercises/labs students also spend time using/applying materials from lectures to perform semester group project
Students' workload	55 hours confrontation time (lectures, exercises, and labs) plus 35 hours additional student individual work/homework time and/or group work time, depending on selection of semester theme
ECTS credits:	3 ECTS
Prerequisites:	Programming, algorithms and data structures.
Goals:	That the student obtains knowledge about fundamental and selected advanced, current topics and issues in the development and use of database systems.
Contents:	Database fundamentals: introduction, database models (including entity-relational, relational, and object-oriented), SQL, integrity constraints, indexing and hashing, query processing and optimization, transactions, concurrency control. Example advanced, current topics: data mining, spatial databases, temporal databases, database tuning, data warehousing, etc.
Examination:	oral examination, pass/fail grade
Teaching media:	slide projector, whiteboard/chalkboard
Literature:	<i>Fundamentals of Database Systems</i> , 4th edition, by Elmasri & Navathe, Addison Wessely, 2004.

Degree programme:	Information Technology (Master)
Course name:	Fuzzy Logic
Abbreviation or number:	FL
Semester:	Fall Semester
Responsible lecturer:	Henrik Legind Larsen
Lecturers:	Henrik Legind Larsen
Language:	English
Relation to curriculum:	compulsory for students choosing Fuzzy Logic semester theme, optional for those choosing other themes
Teaching type / hours:	lectures, exercises/labs students also spend time using/applying materials from lectures to perform semester group project
Students' workload	55 hours confrontation time (lectures, exercises, and labs) plus 35 hours additional student individual work/homework time and/or group work time, depending on selection of semester theme
ECTS credits:	3 ECTS
Prerequisites:	programming, algorithms, and data structures
Goals:	That the student obtains knowledge about fundamental principles and models in fuzzy logic and fuzzy logic based techniques and their applications in information systems.
Contents:	Fuzzy set theory and fuzzy logic, fuzzy aggregation operators, fuzzy relations, fuzzy knowledge representation, fuzzy logic algorithms, possibility theory, fuzzy classification, and object recognition, applications in information systems.
Examination:	oral examination, pass/fail grade, or examined as part of the project exam (with marks assigned) for those students choosing Fuzzy Logic as semester theme
Teaching media:	slide projector, whiteboard/chalkboard
Literature:	G. J. Klir and B. Yuan, <i>Fuzzy Sets and Fuzzy Logic</i> , Prentice Hall, 1995. H. T. Nguyen and E.A. Walker, <i>A First Course in Fuzzy Logic, Second Edition</i> , Chapan & Hall/CRC, 2000.

Degree programme:	Information Technology (Master)
Course name:	Semester Project
Abbreviation or number:	---
Semester:	Fall Semester
Responsible lecturer:	A semester project supervisor is assigned to student groups based on the theme and specific topic chosen for the project.
Lecturers:	Lectures given in project related (PE) courses on the semester provide supporting material for project work. The mode in which courses are taken (PE or SE) depends on the theme chosen, which then determines which lecturers are supporting and conveying project related material.
Language:	English
Relation to curriculum:	compulsory
Teaching type / hours:	Lectures that are given in project related (PE) courses provide material to support project work. The details for those courses can be found on the corresponding course template descriptions for the courses on the semester. In addition, students have access to and the support of a project supervisor, who, through periodic meetings and interactions guides the students through the process of completing the project.
Students' workload	Students spend time attending lectures for the project related PE courses that provide material to support project work. In addition the students spend substantial time outside of the classroom in order to complete their group projects.
ECTS credits:	Project work along with project unit (PE) courses make up 24 ECTS credits.
Prerequisites:	The prerequisites are dependent upon the semester theme chosen, as this determines which project unit courses that are taken. See corresponding course template descriptions for details.
Goals:	The goals are to enhance the students' learning experience through having them work with, apply, synthesize, and reflect upon the information and materials they receive through lectures as they put it to use to carry out the group project.
Contents:	The contents of the project is dependent upon the semester theme chosen. The possible themes are computer vision systems, fuzzy logic information technology, and control systems.
Examination:	A project report is produced and handed in to the project supervisor. An exam is carried out in which the students present their project to the supervisor and a sensor who are then allowed to ask questions in order to evaluate and assess the students.
Teaching media:	Students are provided with the materials required to carry out the project.
Literature:	The literature used in supporting the project depends on the theme and topic chosen. See corresponding course template descriptions for the semester for details.

Degree programme:	Information Technology (Master)
Course name:	Software Technology
Abbreviation or number:	ST
Semester:	Fall Semester
Responsible lecturer:	Peter Nürnberg
Lecturers:	Peter Nürnberg
Language:	English
Relation to curriculum:	compulsory
Teaching type / hours:	lectures, exercises/labs students also spend time using/applying materials from lectures to perform semester group project
Students' workload	55 hours confrontation time (lectures, exercises, and labs) plus 35 hours additional student individual work/homework time and/or group work time, depending on selection of semester theme
ECTS credits:	3 ECTS
Prerequisites:	Programming, algorithms and data structures.
Goals:	That the student obtains theoretical and practical knowledge about advanced topics in software technology, including the software development process, software evolution, software architecture, and software tools.
Contents:	Advanced analysis, design and implementation, software development methods, advanced topics in programming languages, architectural abstractions (frameworks, patterns, components), conceptual modeling.
Examination:	examined as part of the project exam (with marks assigned)
Teaching media:	slide projector, whiteboard/chalkboard
Literature:	<u>Extreme Programming Explained: Embrace Change</u> . K. Beck; <u>Design Patterns: Elements of Reusable Object-Oriented Software</u> . E. Gamma, R. Helm, R. Johnson, J. Vlissides; <u>Refactoring: Improving the Design of Existing Code</u> . M. Fowler; <u>Writing Effective Use Cases</u> . A. Cockburn

6 Courses from Lemgo (3rd Semester)

Degree programme:	Information Technology (Master)
Course name:	Management Skills and Business Administration
Abbreviation / number	MBA / 5906
Semester:	2nd semester, summer
Responsible lecturer:	Prof. Dr. Reinhard Doleschal
Lecturers:	Prof. Dr. Reinhard Doleschal; Ass. phil. Claudia Mertens
Language:	English
Relation to curriculum:	Compulsory course
Teaching type / hours:	Seminar / 5 hours per week
Students' workload:	180 hours = 75 hours confrontation time (lectures, exercises, and labs) plus 105 hours additional student individual work/homework time
ECTS credits:	6 CR
Prerequisites:	Being open minded
Goals:	<p>The students</p> <ul style="list-style-type: none"> ... are familiar with financing and accounting models of medium-sized enterprises and know the meaning of outside financing. ... know methods and instruments of business management and controlling. ... are familiar with means and methods of marketing. ... understand strategies and models of internationalisation and globalisation. ... know the basics of project management and have already done projects themselves. ... are able to handle modern media and have gained experience in presentations. ... are familiar with aspects of teamwork / teamroles. ... have developed strategies to deal with stress and conflicts. ... know the conventions for writing a letter of application and a CV are familiar with typical questions in job interviews and typical tasks in assessment centers.
Contents:	<ul style="list-style-type: none"> - Accounting - Financing - Balance Scorecard - Marketing and Research - Internationalisation - Communication skills - Presentation skills & rhetorics - Job advertisements & job applications - Intercultural studies - Teamwork - Creativity - How to deal with conflicts - How to deal with stress - How to lead a discussion - Organisation of projects - Time management

Examination:	Presentation with grade
Teaching media:	Powerpoint and Beamer, Metaplan board, Flipchart
Literature:	Porter, M.P. (1990): The Competitive Advantage of Nations, Worcester: MacMillian Press Hammer, M., Champy, J. (1993) Re-engineering the Corporation. Harper Business Prahalad, C.K., Hamel, G. (1990): The Core Competences of the Corporation, Harvard Business Review, May-June, pp. 79-91 Kaplan, R.S., Norton, D.P. (1996): The Balanced Scorecard. Harvard Business School Press.

Degree programme:	Information Technology (Master)
Course name:	Project Work
Abbreviation / number:	PIT / 5909
Semester:	3rd semester, winter
Responsible lecturer:	A project supervisor is assigned to each student group based on one topic. A group consists of 2 or 3 students.
Lecturers:	Depends on topic. It must be a professor responsible for at least one course in Information Technology (Master)
Language:	English
Relation to curriculum:	compulsory
Teaching type:	Students have access to and the support of a project supervisor, who, through periodic meetings and discussions, guides the students through the project.
Students' workload	540 hours: 27 hours per week over 20 weeks
ECTS credits:	18 ECTS credits.
Prerequisites:	The prerequisites are dependent upon the project theme chosen.
Goals:	The goals are to enhance the students' learning experience through having them work with, apply, synthesize, and reflect upon the information and materials they received through lectures as they put it to use in the group project. As the project work is a team work of two or three students, they need to meet respective requirements and rules.
Contents:	Possible topics are offered from the area of industrial information technology. The students need to organize the project work, check state-of-the-art solutions for the given problem, suggest a proposal, investigate the proposal and provide the results.
Examination:	Each student has to produce a project report of approx. 30 pages and hand it in to the project supervisor. The project team has to present the results, where each member has to present her/his contribution. Presentation time for one student approx. 15 min. The supervisor is allowed to ask questions in order to evaluate and assess the students.
Teaching media:	Students are provided with the materials required to carry out the project.
Literature:	A literature survey needs to be done by the student.

Degree programme:	Information Technology (Master)
Course name:	Scientific Methods and Writing
Abbreviation / number:	SMW / 5911
Semester:	3rd semester, winter
Responsible lecturer:	Oliver Niggemann
Lecturers:	Oliver Niggemann, Volker Lohweg
Language:	English
Relation to curriculum:	compulsory
Teaching type / hours:	Lecture / 2 hours per week, Exercise / 1 hour per week
Students' workload	90 hours = 45 hours confrontation time (lectures, exercises) plus 45 hours additional student individual work/homework time
ECTS credits:	3 ECTS credits.
Prerequisites:	none
Goals:	Students acquire basic knowledge about scientific writing and presenting. They understand typical structures of scientific papers and typical presentation styles. Good and bad examples for written, scientific English are discussed.
Contents:	<ol style="list-style-type: none"> 1. Motivation 2. The Principles behind good and bad presentation styles <ol style="list-style-type: none"> 2.1 Content 2.2 Structure 2.3 Design and Layout 2.4 The state of the mind 3. Hints for good presentations and slides 4. Hints for writing scientific papers 5. Hands-on training: A paper and a presentation on a computer science topic
Examination:	Project work including a written scientific paper and a presentation (grade is not based on the content but on the writing and presentation skills)
Teaching media:	Beamer, charts, blackboard, books
Literature:	<ol style="list-style-type: none"> 1) G. Reynolds. presentation zen. New Riders, 2008 2) J. M. W. Williams. STYLE – Towards Clarity and Grace. The University of Chicago Press, 1990. 3) W. Zinsser. On Writing Well. HarperCollins, 2006. 4) W. Strunk Jr., E.B. White. The Elements of Style. Allyn & Bacon, 2000.

Degree programme:	Information Technology (Master)
Course name:	Seminar
Abbreviation / number:	SIT / 5910
Semester:	3rd semester, winter
Responsible lecturer:	Oliver Niggemann
Lecturers:	Oliver Niggemann, Volker Lohweg, Jürgen Jasperneite, Stefan Witte, Stefan Heiss, Uwe Meier, Thomas Korte
Language:	English
Relation to curriculum:	compulsory
Teaching type / hours:	Exercise / 1 hour per week
Students' workload	90 hours = 15 hours confrontation time (exercise) plus 75 hours additional student individual work/homework time
ECTS credits:	3 ECTS credits.
Prerequisites:	none
Goals:	Students learn to approach a given topic in a scientific way. This includes (i) a literature research, (ii) a state-of-the-art overview, and (iii) the compilation into a paper and a presentation.
Contents:	<ol style="list-style-type: none"> 1. Introduction <ol style="list-style-type: none"> 1.1 What is science and what not? 1.2 Engineering and computer science as special fields of science 2. Each student chooses a topic and generates a state-of-the-art overview. This is done in form of a scientific paper. This work overlaps with the course "Scientific Methods and Writing". 3. The work is presented in a seminar.
Examination:	Project work including a written scientific paper and a presentation (grade is only based on the content, not on the writing and presentation skills)
Teaching media:	Beamer, charts, blackboard, books
Literature:	<ol style="list-style-type: none"> 1) Karl Popper. The Logic of Scientific Discovery. 1934 2) Francis Bacon. Novum Organum. 1620. 3) Nassim Nicholas Taleb. The Black Swan: The Impact of the Highly Improbable. Penguin, 2008.

7 Courses from Wroclaw (3rd Semester)

Degree programme:	Information Technology (Master)
Course name:	Information System Modeling and Analysis
Abbreviation or number:	WRUT3_01
Semester:	Third semester
Responsible lecturer:	Prof. Zbigniew Huzar
Lecturers:	Prof. Zbigniew Huzar
Language:	English
Relation to curriculum:	Mandatory at third semester
Teaching type / hours:	Lectures 30, classes 30
Students' workload:	The equivalent of five weeks full time work. This includes approximately 75 hours of teacher led education. Plus 105 hours additional student individual work/homework.
ECTS credits:	6 ECTS credits
Prerequisites:	Practise in object-oriented programming
Goals:	The aim of the subject is to prepare students: - to the lecture on software development methodologies, - to participate in a group project on software system development.
Contents:	The following main topics are in the scope of the subject: - notions used in modern object-oriented approach to model-driven software system development, - representation of the notions in the UML, recently used standard modeling language, and - outline of the UML application in software systems development, especially in domain analysis and software requirement.
Examination:	Final test
Teaching media:	Transparencies / Powerpoint presentations, computer based exercises
Literature:	J. Rumbaugh, I. Jacobson, G. Booch, The Unified Modeling Language Reference Manual, Second Edition, Addison-Wesley 2004

Degree programme:	Information Technology (Master)
Course name:	Project
Abbreviation or number:	INZ0020
Semester:	Third semester
Responsible lecturer:	Member of the Faculty education staff
Lecturers:	Member of the Faculty education staff
Language:	English
Relation to curriculum:	Mandatory
Teaching type / hours:	Project - 30h, seminar - 30h
Students' workload:	The equivalent of five weeks full time work. This includes approximately 150 hours of teacher led education.
ECTS credits:	12 ECTS credits
Prerequisites:	No
Goals:	The aim of the course is to provide practical guidelines for project management and the Master Thesis preparation.
Contents:	During the course students will select the subject of the project related to different courses chosen in current or previous semesters as well as a topic of their Master Thesis. Students will be familiarized with the routines employed for the thesis preparation.
Examination:	One test at the end of lectures and classes
Teaching media:	Transparencies/Powerpoint presentations, computer based exercises.
Literature:	Depending on the project/seminar topic

Degree programme:	Information Technology (Master)
Course name:	Software System Development
Abbreviation or number:	WRUT3_02
Semester:	Third semester
Responsible lecturer:	Dr. Bogumiła Hnatkowska
Lecturers:	Dr. Bogumiła Hnatkowska
Language:	English
Relation to curriculum:	Mandatory at third semester
Teaching type / hours:	Lecture – 24 h , Project – 36 h
Students' workload:	The equivalent of four weeks full time work. This includes approximately 60 hours of teacher led education. Plus 120 hours additional student individual work/homework.
ECTS credits:	6 ECTS credits
Prerequisites:	Basic knowledge of Unified Modelling Language (UML) Basic knowledge of database design and database management systems Good knowledge of object-oriented paradigm Good experiences in programming
Goals:	Build a part of software system according to presented methodology Give experiences in using UML for software system design and documentation Give experiences in using different CASE tools during software project Give an overview of the most popular attempts to software development.
Contents:	The lecture deals with different aspects of software engineering, especially presents: <ul style="list-style-type: none"> - Basic notions from classical (heavy) methodologies, e.g. Rational Unified Process (RUP), and Unified Software Development Process (USDP); - MDA approach to software development; - Basic notions from agile methodologies, e.g. eXtreme Programming; - Chosen aspects of user interface (UI) designing on the technical level, in particular techniques and guidelines supporting GUI window design. - Code and documents quality attributes, and chosen software quality metrics. <p>The aim of the project is to build a software system prototype. The students work in teams. They follow USDP/RUP methodology to build the prototype. They experience with building basic intermediate artifacts (e.g. vision of the system, software requirement specification, design model, deployment model), as a final product itself.</p>
Examination:	Test with 5-10 closed questions and 5-10 opened.
Teaching media:	Transparencies / Powerpoint presentations, computer based exercises
Literature:	Booch G., Rumbaugh J., Jacobson I., The Unified Software Development Process, Addison Wesley, 1999. Rational Unified Process (site distributed with Rational Suite Enterprise), 2005. L. Maciaszek, B.L. Liong, Practical software engineering: a case study approach, Pearson Addison Wesley, 2005.