Description of the degree program

Computer Science (Master)
PO 6

Date: 13.10.2026

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Obligatory elective subjects in Computer Science

Title	Advanced Topics in IT-Security and Privacy		
Number	4210000100	**Module version**	
Shorttext		**Language**	german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Martin Johns
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
Hinweise zu aktueller Literatur erhalten Sie im Rahmen der Veranstaltung.			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title	Application Security		
Number	4210000110	**Module version**	V1
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Martin Johns
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	english german		
Contents			
Objective qualification			
Literature			
Referenzen werden in der Veranstaltung bekannt gegeben			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	english german
Literature			
Referenzen werden in der Veranstaltung bekannt gegeben			

	2,0	Exercise	english ger-man
Literature			
Referenzen werden in der Veranstaltung bekannt gegeben			

Title	Security Lab		
Number	4210000090	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Martin Johns
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	Prior to taking this module, the students should successfully complete the module “Einführung in die IT-Sicherheit”.		
Expected performance/ Type of examination			
Course achievement	non-graded work: successful completion of the given tasks; presentation of 30 minutes		
Examination language	german		

Contents

- basic techniques and tools for security analysis
- security analysis of modern software and IT systems
- application of attack and defense techniques
- tools for analysis of malicious code and vulnerabilities

Objective qualification

After completing this course, the students possess the following knowledge and capabilities. They are able to …
- independently analyse the security of systems
- design offensive and defense security strategies
- discover and exploit security vulnerabilities
- develop, circumvent, and improve security defenses

Literature

- Gollmann. Computer Security. Wiley & Sons, 2011
- Szor. The Art of Computer Virus Research and Defense. Addison-Wesley, 2005

Further references will be announced in the course

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
	4,0	Internship	german

Literature

- Gollmann. Computer Security. Wiley & Sons, 2011
- Szor. The Art of Computer Virus Research and Defense. Addison-Wesley, 2005

Weitere Referenzen werden in der Veranstaltung bekanntgegeben.

Title	Security Lab 2		
Number	4210630	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Anwendungs-sicherheit
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Martin Johns
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examina-tion			
Course achievement	1 Coursework: Successful completion of 66% of the assignments and presentation on the content of the assignment (30 minutes)		
Examination language	german		

Contents

- Fortgeschrittene Sicherheitsanalysen von IT-Systemen
- Methoden zur Aufbereitung udn Analyse von Software
- Werkzeuge zur Exploration von IT-Netzen und IT-Systemen

Objective qualification

After completing the module, students will be able to independently evaluate, compare and apply advanced IT security and software analysis techniques.

Literature

- Gollmann. Computer Security. Wiley & Sons, 2011
- Zalewski. The Tangled Web: A Guide to Securing Modern Web Applications, 2011
- weitere Referenzen werden in der Veranstaltung bekannt gegeben

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language

	4,0	Internship	german
Literature			
- Gollmann. Computer Security. Wiley & Sons, 2011 - Zalewski. The Tangled Web: A Guide to Securing Modern Web Applications, 2011 - weitere Referenzen werden in der Veranstaltung bekannt gegeben			

Title	Practical Course in Industrial Software		
Number	4210000070	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Martin Johns
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
Erforderliche Literatur wird ausgegeben			

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Internship	german
	1,0	Colloquium	german
Literature			
Vortragsspezifisch			

Title	Web Security		
Number	4210000080	**Module version**	V1
Shorttext		**Language**	english german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Martin Johns
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	english german		
Contents			
Objective qualification			
Literature			
- Gollmann. Computer Security. Wiley & Sons, 2011 - Zalewski. The Tangled Web: A Guide to Securing Modern Web Applications, No Starch Press, 2011 - Referenzen werden in der Veranstaltung bekannt gegeben			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

	2,0	Lecture	english german

Literature

- Gollmann. Computer Security. Wiley & Sons, 2011
- Zalewski. The Tangled Web: A Guide to Securing Modern Web Applications, No Starch Press, 2011
- Weitere Referenzen werden in der Veranstaltung bekannt gegeben

	2,0	Exercise	english german

Title	Advanced FPGA-Design		
Number	4211510	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1 Semester	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Guillermo Payá Vayá
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	The courses “Hardware-Software-Systems”, “Digital Circuits Design”, and “Hardware Praktikum” are recommended as preparation for this course.		
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam		
Course achievement			
Examination language	english german		

Contents

1. Introduction to Reconfigurable Computing
2. FPGA Basic Architecture (incl. DSP blocks, embedded memories, soft and hard processors) (Review)
3. Additional Architectural Elements of FPGAs (Boundary scan, I/O cells (PLLs), MIG, transceivers, analog-to-digital converters, ...)
4. FPGA Memory Technologies (SRAM, EPROM, Flash, Anti-Fuse, MRAM)
5. High-Performance Circuit Design on FPGAs
6. Dynamic and Partial Reconfiguration Mechanisms (incl. Space-Time FPGAs)
7. Design Tools for FPGAs (incl. VTR)
8. FPGA-Based Applications

Objective qualification

After completing the module, the students know how to design and optimize complex circuits on modern FPGA devices. Moreover, they are capable to efficiently use all the embedded dedicated hardware modules, e.g., DSPs, different embedded memories, I/O high speed interfaces, or analog-to-digital converters. This course makes emphasis on the design of high performance circuits by understanding the FPGA architecture limitations and including dynamic and partial reconfiguration mechanisms. The students will be introduced to emerging reconfigurable logic devices and their use in demanding technical applications.

Literature

- Palchaudhuri, A.; Chakraborty, R.S.; „High Performance Integer Arithmetic Circuit Design on FPGA“, Springer, 2016

- Deschamps, J-P.; Sutter, G.D.; Cantó, E. : „Guide to FPGA Implementation of Arithmetic Functions“, Springer, 2012

- Rodriguez-Andina, J.J.; et. al.: „FPGAs. Fundamentals, Advanced Features, and Applications in Industrial Electronics“, CRC Press, 2017

- Ashenden, P.: "The Designers Guide to VHDL", Morgan Kaufmann, 3rd revised edition, November 2006

- Bergeron, J.: "Writing Testbenches: Functional Verification of HDL Models", Springer-Verlag, 2003

- Betz, V.; Rose, J.; Marquardt, A .: "Architecture and CAD for Deep-Submicron FPGAs", Kluwer, 1999

- Bobda, C.: "Introduction to Reconfigurable Computing", Springer-Verlag, 2007

- Grout, I.: "Digital System Design with FPGAs and CPLDs", Elsevier Science & Technology, 2008

- Hunter, R.; Johnson, T.: "VHDL", Springer-Verlag, 2007

- Meyer-Baese, U.: "Digital Signal Processing with Field Programmable Gate Arrays", Springer-Verlag, 2007

- Rahman, A.: "FPGA based Design and applications", Springer-Verlag, 2008

- Sikora, A.: "Programmierbare Logikbauelemente", Hanser-Verlag, 2001

- Wilson, P.: "Design Recipes for FPGAs", Elsevier Science & Technology, 2007

Further references will be announced in the course

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Advanced FPGA-Design	4,0	Lecture/Exercise	english german

Literature

- Palchaudhuri, A.; Chakraborty, R.S.; „High Performance Integer Arithmetic Circuit Design on FPGA“, Springer, 2016 - Deschamps, J-P.; Sutter, G.D.; Cantó, E. : „Guide to FPGA Implementation of Arithmetic Functions“, Springer, 2012 - Rodriguez-Andina, J.J.; et. al.: „FPGAs. Fundamentals, Advanced Features, and Applications in Industrial Electronics“, CRC Press, 2017 - Ashenden, P.: "The Designers Guide to VHDL", Morgan Kaufmann, 3rd revised edition, November 2006 - Bergeron, J.: "Writing Testbenches: Functional Verification of HDL Models", Springer-Verlag, 2003 - Betz, V.; Rose, J.; Marquardt, A .: "Architecture and CAD for Deep-Submicron FPGAs", Kluwer, 1999 - Bobda, C.: "Introduction to Reconfigurable Computing", Springer-Verlag, 2007 - Grout, I.: "Digital System Design with FPGAs and CPLDs", Elsevier Science & Technology, 2008 - Hunter, R.; Johnson, T.: "VHDL", Springer-Verlag, 2007 - Meyer-Baese, U.: "Digital Signal Processing with Field Programmable Gate Arrays", Springer-Verlag, 2007 - Rahman, A.: "FPGA based Design and applications", Springer-Verlag, 2008 - Sikora, A.: "Programmierbare Logikbauelemente", Hanser-Verlag, 2001 - Wilson, P.: "Design Recipes for FPGAs", Elsevier Science & Technology, 2007 (EN) Further references will be announced in the course

Title	Application-Specific Instruction-Set Processors		
Number	4211450	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Guillermo Payá Vayá
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	Graded work (examination): Written exam (90 minutes) or oral exam (30 minutes)		
Course achievement			
Examination language	english		

Contents

1. Introduction to Embedded Computer Architectures.
2. Fundamentals of Processor Design.
3. Application-Specific Instruction-Set Processor (ASIP). Customizable processors.
4. Computer Arithmetics: Hardware acceleration of complex arithmetic functions.
5. Reconfigurable Processor Architectures.
6. Approximate and Stochastic Processor Architectures.
7. Fault-Tolerant Processor Architectures.
8. Cryptographic Processor Architectures.
9. Neuromorphic Processor Architectures: AI Processor Architectures.

Objective qualification

After completing the module, the students know how to customize and optimize a processor architecture (instruction, data and task level parallelism). They are capable of implementing application-specific instruction set processors (ASIPs). They can implement arithmetic-oriented hardware extensions and know new development tendencies of processors, e.g., highly parallel processors and reconfigurable processors.

Literature

• Gries, M.; Keutzer, K.; "Building ASIPS: The Mescal Methodology", Springer, 2010
• Leibson, S.: "Designing SOCs with Configured Cores. Unleashing the Tensilica Xtensa and Diamond Cores", Morgan Kaufmann, 2006
• Henkel, J.; Parameswaran, S.:"Designing Embedded Processors", Springer, 2007
• Nurmi, J.: "Processor Design. System-On-Chip Computing for ASICs and FPGAs", Springer, 2007
• Flynn, M. J.; Luk, W.: "Computer System Design. System-on-Chip", Wiley, 2011
• González, A.; Latorre, F.; Magklis, G.: "Processor Microarchitecture: An Implementation Perspective", Morgan&Claypool Publishers, 2010
• Fisher, J.; Faraboschi, P.; Young, C.: "Embedded Computing: A VLIW Approach to Architecture, Compilers, and Tools", Morgan Kaufmann, 2005.
• Hennessy, J.L.; Patterson, D. A.; "Computer Architecture: A Quantitative Approach", Morgan Kaufmann, 2011.

• Leuppers, R.; Marwedel, P.: "Retargetable Compiler Technology for Embedded Systems: Tools and Applications", Springer, 2010
• Jacob, B.; "The Memory System: You Can't Avoid It, You Can't Ignore It, You Can't Fake It", Morgan&Claypool Publishers, 2009
• Kaxiras, S.: Martonosi, M.: "Computer Architecture Techniques for Power-Efficiency ", Morgan&Claypool Publishers, 2008
• Olukotun, K.; Hammond, L.; Laudon, J.; "Chip Multiprocessor Architecture: Techniques to Improve Throughput and Latency ", Morgan&Claypool Publishers, 2007
• Zaccaria, V.; Sami, M.G.; Silvano, C.: "Power Estimation and Optimization Methodologies for VLIW-based Embedded Systems", Springer, 2003

• Further references will be announced in the course

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**
Application-Specific Instruction-Set Processors	2,0	Lecture	english

Literature

• Gries, M.; Keutzer, K.; "Building ASIPS: The Mescal Methodology", Springer, 2010
• Leibson, S.: "Designing SOCs with Configured Cores. Unleashing the Tensilica Xtensa and Diamond Cores", Morgan Kaufmann, 2006
• Henkel, J.; Parameswaran, S.:"Designing Embedded Processors", Springer, 2007
• Nurmi, J.: "Processor Design. System-On-Chip Computing for ASICs and FPGAs", Springer, 2007
• Flynn, M. J.; Luk, W.: "Computer System Design. System-on-Chip", Wiley, 2011
• González, A.; Latorre, F.; Magklis, G.: "Processor Microarchitecture: An Implementation Perspective", Morgan&Claypool Publishers, 2010
• Fisher, J.; Faraboschi, P.; Young, C.: "Embedded Computing: A VLIW Approach to Architecture, Compilers, and Tools", Morgan Kaufmann, 2005.
• Hennessy, J.L.; Patterson, D. A.; "Computer Architecture: A Quantitative Approach", Morgan Kaufmann, 2011.
• Leuppers, R.; Marwedel, P.: "Retargetable Compiler Technology for Embedded Systems: Tools and Applications", Springer, 2010
• Jacob, B.; "The Memory System: You Can't Avoid It, You Can't Ignore It, You Can't Fake It", Morgan&Claypool Publishers, 2009
• Kaxiras, S.: Martonosi, M.: "Computer Architecture Techniques for Power-Efficiency ", Morgan&Claypool Publishers, 2008
• Olukotun, K.; Hammond, L.; Laudon, J.; "Chip Multiprocessor Architecture: Techniques to Improve Throughput and Latency ", Morgan&Claypool Publishers, 2007
• Zaccaria, V.; Sami, M.G.; Silvano, C.: "Power Estimation and Optimization Methodologies for VLIW-based Embedded Systems", Springer, 2003

• Further references will be announced in the course

Application-Specific Instruction-Set Processors	2,0	Exercise	english

Literature

• Gries, M.; Keutzer, K.; "Building ASIPS: The Mescal Methodology", Springer, 2010
• Leibson, S.: "Designing SOCs with Configured Cores. Unleashing the Tensilica Xtensa and Diamond Cores", Morgan Kaufmann, 2006
• Henkel, J.; Parameswaran, S.:"Designing Embedded Processors", Springer, 2007
• Nurmi, J.: "Processor Design. System-On-Chip Computing for ASICs and FPGAs", Springer, 2007
• Flynn, M. J.; Luk, W.: "Computer System Design. System-on-Chip", Wiley, 2011
• González, A.; Latorre, F.; Magklis, G.: "Processor Microarchitecture: An Implementation Perspective", Morgan&Claypool Publishers, 2010
• Fisher, J.; Faraboschi, P.; Young, C.: "Embedded Computing: A VLIW Approach to Architecture, Compilers, and Tools", Morgan Kaufmann, 2005.
• Hennessy, J.L.; Patterson, D. A.; "Computer Architecture: A Quantitative Approach", Morgan Kaufmann, 2011.
• Leuppers, R.; Marwedel, P.: "Retargetable Compiler Technology for Embedded Systems: Tools and Applications", Springer, 2010
• Jacob, B.; "The Memory System: You Can't Avoid It, You Can't Ignore It, You Can't Fake It", Morgan&Claypool Publishers, 2009
• Kaxiras, S.: Martonosi, M.: "Computer Architecture Techniques for Power-Efficiency ", Morgan&Claypool Publishers, 2008
• Olukotun, K.; Hammond, L.; Laudon, J.; "Chip Multiprocessor Architecture: Techniques to Improve Throughput and Latency ", Morgan&Claypool Publishers, 2007
• Zaccaria, V.; Sami, M.G.; Silvano, C.: "Power Estimation and Optimization Methodologies for VLIW-based Embedded Systems", Springer, 2003

• Further references will be announced in the course

Title	ASIPLab: Design of Application-Specific Instruction-Set Processors		
Number	4211000010	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Guillermo Payá Vayá
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	The module “Application-Specific Instruction-Set Processors” is recommended as preparation for this course.		
Expected performance/ Type of examination			
Course achievement	- Non-graded work/Coursework - Successful completion of the given tasks; presentation of 30 minutes		
Examination language	english		

Contents

1. Introduction to the architecture principles of processors and their specialization opportunities
2. Introduction to the architecture definitions of an Application-Specific Instruction-Set Processor, such as the LX7 processor architecture, and the extension possibilities of this ASIP
3. Introduction to custom extensions of instruction set of a processor, e.g. the Cadence LX7 processor, using Cadence Xtensa Explorer
4. Introduction to the hardware descrition language “Tensilica Instruction Extension”
5. Verification and Emulation of Processor architectures

Objective qualification

The Lab teaches the concepts and architectures of specialized processors, the underlining theoretical concepts through the architecture modification of the Cadence LX7 processor.
After completing the module, the students are capable to
- understand the concept of Application-Specific Instruction-Set Processors and how to use them
- to specialize a basic processor architecture for an example out of domain of Advanced Driving Assist Systems
- evaluate and assess an architecture for different optimization goals (e.g. maximum computing power or minimal power consumption) zu evaluieren und zu bewerten

Literature

- Gries, M.; Keutzer, K.; "Building ASIPS: The Mescal Methodology", Springer, 2010
- Leibson, S.: "Designing SOCs with Configured Cores. Unleashing the Tensilica Xtensa and Diamond Cores", Morgan Kaufmann, 2006
- Henkel, J.; Parameswaran, S.:"Designing Embedded Processors", Springer, 2007
- Nurmi, J.: "Processor Design. System-On-Chip Computing for ASICs and FPGAs", Springer, 2007
- Flynn, M. J.; Luk, W.: "Computer System Design. System-on-Chip", Wiley, 2011
- González, A.; Latorre, F.; Magklis, G.: "Processor Microarchitecture: An Implementation Perspective", Morgan&Claypool Publishers, 2010

- Fisher, J.; Faraboschi, P.; Young, C.: "Embedded Computing: A VLIW Approach to Architecture, Compilers, and Tools", Morgan Kaufmann, 2005.
- Hennessy, J.L.; Patterson, D. A.; "Computer Architecture: A Quantitative Approach", Morgan Kaufmann, 2011.
- Leuppers, R.; Marwedel, P.: "Retargetable Compiler Technology for Embedded Systems: Tools and Applications", Springer, 2010
- Jacob, B.; "The Memory System: You Can't Avoid It, You Can't Ignore It, You Can't Fake It", Morgan&Claypool Publishers, 2009
- Kaxiras, S.: Martonosi, M.: "Computer Architecture Techniques for Power-Efficiency ", Morgan&Claypool Publishers, 2008
- Olukotun, K.; Hammond, L.; Laudon, J.; "Chip Multiprocessor Architecture: Techniques to Improve Throughput and Latency ", Morgan&Claypool Publishers, 2007
- Zaccaria, V.; Sami, M.G.; Silvano, C.: "Power Estimation and Optimization Methodologies for VLIW-based Embedded Systems", Springer, 2003

Further references will be announced in the course.

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
ASIPLab: Design of Application-Specific Instruction-Set Processors	4,0	Internship	english

Literature

- Gries, M.; Keutzer, K.; "Building ASIPS: The Mescal Methodology", Springer, 2010 - Leibson, S.: "Designing SOCs with Configured Cores. Unleashing the Tensilica Xtensa and Diamond Cores", Morgan Kaufmann, 2006 - Henkel, J.; Parameswaran, S.:"Designing Embedded Processors", Springer, 2007 - Nurmi, J.: "Processor Design. System-On-Chip Computing for ASICs and FPGAs", Springer, 2007 - Flynn, M. J.; Luk, W.: "Computer System Design. System-on-Chip", Wiley, 2011 - González, A.; Latorre, F.; Magklis, G.: "Processor Microarchitecture: An Implementation Perspective", Morgan&Claypool Publishers, 2010 - Fisher, J.; Faraboschi, P.; Young, C.: "Embedded Computing: A VLIW Approach to Architecture, Compilers, and Tools", Morgan Kaufmann, 2005. - Hennessy, J.L.; Patterson, D. A.; "Computer Architecture: A Quantitative Approach", Morgan Kaufmann, 2011. - Leuppers, R.; Marwedel, P.: "Retargetable Compiler Technology for Embedded Systems: Tools and Applications", Springer, 2010 - Jacob, B.; "The Memory System: You Can't Avoid It, You Can't Ignore It, You Can't Fake It", Morgan&Claypool Publishers, 2009 - Kaxiras, S.: Martonosi, M.: "Computer Architecture Techniques for Power-Efficiency ", Morgan&Claypool Publishers, 2008 - Olukotun, K.; Hammond, L.; Laudon, J.; "Chip Multiprocessor Architecture: Techniques to Improve Throughput and Latency ", Morgan&Claypool Publishers, 2007 - Zaccaria, V.; Sami, M.G.; Silvano, C.: "Power Estimation and Optimization Methodologies for VLIW-based Embedded Systems", Springer, 2003 Further references will be announced in the course.

Title	Memory Systems		
Number	4211460	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Guillermo Payá Vayá
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	The module “Application-Specific Instruction-Set Processors” is recommended as preparation for this course.		
Expected performance/ Type of examination	Graded work (examination): Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	english		

Contents

1. Introduction to Memory Systems (Review)
2. Overview on Memory Technology
2.1 Volatile Memories: SRAM, DRAM
2.2 Non-volatile Memories: ROM, Flash Memory, F-RAM, MRAM,...
3. Main Memory: Interfaces, Commands, and Controllers
4. Memory Cache
5. Processing-in-Memory (PIM) / New Data Processing
5.1 Using traditional and 3D-Stacked memories
5.2 Low-latency interfaces

Objective qualification

This course focusses on the main challenges for the design of modern semiconductor storage systems under the aspect of rapidly growing data storage requirements. Current, volatile and non-volatile memory types will be covered from the fundamental semiconductor technology level up to higher levels of system-level abstraction, with a focus on reliability and protection of stored data. Furthermore, Processing-in-Memory Architectures (PIM) based on conventional and 3D-stacked memories are analyzed, taking into account aspects such as low latency and energy consumption.

Literature

• Balasubramonian (2019): "Innovations in the Memory Systems", Morgen & Claypool Publishers
• Hennessy and Patterson (2017): "Computer Architecture. A Quantitative Approach", 6th Edition, Morgan Kaufmann
• Jacob, Ng, and Wang (2008): "Memory Systems: Cache, DRAM, Disk", Morgan Kaufmann "

Further references will be announced in the course.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Memory Systems	2,0	Lecture	english
Literature			
- Balasubramonian (2019): "Innovations in the Memory Systems", Morgen & Claypool Publishers - Hennessy and Patterson (2017): "Computer Architecture. A Quantitative Approach", 6th Edition, Morgan Kaufmann - Jacob, Ng, and Wang (2008): "Memory Systems: Cache, DRAM, Disk", Morgan Kaufmann " Further references will be announced in the course.			
Memory Systems	2,0	Exercise	english

Title	Verification, Validation and Testing of ASIC Designs		
Number	4211500	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Theoretische Informatik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Guillermo Payá Vayá
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	graded work (examination): oral exam (30 minutes)		
Course achievement			
Examination language	english		

Contents

1. Einführung in Verifikation, Validierung und Testing 2. Pre-Silicon Verifikation 2.1 Einführung in ASIC Design Verifikation 2.2 Herangehensweisen zu funktionaler Verifikation 2.3 Verifikationswerkzeuge 2.4 Verifikation Strategien 2.5 Design for Reuse 3. Post-Silicon Validierung 3.1 Einführung in ASIC Validierung 3.2 Traditionelle Post-Silicon Validierung (in der Industrie) 3.3 Reversi Test Generation System 4. Run-Time Verifikation 4.1 Motivation für Laufzeit-Verifikation 4.2 Klassifikation von Laufzeit-Verifikationslösungen 4.3 Dynamische Implementierung von Verifikations- Architekturen 4.4 Run-time Verifikation von einfachen Cores 4.5 Hardware Patching Herangehensweisen 5. Testing 5.1 Einführung zu VLSI Testing 5.2 Design for Testability 5.3 Test Generation

Objective qualification

Die Studierenden lernen Techniken zur Verifikation, Validierung und dem Testen von ASIC-Designs kennen. Auf Basis von praktischen Beispielen und aktuellen Entwicklungswerkzeugen werden die Studierenden an Herausforderungen der heutigen Chipentwicklung und dem Testen herangeführt.

Literature

- Wagner and Bertacco (2011): "Post-Silicon and Runtime Verification for Modern Processors" - Wang, Stroud, and Touba (2008): "System-on-Chip Test Architectures: Nanometer Design for Testability" - Mishra and Dutt (2005): "Functional Verification of Programmable Embedded Architectures: A Top-Down Approach" - Haque, Khan, and Michelson (2001): "The Art of Verification with VERA" - Keating and Bricaud (1999): "Reuse Methodology Manual" - Bergeron (2000): "Writing Testbenches. Functional Verification of HDL Models"

Further references will be announced in the course.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Verification, Validation and Testing of ASIC Designs	4,0	Lecture/Exercise	english
Literature			
- Wagner and Bertacco (2011): "Post-Silicon and Runtime Verification for Modern Processors" - Wang, Stroud, and Touba (2008): "System-on-Chip Test Architectures: Nanometer Design for Testability" - Mishra and Dutt (2005): "Functional Verification of Programmable Embedded Architectures: A Top-Down Approach" - Haque, Khan, and Michelson (2001): "The Art of Verification with VERA" - Keating and Bricaud (1999): "Reuse Methodology Manual" - Bergeron (2000): "Writing Testbenches. Functional Verification of HDL Models" Weitere Referenzen werden in der Veranstaltung bekannt gegeben.			

Title	VLSI-Design		
Number	4211480	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1 Semester	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Guillermo Payá Vayá
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	The modules “Hardware-Software-Systeme” and “Hardware Praktikum” are recommended as preparation for this course.		
Expected performance/ Type of examination	Graded work (examination): Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	english		

Contents

- Introduction to VLSI Design
- Fundamentals of CMOS Transistors
- Fabrication and Layout of CMOS Integrated Circuits
- CMOS Circuits (Combinational and Sequential Logic Circuits)
- Design Methodologies
- Issues in Chip Design

Objective qualification

This lecture deals with the design of digital circuits in CMOS technology. The students learn about alternative techniques for the realization of basic circuits as well as their manufacturing and design process. By using practical examples, various forms of implementation of integrated circuits are discussed and current challenges of today's chip development in modern semiconductor technologies are presented. After completing the module, students are able to independently design VLSI chips.

Literature

- D. Harris, N. Weste: "CMOS VLSI Design.", Pearson Education, Inc (2010).
- H. Veendrick: "Nanometer CMOS ICs ", Springer, 2007
- Y. Taur, T. Ning: "Fundamentals of Modern VLSI Devices", Cambridge University Press, 1998
- J.M. Rabaey, A. P. Chandrakasan, and B. Nikoli#; “Digital Integrated Circuits: a Design Perspective”. Vol. 7. Upper Saddle River, NJ: Pearson Education, 2003.
- J. Uyemura: "CMOS Logic Circuit Design", Kluwer Academic Publishers, 1999
- K. Reifschneider: "CAE-gestützte IC-Entwurfsmethoden", Prentice Hall, 1998
- K. Itoh: "VLSI Memory Chip Design", Springer, 2001
- D. Jansen: "Handbuch der Electronic Design Automation", Carl Hanser Verlag, 2002
- R. J. Baker, H. W. Li, D. E. Byce: "CMOS Circuit Design. Layout, and Simulation", IEEE Press 1998
- R. Hunter, T. Johnson: "VHDL", Springer, 2007
- D. Perry: "VHDL", McGraw-Hill, 1998

- P. Ashenden: "The Designers Guide to VHDL", Morgan Kaufmann, 2002

Further references will be announced in the course.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
VLSI-Design	2,0	Lecture	english
Literature			
- D. Harris, N. Weste: "CMOS VLSI Design.", Pearson Education, Inc (2010). - H. Veendrick: "Nanometer CMOS ICs ", Springer, 2007 - Y. Taur, T. Ning: "Fundamentals of Modern VLSI Devices", Cambridge University Press, 1998 - J.M. Rabaey, A. P. Chandrakasan, and B. Nikoli#; “Digital Integrated Circuits: a Design Perspective”. Vol. 7. Upper Saddle River, NJ: Pearson Education, 2003. - J. Uyemura: "CMOS Logic Circuit Design", Kluwer Academic Publishers, 1999 - K. Reifschneider: "CAE-gestützte IC-Entwurfsmethoden", Prentice Hall, 1998 - K. Itoh: "VLSI Memory Chip Design", Springer, 2001 - D. Jansen: "Handbuch der Electronic Design Automation", Carl Hanser Verlag, 2002 - R. J. Baker, H. W. Li, D. E. Byce: "CMOS Circuit Design. Layout, and Simulation", IEEE Press 1998 - R. Hunter, T. Johnson: "VHDL", Springer, 2007 - D. Perry: "VHDL", McGraw-Hill, 1998 - P. Ashenden: "The Designers Guide to VHDL", Morgan Kaufmann, 2002 Further references will be announced in the course.			
	2,0	Exercise	english

Title	VLSI-Lab		
Number	4211000020	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Guillermo Payá Vayá
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	The modules “Hardware-Software-Systems” and “Hardware Praktikum” are recommended as preparation for the laboratory. In addition, the modules “VLSI Design” and “Verification, Validation and Testing of ASIC Designs” are recommended to attend in parallel during the realization of this laboratory.		
Expected performance/ Type of examination			
Course achievement	non-graded work: successful completion of the given tasks; presentation of 30 minutes		
Examination language	english		

Contents

The Chip Design Laboratory is divided into three successive phases. All phases of the laboratory consist of interactive self-study and seminars. The latter provide students with the knowledge necessary to work on the tasks in small groups in self-study. During the independently organized work in the groups on a defined task (self-study), a research associate of the institute checks the progress and gives assistance if necessary. Phase 0: Chip conception and specification The hardware modules to be implemented in phase 1 are designed and specified in small groups during this phase. This phase is based on the target application to be executed on the hardware. The application as well as the hardware modules in form of a microcontroller, peripheral modules and co-processors are selected and all necessary features of these are summarized and documented in this phase. Phase 1: Module implementation and verification At the beginning of phase 1, the students implement individual hardware modules specified in phase 0, i.e., a microcontroller, peripheral modules and co-processors, in small groups using VHDL. The knowledge from previous courses, which is required for VHDL design and testbenches (with System-C), is refreshed and extended in two seminars. Phase 2: Chip design and prototyping After the module development, different groups perform: • functional verification and emulation using a FPGA evaluation board (in-circuit emulation), • performing a complete ASIC synthesis and back-end flow based on a library of standard cells, and • porting a small application onto the system...

Objective qualification

The Chip-Design-Lab is a practical laboratory for the design of integrated digital circuits. In this laboratory, students design digital circuits using a RISC-V microcontroller with peripheral modules. During the different phases of the lab, the students design, specify, implement and verify digital circuits with hardware description languages, industrial EDA tools, System-C testbenches and hardware test setups. The qualification goals taught in this laboratory are successful project work in the field of digital circuit design from the specification to the in-circuit test of the designed circuit. The students gain knowledge about project planning, development work and teamwork. At the same time, students acquire specialized knowledge in their own work with used tools and hardware description languages. The goal is the successful and self-developed completion of the project and the exchange of the knowledge gained in teamwork.
Literature
• Rabaey, J. M., Chandrakasan, A. P., & Nikoli#, B. (2003). Digital integrated circuits: a design perspective (Vol. 7). Upper Saddle River, NJ: Pearson Education. • Weste, N. H., & Harris, D. (2015). CMOS VLSI design: a circuits and systems perspective. Pearson Education India. • Brunvand, E. (2010). Digital VLSI chip design with Cadence and Synopsys CAD tools. Addison-Wesley. • Ashenden, P. J. (2010). The designer's guide to VHDL. Morgan Kaufmann. • Ashenden, P. (2008). Digital Design: An Embedded Systems Approach Using VHDL. Morgan Kaufmann. Further references will be announced in the course.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
VLSI-Lab	4,0	Internship	english
Literature			
• Rabaey, J. M., Chandrakasan, A. P., & Nikoli#, B. (2003). Digital integrated circuits: a design perspective (Vol. 7). Upper Saddle River, NJ: Pearson Education. • Weste, N. H., & Harris, D. (2015). CMOS VLSI design: a circuits and systems perspective. Pearson Education India. • Brunvand, E. (2010). Digital VLSI chip design with Cadence and Synopsys CAD tools. Addison-Wesley. • Ashenden, P. J. (2010). The designer's guide to VHDL. Morgan Kaufmann. • Ashenden, P. (2008). Digital Design: An Embedded Systems Approach Using VHDL. Morgan Kaufmann. Further references will be announced in the course.			

Title	Advanced Topics in Concurrent Programming		
Number	4212000040	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Roland Meyer
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	english german		

Contents

Students learn programming strategies for weakly consistent memory models. The content depends on current developments in research, for example
• popular memory models such as TSO, ARM8, Release-Acquire,
• the formalization of these models, both operational and axiomatic,
• the guarantees that are possible for a memory despite weak consistency,
• DRF theorems and robustness,
• conflict resolution strategies,
• conflict-free data types.

Objective qualification

Upon completion of this module, students will have a deep understanding of recent developments and research trends in the field of concurrent programming.

Literature

Leslie Lamport. 1979. How to Make a Multiprocessor Computer That Correctly Executes Multiprocess Programs. IEEE Trans. Computers 28. 690-691.

Glynn Winskel. 1993. The Formal Semantics of Programming Languages: An Introduction. MIT Press.

Marc Shapiro, Nuno Preguiça, Carlos Baquero, and Marek Zawirski . 2011. Conflict-Free Replicated Data Types. In SSS. 386-400.

Ahmed Bouajjani, Roland Meyer, and Eike Möhlmann. 2011. Deciding Robustness against Total Store Ordering. In ICALP. 428-440.

Ahmed Bouajjani, Egor Derevenetc, Roland Meyer. 2013. Checking and Enforcing Robustness against TSO. In ESOP. 533-553.

Jade Alglave, Luc Maranget, and Michael Tautschnig. 2014. Herding Cats: Modelling, Simulation, Testing, and Data Mining for Weak Memory. In TOPLAS. 1-74.

Jade Alglave, Patrick Cousot, and Luc Maranget. 2016. Syntax and semantics of the weak consistency model specification language CAT.

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Advanced Topics in Concurrent Programming	2,0	Lecture	english german
Advanced Topics in Concurrent Programming	2,0	Exercise	german

Title	Advanced Topics in Verification		
Number	4212000050	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Roland Meyer
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	english german		

Contents

Current topics in verification.

Objective qualification

Upon completion of this module, students will have a deep understanding of recent developments and research trends in the field of verification.

Literature

Pascal Baumann, Eren Keskin, Roland Meyer and Georg Zetzsche. 2024. Separability in Büchi VASS and Singly Non-Linear Systems of Inequalities. In ICALP. 126:1-126:19.

Eren Keskin and Roland Meyer. On the Separability Problem of VASS Reachability Languages. In LICS. 49:1-49:14.

Sören van der Wall and Roland Meyer. 2025. SNIP: Speculative Execution and Non-Interference Preservation for Compiler Transformations. In POPL. 1506-1535.

Thomas Haas, René Pascasl Maseli, Roland Meyer, and Hernán Ponce de León. 2023. Static Analysis of Memory Models for SMT Encodings. In OOPSLA. 1618-1647.

Roland Meyer, Thomas Wies, and Sebastian Wolff. 2023. Embedding Hindsight Reasoning in Separation Logic. In PLDI. 1848-1871.

Roland Meyer, Anton Opaterny, Thomas Wies, and Sebastian Wolff. 2023. nekton: A Linearizability Proof Checker. In CAV. 170-183.

Eren Keskin and Roland Meyer. 2023. Separability and Non-Determinizability of WSTS. In CONCUR. 8:1-8:17.

Roland Meyer, Thomas Wies, and Sebastian Wolff. 2023. Make Flows Small Again: Revisiting the Flow Framework. In TACAS. 628-646.

Thomas Haas, Roland Meyer, and Hernán Ponce de León. 2022. CAAT: consistency as a theory. In OOPSLA. 114-144.

Roland Meyer, Thomas Wies, and Sebastian Wolff. 2022. A concurrent program logic with a future and history. In OOPSLA: 1378-1407.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Advanced Topics in Verification	4,0	Lecture/Exercise	english german

Title	Algebraic Automata Theory		
Number	4212560	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	Prof. Dr. Roland Meyer
Workload (h)	300		
Class attendance (h)	84	**Self studying (h)**	216
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
Jean-Eric Pin, Mathematical Foundations of Automata Theory, manuscript, 2016 Jacques Sakarovitch, Elements of Automata Theory, CUP 2009 Nicholas Pippenger, Theories of Computability, Revised Edition (CUP 2009)			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

	6,0	Lecture/Exercise	german
Literature			
Jean-Eric Pin, Mathematical Foundations of Automata Theory, manuscript, 2016 Jacques Sakarovitch, Elements of Automata Theory, CUP 2009 Nicholas Pippenger, Theories of Computability, Revised Edition (CUP 2009)			

Title	Algorithmic Automata Theory		
Number	4212530	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	Prof. Dr. Roland Meyer
Workload (h)	300		
Class attendance (h)	84	**Self studying (h)**	216
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	english		

Contents

Objective qualification

Literature

J. Esparza. Automata theory - an algorithmic approach. Lecture notes for a course on finite and omega-automata, 2012. [available online]

H. Comon, M. Dauchet, R. Gilleron, C. Löding, F. Jacquemard, D. Lugiez, S. Tison, M. Tommasi. Tree Automata Techniques and Applications, 2007. [available online]

M. Hofmann and M. Lange. Automatentheorie und Logik. Springer-Verlag, 2011.

W. Thomas. Languages, Automata and Logic. In Handbook of Formal Languages, volume 3, pages 389-455, Springer-Verlag, 1996. [available online]

A. Bouajjani, J. Esparza, O. Maler. Reachability analysis of pushdown automata: application to model checking. In Proc.of the 8th International Conference on Concurrency Theory, CONCUR, volume 1243 of LNCS, pages 135-150, Springer-Verlag, 1997. [available online]

L. Libkin. Elements of Finite Model Theory. Texts in Theoretical Computer Science. An EATCS Series. Springer-Verlag, 2004.

J. Esparza. Reachability in Live and Safe Free-Choice Petri Nets is NP-complete. [available online]

K.N.Verma, H. Seidl, T. Schwentick. On the Complexity of Equational Horn Clauses. [available online]

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture	english
	2,0	Exercise	english

Title	Computability and Decidability		
Number	4212460	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	5 / 8,0	**Module owner**	Prof. Dr. Roland Meyer
Workload (h)	240		
Class attendance (h)	70	**Self studying (h)**	170
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
Kfoury, Moll, Arbib: A programming approach to computability. Springer 1982 (siehe UB)			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	5,0	Lecture/Exercise	german
Literature			
Kfoury, Moll, Arbib: A programming approach to computability. Springer 1982 (siehe UB)			

Title	Complexity Theory		
Number	4212550	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	Prof. Dr. Roland Meyer
Workload (h)	300		
Class attendance (h)	84	**Self studying (h)**	216
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (180 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	english		

Contents

Objective qualification

Literature

- S. Arora und B.Barak: Computational complexity,
Cambridge University Press 2009

- C.H.Papadimitriou: Computational complexity
Addison-Wesley Publ. Company 1995

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	4,0	Lecture	english
	2,0	Exercise	english

Title	Concurrency Theory		
Number	4212570	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	Prof. Dr. Roland Meyer
Workload (h)	300		
Class attendance (h)	84	**Self studying (h)**	216
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	english german		

Contents

Objective qualification

Literature

L. Priese and H. Wimmel. Petri-Netze. Springer, 2003.

W. Reisig. Petri nets: An Introduction. Monographs in Theoretical Computer Science. An EATCS Series. Springer, 1985.

P. H. Starke. Analyse von Petri-Netz-Modellen. Leitfäden und Monographien der Informatik. Teubner, 1990.

J. Esparza and S. Melzer. Verification of Safety Properties Using Integer Programming: Beyond the State Equation. Formal Methods in System Design, 2000.

J. Esparza. Decidability and complexity of Petri net problems – an introduction. Lectures on Petri Nets I: Basic Models. Springer, 1998.

J. Esparza and M. Nielsen. Decibility issues for Petri nets-a survey. Journal of Information Processing and Cybernetics EIK, 30(3):143-160, 1994.

J. Esparza and K. Heljanko. Unfoldings. Monographs in Theoretical Computer Science. An EATCS Series. Springer, 2008.

C. Rackoff. The covering and boundedness problems for vector addition systems. Theoretical Computer Science. Volume 6, issue 2, 1978.

C. Dufourd et al. Reset nets between decidability and undecidability. Automata, Languages and Programming, 1998.

P. Jan#ar. Undecidability of bisimilarity for Petri nets and some related problems. Theoretical Computer Science. Volume 148, issue 2, 1995.

P. Jan#ar, J. Esparza, and F. Moller, Petri nets and regular processes. Journal of Computer and System Sciences. Volume 59, issue 3, 1999.

A. Finkel and Ph. Schnoebelen. Well-structured transition systems everywhere! Theoretical Computer Science. Volume 256, issue 1-2, 2001.

C. ST. J. A. Nash-Williams. On well-quasi-ordering finite trees. In Mathematical Proceedings of the Cambridge Philosophical Society. Cambridge Univsity Press, 1963.

P. A. Abdulla, A. Collomb-Annichini, A. Bouajjani, and B. Jonsson. Using forward reachability analysis for verification of lossy channel systems. Formal Methods in System Design. Volume 25, issue 1, 2004.

A. Finkel and Goubault-J. Larrecq. Forward analysis for WSTS, part I: Completions. 26th International Symposium on Theoretical Aspects of Computer Science, 2009.

G. Geeraerts, J.-F. Raskin, L. Van Begin. Expand, Enlarge and Check: new algorithms for the coverability problem of WSTS. Journal of Computer and System Sciences, 72(1):180-203, 2005.

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M. F. Atig, A. Bouajjani, S. Burckhardt, M. Musuvathi. On the Verification Problem for Weak Memory Models.

P. A. Abdulla, M. F. Atig, Y.-F. Chen, C. Leonardsson, A. Rezine. Counter-Example Guided Fence Insertion under Weak Memory Models.

M. F. Atig, A. Bouajjani, G. Parlato. Getting Rid of Store-Buffers in TSO Analysis.

R. Milner. Communicating and mobile systems: the pi-calculus. Cambridge University Press, 1999.

D. Sangiorgi, D. Walker. Pi-Calculus: A Theory of Mobile Processes. Cambridge University Press, 2001.

R. Meyer. On boundedness in depth in the #-calculus. Fifth IFIP International Conference On Theoretical Computer Science, 2008.

R. Meyer. Structural Stationarity in the pi-Calculus. PhD thesis, Department of Computing Science, University of Oldenburg, 2008.

T. Wies, D. Zufferey, and T. Henzinger. Forward analysis of depth-bounded processes. FoSSaCS, 2010.

E. D'Osualdo, C.H.-L. Ong. On Hierarchical Communication Topologies in the pi-calculus. Programming Languages and Systems: ESOP, 2016.

M. Mukund. Automata on Distributed Alphabets. Modern Applications of Automata Theory, 2012.

P. Saivasan. Analysis of Automata-theoretic models of Concurrent Recursive Programs. PhD thesis, Chennai Mathematical Institute, 2016.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

Concurrency Theory	4,0	Lecture	english german

Literature

L. Priese and H. Wimmel. Petri-Netze. Springer, 2003.

W. Reisig. Petri nets: An Introduction. Monographs in Theoretical Computer Science. An EATCS Series. Springer, 1985.

P. H. Starke. Analyse von Petri-Netz-Modellen. Leitfäden und Monographien der Informatik. Teubner, 1990.

J. Esparza and S. Melzer. Verification of Safety Properties Using Integer Programming: Beyond the State Equation. Formal Methods in System Design, 2000.

J. Esparza. Decidability and complexity of Petri net problems – an introduction. Lectures on Petri Nets I: Basic Models. Springer, 1998.

J. Esparza and M. Nielsen. Decibility issues for Petri nets-a survey. Journal of Information Processing and Cybernetics EIK, 30(3):143-160, 1994.

J. Esparza and K. Heljanko. Unfoldings. Monographs in Theoretical Computer Science. An EATCS Series. Springer, 2008.

C. Rackoff. The covering and boundedness problems for vector addition systems. Theoretical Computer Science. Volume 6, issue 2, 1978.

C. Dufourd et al. Reset nets between decidability and undecidability. Automata, Languages and Programming, 1998.

P. Jan#ar. Undecidability of bisimilarity for Petri nets and some related problems. Theoretical Computer Science. Volume 148, issue 2, 1995.

P. Jan#ar, J. Esparza, and F. Moller, Petri nets and regular processes. Journal of Computer and System Sciences. Volume 59, issue 3, 1999.

A. Finkel and Ph. Schnoebelen. Well-structured transition systems everywhere! Theoretical Computer Science. Volume 256, issue 1-2, 2001.

C. ST. J. A. Nash-Williams. On well-quasi-ordering finite trees. In Mathematical Proceedings of the Cambridge Philosophical Society. Cambridge Univsity Press, 1963.

P. A. Abdulla, A. Collomb-Annichini, A. Bouajjani, and B. Jonsson. Using forward reachability analysis for verification of lossy channel systems. Formal Methods in System Design. Volume 25, issue 1, 2004.

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G. Geeraerts, J.-F. Raskin, L. Van Begin. Expand, Enlarge and Check: new algorithms for the coverability problem of WSTS. Journal of Computer and System Sciences, 72(1):180-203, 2005.

P. Abdulla, A. Bouajjani, B. Jonsson. On-the-Fly Analysis of Systems with Unbounded, Lossy Fifo Channels. In Proc. of the 10th International Conference on Computer Aided Verification, CAV, volume 1427 of LNCS, pages 305-318, Springer, 1998.

M. F. Atig, A. Bouajjani, S. Burckhardt, M. Musuvathi. On the Verification Problem for Weak Memory Models.

P. A. Abdulla, M. F. Atig, Y.-F. Chen, C. Leonardsson, A. Rezine. Counter-Example Guided Fence Insertion under Weak Memory Models.

M. F. Atig, A. Bouajjani, G. Parlato. Getting Rid of Store-Buffers in TSO Analysis.

R. Milner. Communicating and mobile systems: the pi-calculus. Cambridge University Press, 1999.

D. Sangiorgi, D. Walker. Pi-Calculus: A Theory of Mobile Processes. Cambridge University Press, 2001.

Concurrency Theory	2,0	Exercise	english german

Literature

L. Priese and H. Wimmel. Petri-Netze. Springer, 2003.

W. Reisig. Petri nets: An Introduction. Monographs in Theoretical Computer Science. An EATCS Series. Springer, 1985.

P. H. Starke. Analyse von Petri-Netz-Modellen. Leitfäden und Monographien der Informatik. Teubner, 1990.

J. Esparza and S. Melzer. Verification of Safety Properties Using Integer Programming: Beyond the State Equation. Formal Methods in System Design, 2000.

J. Esparza. Decidability and complexity of Petri net problems – an introduction. Lectures on Petri Nets I: Basic Models. Springer, 1998.

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P. Jan#ar. Undecidability of bisimilarity for Petri nets and some related problems. Theoretical Computer Science. Volume 148, issue 2, 1995.

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A. Finkel and Ph. Schnoebelen. Well-structured transition systems everywhere! Theoretical Computer Science. Volume 256, issue 1-2, 2001.

C. ST. J. A. Nash-Williams. On well-quasi-ordering finite trees. In Mathematical Proceedings of the Cambridge Philosophical Society. Cambridge Univsity Press, 1963.

P. A. Abdulla, A. Collomb-Annichini, A. Bouajjani, and B. Jonsson. Using forward reachability analysis for verification of lossy channel systems. Formal Methods in System Design. Volume 25, issue 1, 2004.

A. Finkel and Goubault-J. Larrecq. Forward analysis for WSTS, part I: Completions. 26th International Symposium on Theoretical Aspects of Computer Science, 2009.

G. Geeraerts, J.-F. Raskin, L. Van Begin. Expand, Enlarge and Check: new algorithms for the coverability problem of WSTS. Journal of Computer and System Sciences, 72(1):180-203, 2005.

P. Abdulla, A. Bouajjani, B. Jonsson. On-the-Fly Analysis of Systems with Unbounded, Lossy Fifo Channels. In Proc. of the 10th International Conference on Computer Aided Verification, CAV, volume 1427 of LNCS, pages 305-318, Springer, 1998.

M. F. Atig, A. Bouajjani, S. Burckhardt, M. Musuvathi. On the Verification Problem for Weak Memory Models.

P. A. Abdulla, M. F. Atig, Y.-F. Chen, C. Leonardsson, A. Rezine. Counter-Example Guided Fence Insertion under Weak Memory Models.

M. F. Atig, A. Bouajjani, G. Parlato. Getting Rid of Store-Buffers in TSO Analysis.

R. Milner. Communicating and mobile systems: the pi-calculus. Cambridge University Press, 1999.

D. Sangiorgi, D. Walker. Pi-Calculus: A Theory of Mobile Processes. Cambridge University Press, 2001.

Title	Program Analysis Lab		
Number	4212590	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Roland Meyer
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Program Analysis Lab	4,0	Internship	german
Literature			
Varies depending on the topic			

Title	Semantics		
Number	4212000000	**Module version**	
Shorttext		**Language**	german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	Prof. Dr. Roland Meyer
Workload (h)	300		
Class attendance (h)	84	**Self studying (h)**	216
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	6,0	Lecture/Exercise	german

Title	Games with Perfect Information		
Number	4212540	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Roland Meyer
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	english		

Contents

Objective qualification

Literature

B. Khoussainov, A. Nerode. Automata Theory and its Applications. Birkhäuser, 2001.

M. Hofmann and M. Lange. Automatentheorie und Logik. Springer-Verlag, 2011.

Th. Cachat. Symbolic Strategy Synthesis for Games on Pushdown Graphs. In Proc. of the 29th International Colloquium on Automata, Languages and
Programming, ICALP, pages 704-715, Springer, 2002.

I. Walukiewicz. Pushdown Processes: Games and Model Checking. In Journal Information and Computation - Special issue on FLOC '96, pages 234–263.
Academic Press, 2001. Pages 234–263

L. Holik, R. Meyer, S. Muskalla. Summaries for Context-Free Games. In Proc.of 36th IARCS Annual Conference on Foundations of Software Technology and
Theoretical Computer Science, FSTTCS, pages 41:1-41:16. LIPIcs, 2016.

O. Serre. Note on winning positions on pushdown games with omega-regular winning conditions. In Information Processing Letters, Vol 85 Issue 6, pages 285-291. Elsevier, 2003.

D. A. Martin. A purely inductive proof of Borel determinacy. In Proc. Sympos. Pure Math., Vol 42, page 303–30. AMS, 1985.

U. Zwick, M. Paterson. The complexity of mean payoff games on graphs. In Theoretical Computer Science, Vol. 158, Issues 1–2, pages 343–359. Elsevier, 1996.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Games with Perfect Information	4,0	Lecture/Exercise	english

Literature

B. Khoussainov, A. Nerode. Automata Theory and its Applications. Birkhäuser, 2001.

M. Hofmann and M. Lange. Automatentheorie und Logik. Springer-Verlag, 2011.

Th. Cachat. Symbolic Strategy Synthesis for Games on Pushdown Graphs. In Proc. of the 29th International Colloquium on Automata, Languages and
Programming, ICALP, pages 704-715, Springer, 2002.

I. Walukiewicz. Pushdown Processes: Games and Model Checking. In Journal Information and Computation - Special issue on FLOC '96, pages 234–263.
Academic Press, 2001. Pages 234–263

L. Holik, R. Meyer, S. Muskalla. Summaries for Context-Free Games. In Proc.of 36th IARCS Annual Conference on Foundations of Software Technology and
Theoretical Computer Science, FSTTCS, pages 41:1-41:16. LIPIcs, 2016.

O. Serre. Note on winning positions on pushdown games with omega-regular winning conditions. In Information Processing Letters, Vol 85 Issue 6, pages 285-291. Elsevier, 2003.

D. A. Martin. A purely inductive proof of Borel determinacy. In Proc. Sympos. Pure Math., Vol 42, page 303–30. AMS, 1985.

U. Zwick, M. Paterson. The complexity of mean payoff games on graphs. In Theoretical Computer Science, Vol. 158, Issues 1–2, pages 343–359. Elsevier, 1996.

Title	Advanced Networking 1		
Number	4213360	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 examination: oral examination, 20 minutes or take-home exam		
Course achievement	1 course achievement: 2-4 short presentations, depending on complexity		
Examination language	english		
Contents			
New topics in Computer Networks			
Objective qualification			
On completion of this module, the students have a deep understanding of recent advances and research trends in the area of computer networking.			
Literature			
aktuelle Literatur wird in der Veranstaltung bekanntgegeben			

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Seminar	english
Literature			
Current literature will be announced in the course			

Title	Advanced Networking 2		
Number	4213370	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 examination: oral examination, 20 minutes or take-home exam		
Course achievement	1 course achievement: 2-4 short presentations, depending on complexity		
Examination language	english		
Contents			
More advanced new topics of the Computer Networks			
Objective qualification			
On completion of this module, the students have a deep understanding of recent advances and research trends in the area of computer networking.			
Literature			
aktuelle Literatur wird in der Veranstaltung bekanntgegeben			

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Advanced Networking 2 Seminar	2,0	Seminar	english
Literature			
will be announced in the seminar			

	1,0	Colloquium	english

Title	Computer Networks 2		
Number	4213390	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	INF 2230 (Computer Networks) or equivalent knowledge		
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (20 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	english		

Contents

- Internet protocols
- IP
- TCP
- Routing methods
- Newer protocols and methods

Objective qualification

On completion of this module, students will have deepened their knowledge from the course 'Computer Networks 1'. They will be familiar with the processes used on the Internet and the procedures involved.

Literature

Andrew Tanenbaum, David Wetherall, Nick Feamster, Computer Networks, 6.Ed. 2021, Print-ISBN: 978-1-292-37406-2, E-ISBN: 978-1-292-37401-7
James Kurose, Keith Ross. Computer Networking. A Top-Down Approach, 2021, 8th edition, Print-ISBN: 978-1-292-40546-9, E-ISBN: 978-1-292-40551-3.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	english

Literature

- Andrew S. Tanenbaum; David J. Wetherall: Computer Networks. International Edition. 5th edition. Pearson, 2010. ISBN-10: 0132553171 / ISBN-13: 9780132553179 - James F. Kurose; Keith W. Ross: Computer Networking: A Top-Down Approach. International Edition. 6th edition. Pearson, 2012. ISBN-10: 0273768964 / ISBN-13: 9780273768968

Title	Managing information security		
Number	4213380	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (20 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	german		

Contents

- Motivation / Why technology alone is not enough
- Fundamentals (terms, concepts, etc.)
- Presentation of the two security standards ISO/IEC 27001 (and associated auxiliary standards) and BSI IT-Grundschutz
- Details on risk analysis (approaches, problems, examples)
- The human factor – awareness
- Review of security measures
- Business continuity management (emergency planning)

Objective qualification

Students will be able to analyse and assess hazards and risks based on the individual situation of a company and, building on this, establish a management system that covers the entire life cycle of a technical and organisational security infrastructure that is optimally adapted.

Literature

1) The information security standard: ISO/IEC 27001:2005
2) IT baseline protection standards 100-1 to 100-4 and the IT baseline protection catalogues of the Federal Office for Information Security
3) References for the respective lecture chapters

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
	1,0	Exercise	german

Title	Mobile Computing Lab (MPO 2010)		
Number	4213000050	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 Examination: successful completion of the tasks incl. colloquium		
Course achievement			
Examination language	english german		
Contents			
- Mobile computing background - Design and implementation of applications for mobile computer networks			
Objective qualification			
On completion of the module, students will be familiar with the current state of the art in mobile computing and will be able to design and implement applications independently.			
Literature			
Die Literaturquellen variieren je nach Thema.			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Mobile Computing Lab	4,0	Internship	english german

Title	Mobile Communications		
Number	4213400	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (20 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	english german		

Contents

- Technical fundamentals of mobile communications
- Media access
- Wireless Telecommunications Systems
- Wireless LANs
- Network layer aspects
- Transport Layer Aspects
- Mobility support

Objective qualification

On completion of the module, students will be familiar with the fundamental challenges and solutions in mobile communications.

Literature

- Jochen Schiller: Mobilkommunikation, Pearson Studium. 2003

Siehe auch Aktualisierung auf der Webseite der Lehrveranstaltung

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Mobile Communications	4,0	Lecture/Exercise	english german
Literature			
J. Schiller: Mobilkommunikation - Techniken für das allgegenwärtige Internet, 2. Auflage, Addison-Wesley 2003			
	2,0	Exercise	english german

Title	Networked Systems and Applications Lab		
Number	4213000000	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	english german		
Contents			
Objective qualification			
After completing this module, students have a deeper understanding of selected aspects and newer developments in the area of networked systems and applications. They gained experience in the design, implementation, evaluation, simulation or analysis of such systems, components or applications.			
Literature			
Die Literaturquellen variieren je nach Thema.			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Internship	english german
	1,0	Colloquium	english german

Title	Networking and Multimedia Lab		
Number	4213000020	**Module version**	V3
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Processing of tasks including colloquium or Take-Home-Exam.		
Course achievement			
Examination language	english german		
Contents			
Objective qualification			
Literature			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	english german

Title	Practical Course Computer Networks		
Number	4213000010	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	english german		
Contents			
Objective qualification			
Literature			
Hinweise zu aktueller Literatur erhalten Sie im Rahmen der Veranstaltung.			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Internship	english german
Literature			
Hinweise zu aktueller Literatur erhalten Sie im Rahmen der Veranstaltung.			

	1,0	Colloquium	english ger-man

Title	Practical Course Computer Networks Administration		
Number	4213000030	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	english german		
Contents			
Objective qualification			
Literature			
Hinweise zu aktueller Literatur erhalten Sie im Rahmen der Veranstaltung.			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Practical Course Computer Networks Administration	3,0	Internship	english german
Literature			
Hinweise zu aktueller Literatur erhalten Sie im Rahmen der Veranstaltung.			

	1,0	Colloquium	english ger-man

Title	Recent Topics in Computer Networking		
Number	4213350	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: oral exam (20 minutes) or Take-Home-Exam.		
Course achievement	1 course achievement: 2 short/partial presentations		
Examination language	english german		
Contents			
new topics in the field of Computer Networks			
Objective qualification			
On completion of this module, the students have obtained a deep, detailed insight into several specific topics, which are fundamental for a further development of research and computer networking skills especially in the recent fields of WSNs and DTNs.			
Literature			
http://www.ibr.cs.tu-bs.de/courses/			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

Recent Topics in Computer Networking	3,0	Lecture/Exercise	english ger-man
Literature			
will be announced in the course depending on the topic			

Title	Selected Topics in Networked Systems 1		
Number	4213340	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (20 minutes) or term Paper or presentation or deveplopment and documentation of computer programs or experimental work or portfolio or Take-Home-Exam.		
Course achievement			
Examination language	english german		
Contents			
New topics from the field of networked systems (depending on the courses offered).			
Objective qualification			
After completing this module, students will have a deeper understanding of selected aspects and recent developments in the field of networked systems and, where applicable, applications based on them.			
Literature			
Literature varies depending on the topic			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	english german
Literature			
Literatur variiert, je nach Thema			

Title	Selected Topics in Networked Systems 2		
Number	4213410	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (20 minutes) or term Paper or presentation or deveplopment and documentation of computer programs or experimental work or portfolio or Take-Home-Exam.		
Course achievement			
Examination language	english german		
Contents			
New topics from the field of networked systems (depending on the courses offered).			
Objective qualification			
After completing this module, students will have a deeper understanding of selected aspects and recent developments in the field of networked systems and, where applicable, applications based on them.			
Literature			
Literature varies according to the topic			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Online-lecture	english german
	2,0	Online-exercise	english german

Title	Wireless Networking Lab		
Number	4213000040	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 Examination: successful completion of the tasks incl. colloquium		
Course achievement			
Examination language	english german		
Contents			
- Wireless (sensor) network technology - Design and implementation of applications for wireless (sensor) networks			
Objective qualification			
Upon completion of this module, students will be familiar with the current state of the art in wireless (sensor) networks. They will be able to design and implement applications independently.			
Literature			
The literature sources vary depending on the topic.			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Wireless Networking Lab	3,0	Internship	english german
Literature			
Literature sources vary depending on the topic.			

	1,0	Colloquium	english ger-man

Title	Selected Topics in Information Systems		
Number	4214670	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Informations-systeme
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Wolf-Tilo Balke
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examina-tion	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	english		
Contents			
changing current topics from the fields of databases and information systems			
Objective qualification			
Upon completion of this module, students will have a deeper understanding of recent developments and research trends in the field of databases and information systems.			
Literature			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

	2,0	Lecture/Exercise	english

Literature

- Digital_Humanities. Anne Burdick, Johanna Drucker, Peter Lunenfeld, Todd Presner and Jeffrey Schnapp. MIT Press, Cambridge, Massachusetts London, England. 152 pp. February 2016 (Online-Version: https://mitpress.mit.edu/sites/default/files/titles/content/9780262018470_Open_Access_Edition.pdf).

- Search User Interfaces, Marti Hearst, Cambridge University Press, 2009. (Online-Version: http://searchuserinterfaces.com/book/)

- Introduction to Information Retrieval, C.D. Manning, P. Raghavan, H. Schütze, Cambridge University Press, 2008. (Online-Version: http://nlp.stanford.edu/IR-book/information-retrieval-book.html)

- Foundations of Statistical Natural Language Processing, Chris Manning and Hinrich Schütze, MIT Press, Cambridge, MA, 1999.

	1,0	Exercise	english

Literature

- Digital_Humanities. Anne Burdick, Johanna Drucker, Peter Lunenfeld, Todd Presner and Jeffrey Schnapp. MIT Press, Cambridge, Massachusetts London, England. 152 pp. February 2016 (Online-Version: https://mitpress.mit.edu/sites/default/files/titles/content/9780262018470_Open_Access_Edition.pdf).

- Search User Interfaces, Marti Hearst, Cambridge University Press, 2009. (Online-Version: http://searchuserinterfaces.com/book/)

- Introduction to Information Retrieval, C.D. Manning, P. Raghavan, H. Schütze, Cambridge University Press, 2008. (Online-Version: http://nlp.stanford.edu/IR-book/information-retrieval-book.html)

- Foundations of Statistical Natural Language Processing, Chris Manning and Hinrich Schütze, MIT Press, Cambridge, MA, 1999.

Title	Data Warehousing and Data Mining Techniques		
Number	4214590	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Informations-systeme
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Wolf-Tilo Balke
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	graded work: written exam(90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement	non-graded work: 50% of the exercises must be passed		
Examination language	english german		

Contents

This module will give a broad overview over all methods that are necessary for building and using data warehouses in large-scale applications. Besides typical techniques for warehouse design, indexing, and online analytical processing (OLAP), also advanced data mining techniques, such as classification, clustering, frequent item set mining, and association rules are covered in the lecture. In paticular,
- Statistical methods in databases
- Knowledge discovery and mining of local structures
- Frequent Item Set Mining and Association Rules
- Hierarchical and partitioning clustering algorithms
- (Linear) classification and support vector machines
- Architecture of data warehouses (ROLAP, MOLAP,...)
- Multi-dimensional data models (star, snowflake)
- Extraction, data transformation and cleaning
- Techniques for online analytical processing (OLAP)
- Storage- and Index structures for data warehouses

Objective qualification

On completion of this module, students know the basic designs, theoretical foundations, and practical applications of data warehouses and have a good overview of typical data mining techniques employed in data warehouses. Also, they have deep understanding of suitable data structures and the respective algorithms. This enables students to identify and recognize typical data warehouse problems in common business cases. They are able to assess and analyze these problems, and based on their results and their technical proficiency with common tools, techniques, and concepts, they are able to assess and develop requirements and designs for suitable data warehouse solutions and data analysis. Furthermore, the students are aware of typical challenges arising from the introduction of data warehouse solutions, and are have an understanding of the impact of these solutions on a company’s workflows.

Literature

- William H. Inmon: Building the Data Warehouse. Wiley & Sons. ISBN 10: 0-7645-9944-5

- Ralph Kimball, Margy Ross: The Data Warehouse Toolkit. Wiley & Sons. ISBN 10: 0-471-0024-7

- Andreas Bauer, Holger Günzel: Data Warehouse Systeme. dpunkt Verlag. ISBN 10: 3-89864-251-8

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Data Warehousing and Data Mining Techniques	2,0	Lecture	english german
Literature			
- William H. Inmon: Building the Data Warehouse. Wiley & Sons. ISBN 10: 0-7645-9944-5 - Ralph Kimball, Margy Ross: The Data Warehouse Toolkit. Wiley & Sons. ISBN 10: 0-471-0024-7 - Andreas Bauer, Holger Günzel: Data Warehouse Systeme. dpunkt Verlag. ISBN 10: 3-89864-251-8			
	1,0	Exercise	english german

Title	Distributed data management		
Number	4214580	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Informations-systeme
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Wolf-Tilo Balke
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examina-tion	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement	1 Coursework: 50% of the exercises must be passed		
Examination language	german		

Contents

- Distributed database architectures and data distribution
- Vertical and horizontal fragmentation
- Distributed query processing
- Distributed transactions
- Fundamentals of parallel database systems
- Parallel query processing
- Fundamentals of peer-to-peer networks
- Random graphs, small worlds and scale-free networks
- Structured networks with distributed hash tables
- Schema-based peer-to-peer networks
- Information retrieval in peer-to-peer networks

Objective qualification

After completing this module, students will have acquired fundamental knowledge in the areas of distributed database systems and peer-to-peer data management.

Literature

- Peter Mahlmann, Christian Schindelhauer: P2P Netzwerke. Springer Verlag, 2007.

- Ralf Steinmetz, Klaus Wehrle: Peer-to-Peer Systems and Applications. Springer Verlag, 2005.

- M. Tamer Ozsu, Patrick Valduriez: Principles of Distributed Data Systems. Prentice Hall, 1997.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
	1,0	Exercise	german

Title	Information Retrieval and Web Search Engines		
Number	4214600	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Informationssysteme
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Wolf-Tilo Balke
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	graded work: written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement	non-graded work: 50% of the exercises must be passed		
Examination language	english german		

Contents

The module gives an introduction to Web Information Retrieval with particular emphasis on the algorithms and technologies used in the modern search engines. It covers an introduction to traditional text IR, including Boolean retrieval, vector space model as well as tolerant retrieval. Afterwards, the technical basics of Web IR are discussed, starting with a Web size estimation and duplicate detection followed by link analysis and crawling. This leads on to the study of the modern search engine evaluation methods and various test collections. Finally, applications of classification and clustering in the IR domain are discussed. During the module the theoretical basis is illustrated by examples of modern search systems, such as Google, Bing, Yahoo!, etc. In particular,
- Structured vs. unstructured data
- Text retrieval, probabilistic, fuzzy- and vector space models
- Assessment of retrieval quality, precision-recall analysis
- Architecture of Web information systems and search engines
- Structure of the WWW, Web crawling and indexing
- Document clustering and ontologies for search
- Text and link metrics, Page-Rank, HITS, etc.

Objective qualification

On completion of this module, students should be able to understand the principles used in the design of modern search engines, especially with respect to the relevance ranking, indexing and crawling. Moreover, they are able to discuss the differences between traditional text- and Web IR and compare different algorithms to perform relevance ranking on the Web. They also understand the differences between classification and clustering and can discuss their applications in the IR domain. Finally, students can explain query expansion and reformulation methods, understand the principles used in the evaluation of search engines, and are aware of query optimization issues.

Literature

- Christopher D. Manning, Prabhakar Raghavan, Hinrich Schütze: Introduction to Information Retrieval. Cambridge University Press, 2008.
http://www.informationretrieval.org

- Ricardo Baeza-Yates, Berthier Ribeiro-Neto: Modern Information Retrieval. Addison-Wesley, 1999.

- Richard K. Belew: Finding Out About: A Cognitive Perspective on Search Engine Technology and the WWW. Cambridge University Press, 2000.

- Cornelis Joost van Rijsbergen: Information Retrieval. Butterworths, second edition, 1979. http://www.dcs.gla.ac.uk/Keith/Preface.html

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Information Retrieval und Web Search Engines	3,0	Lecture/Exercise	english german

Literature

- Christopher D. Manning, Prabhakar Raghavan, Hinrich Schütze: Introduction to Information Retrieval. Cambridge University Press, 2008. http://www.informationretrieval.org

- Ricardo Baeza-Yates, Berthier Ribeiro-Neto: Modern Information Retrieval. Addison-Wesley, 1999.

- Richard K. Belew: Finding Out About: A Cognitive Perspective on Search Engine Technology and the WWW. Cambridge University Press, 2000.

- Cornelis Joost van Rijsbergen: Information Retrieval. Butterworths, second edition, 1979. http://www.dcs.gla.ac.uk/Keith/Preface.html

Title	Multimedia databases		
Number	4214610	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Informations-systeme
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Wolf-Tilo Balke
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examina-tion	1 graded work: Written exam, 90 minutes, or oral exam, approx. 30 minutes, or Take-Home-Exam.		
Course achievement	1 non-graded work: 50% of the exercises must be passed		
Examination language	english german		

Contents

- General structure of multimedia databases
- Advanced document types, multimedia documents
- Image-content search, low-level and high-level features
- High-dimensional indexing, inverted files, R-, M- and X-trees
- Search in audio files, acoustic features, e.g. pitch recognition
- Music retrieval, Hidden Markov Models, Query by Humming, etc.
- Video retrieval, segmentation and shot detection
- Video similarity, video signatures, abstracting and summaries

Objective qualification

Upon completion of this module, students will have basic knowledge in the field of multimedia databases.

Literature

- Ingo Schmitt: Ähnlichkeitssuche in
Multimedia-Datenbanken. Oldenbourg Wissenschaftsverlag, 2005.

- Vittorio Castelli, Lawrence D. Bergman: Image Databases. Wiley & Sons, 2002.

- Ralf Steinmetz: Multimedia-Technologie: Grundlagen, Komponenten und Systeme. Springer Verlag, 1999.

- Setrag Khoshafian, Brad Baker: Multimedia and Imaging Databases. Morgan Kaufmann, 1996.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Lecture/Exercise	english german

Title	Knowledge based systems and deductive database systems		
Number	4214620	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Informations-systeme
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Wolf-Tilo Balke
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examina-tion	1 written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement	50% of the exercises must be passed		
Examination language	english german		

Contents

This module will give a broad overview over all methods and approaches that are necessary for reasoning over large knowledge bases using first order predicate logics. Moreover, the architecture of the Semantic Web is investigated with the a special focus on Semantic Web standards, modeling languages, ontologies and ontology languages, and advanced Semantic Web techniques. In particular,
- Logic programming, predicate logic as a data model
- Top-down and bottom-up strategies for query processing
- Datalog and processing recursive Datalog queries
- Query optimization with Magic Sets
- Knowledge representation
- Object-oriented extension, path queries
- Recursion in databases, Common Table Expressions
- User-Defined Types and User-Defined Functions
- Semantic Web standards (RDF, OWL, etc.)
- Semantic Web architecture and techniques

Objective qualification

On completion of this module, students are aware of the challenges and problems which arise from reasoning processes over large knowledge bases. This covers technical aspects (algorithms,implementations, etc.) and also methodological aspects (e.g. uncertainty, etc.). Furthermore, the students will be able to discuss the strengths and weaknesses of different approaches to reasoning and will be able to competently propose solution strategies to practical problem scenarios.

Literature

- S. Ceri, G. Gottlob, L. Tanca: Logic Programming and
Databases - Surveys in Computer Science. Springer Verlag,
1990.

- S.K. Das: Deductive Databases and Logic Programming. Addison-Wesley, 1992.

- J. Ullman: Principles of Databaseand Knowledge-Base Systems,Volume II: The New Technologies. W.H. Freeman & Co., 1989.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Knowledge-Based Systems and Deductive Database Systems	3,0	Lecture/Exercise	english german

Title	Digital Image Processing		
Number	4215000010	**Module version**	V3
Shorttext		**Language**	english german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Martin Eisemann
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	Written exam, 90 minutes, or Written exam+, 90 minutes, oder oral exam, 30 minutes or Take-Home Exam		
Course achievement	Successful completion of homework		
Examination language	english german		

Contents

- Systems theory basics
- Image acquisition and digitization
- Methods of image enhancement
- Image segmentation
- Image compression
- Binary images – operaters and properties
- Description and analysis of images
- Recognition oft wo-dimensional patterns
- Image processing operaters
- Machine learning for image processing and image editing

Objective qualification

After successfully completing this module, students will be able to analyze practical problems in two-dimensional image processing, image analysis and pattern recognition, design suitable solutions and implement them in practice.

Literature

- Radke: Computer Vision for Multimedia, Cambridge University Press
- Nischwitz, Fischer, Haberäcker, Socher: Bildverarbeitung: Band II des Standardwerks Computergrafik und Bildverarbeitung (Computergrafik und Bildverarbeitung, 2)
- Goodfellow et al: Deep Learning – Das umfassende Handbuch, mitp

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Digital Image Processing	4,0	Lecture/Exercise	english german
Literature			
- Radke: Computer Vision for Multimedia, Cambridge University Press - Nischwitz, Fischer, Haberäcker, Socher: Bildverarbeitung: Band II des Standardwerks Computergrafik und Bildverarbeitung (Computergrafik und Bildverarbeitung, 2) - Goodfellow et al: Deep Learning – Das umfassende Handbuch, mitp			

Title	Human-Robot Interaction		
Number	4215000020	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Kognitive Robotik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Jens Lambrecht
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	The course assumes basic knowledge in mathematics and statistics as acquired in the introductory course in mathematics in the computer science curriculum.		
Expected performance/ Type of examination	Written exam (90 minutes) or oral exam (30 min)		
Course achievement			
Examination language	english german		

Contents

This module covers fundamental concepts, methods, and applications of human-robot interaction. Topics include:
• Fundamentals and definitions of human-robot interaction
• Application fields: industrial, service, healthcare, and social robotics
• Safety in collaborative robotic systems and relevant standards (ISO 10218, ISO/TS 15066)
• Physical interaction: haptic feedback, force and impedance control
• Social robots: non-verbal communication, gestures, and facial expressions
• Speech-based and multimodal interaction
• User-centered design and usability evaluation
• Trust, acceptance, and situational awareness
• Ethical, legal, and societal aspects of HRI
• Current research directions and application scenarios

Objective qualification

Upon successful completion of this module, students will have foundational knowledge of the design, evaluation, and safe implementation of human-robot interaction systems. Students will be able to develop interaction concepts for real-world application scenarios and evaluate them with respect to technical, ergonomic, and ethical criteria.
They are able to
• Identify and classify fundamental concepts, paradigms, and application fields of human-robot interaction
• Explain and apply safety requirements and relevant standards (including ISO 10218, ISO/TS 15066) for collaborative robotic systems
• Describe and compare methods of physical and social interaction between humans and robots
• Design user-centered interfaces and interaction concepts and evaluate them with respect to usability
• Analyze factors such as trust, acceptance, and situational awareness in HRI systems and incorporate them into system development

• Reflect on and evaluate the ethical and societal implications of deploying robots in human environments
Literature
• Christoph Bartneck et al.: Human-Robot Interaction: An Introduction • Breazeal, Dautenhahn & Forlizzi: Social Robots that Interact with People • Goodrich & Schultz: Human-Robot Interaction: A Survey • slides, further references will be announced in the course

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Human-Robot Interaction	4,0	Lecture/Exercise	english german

Title	Advanced Robotics Lab		
Number	4215000030	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Kognitive Robotik
Hours per Week / ECTS	8 / 10,0	**Module owner**	Prof. Dr. Jens Lambrecht
Workload (h)	300		
Class attendance (h)	112	**Self studying (h)**	188
Compulsory requirements			
Recommended requirements	This module requires advanced programming skills or experience in software development. Having taken courses in robotics or machine learning is beneficial but not required.		
Expected performance/ Type of examination	Portfolio assessment consisting of different components		
Course achievement			
Examination language	english german		

Contents

In this project module, students independently work on individual topics in the areas of human-robot interaction (HRI) and machine learning in robotics. Starting from an independent problem analysis, students go through the complete development cycle from conception and implementation through to evaluation and presentation of their results. Topics include:
• Independent study of an individual topic in the field of HRI or robot learning
• Analysis of the state of the art and relevant scientific literature
• Conception and planning of a (software) solution
• Implementation and experimental validation on a real system or in simulation
• Documentation of results in the form of a technical report
• Presentation and critical discussion of the developed solution

Objective qualification

Upon completion of this module, students will have a deeper understanding of the development of complex intelligent robotic systems.

Literature

Specific reading materials will be announced individually during the course

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Advanced Robotics Lab	8,0	Internship	english german

Title	Robot Learning		
Number	4215390	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	every 2 years in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Kognitive Robotik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Jens Lambrecht
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 Examination: oral examination (20-30 minutes) or written exam (90 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	english		

Contents

Algorithms and applications of machine learning in
fundamental areas of robotics. These include, but are not limited to
applications in
- motion learning, architectures and their biological
Models
- Kinematics learning for forward and inverse kinematics
- Dynamics learning and hybrid modeling
- Skill learning
- Learning of actions and sequences

To realize such applications, methods of exploratory learning, reinforcement learning, for online regression and evolutionary algorithms, among others, are treated in depth.

Objective qualification

Students acquire the competence to formalize applications of learning methods in robotics, to select suitable methods and to evaluate them with regard to their performance. They acquire the competence to assess chances and possibilities as well as limitations of robot learning. In the exercises, the students deepen their knowledge and apply it practically, also in the form of programming tasks.

Literature

Vorlesungsskripte
aktuelle wissenschaftliche Literatur
weiteres wird in der Vorlesung nach Bedarf bekanntgegeben

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
	4,0	Lecture/Exercise	english

Literature
- Lecture notes - current scientific literature - further information will be announced in the lecture as required

Title	Robotics 1 - Technical and Mathematical Basics		
Number	4215460	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Kognitive Robotik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Jens Lambrecht
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (20 minutes) or Take-Home-Exam. The form of the examination depends on the number of participants and will be announced at the beginnung of the lecture.		
Course achievement			
Examination language	english german		

Contents

They are able to

- understand and correctly apply basic concepts of medical robotics
- model manipulators and describe them in geometrical and mathematical terms
- compute kinematic transforms
- compute and analyze the Jacobian, including singularities and redundancy
- compute differential kinematics and use these in control settings
- apply and judge planning algorithms

Objective qualification

Literature

With successful completion of the module, the students possess knowledge of the technical and mathematical foundations in robotics. They have the basic knowledge to enter advanced studies and are able to apply their knowledge for the analysis and realization of simple robotic applications

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Robotics 1 - Technical and Mathematical Basics	4,0	Lecture/Exercise	english german
Literature			
- P.J. McKerrow: Introduction to Robotics, Addison-Wesley (div. Exemplare in UB) - Vorlesungsumdrucke - further information will be given in the lecture			
	2,0	Exercise	english german

Title	Robotics 2 - Programming, Modelling, Planning		
Number	4215450	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Kognitive Robotik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Jens Lambrecht
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	The course assumes knowledge in mathematics as acquired in the introductory course in mathematics in the computer science curriculum. A previous attendance of the course “Robotics1” is strongly recommended.		
Expected performance/ Type of examination	- Graded work: written exam (90 minutes) or oral exam (about 20 minutes) or Take-Home-Exam. The form of the examination depends on the number of participants and will be announced at the beginnung of the lecture.		
Course achievement			
Examination language	english german		

Contents

Relying on the fundamental concepts of the course “Robotics1”, the course “Robotics2” offers a focus on more practical issues arising in the control if robotic systems. This includes in particular:
- Principles of perception and measurments and robot sensing
- Techniques of modeling and simulation
- Paradigms and best practices of robot programming
- Specification of robotic tasks
- Planning method of robotic actions
- Techniques for the study of work space and singularities
- Distinction of rigid and elastic components
- Advances techniques for controlling robotic systems
- Combinatorial modeling of mechanical systems

Objective qualification

The course conveys basic computer science paradigms, concepts, algorithms of robotics to the students. After a successful completion of the course, the acquired knowledge offers a solid foundation that enables the students to realize advanced robot applications in diverse technological fields. In particular, the students gain following competences:
- Deepened understanding of essential, theoretical foundations of robotics
- Broadened knowledge of practical tasks for running robots
- Further pervasion of a systemic, model-based approach to robotics
- Perception of a robot as a technical system for motion and force generation
- Deepened comprehension of properties of spatial motions
- Expansion of programming competences
- Increased ability to reflect on programming activities

- Qualification for evaluation of computational and geometrical tasks in robotics as well as of algorithms for solving them
Literature
- P.J. McKerrow: Introduction to Robotics - Spong, Hutchinson, Vidyasagar, ‘Robot Modeling and Control’, 2005. Scripts, slides, and further references are announced in the course

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Robotics 2	4,0	Lecture/Exercise	english german
Literature			
- P.J. McKerrow: “Introduction to Robotics”. Addison-Wesley (div. Exemplare in UB) - R.M. Murray, Z. Li, S.S. Sastry: “A Mathematical Introduction to Robotic Manipulation”. (online) - K.M. Lynch, F.C. Park: “Modern Robotics: Mechanics, Planning, and Control”. (online) Scripts, slides, and further references are announced in the course.			

Title	Robotics Lab		
Number	4215000000	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Kognitive Robotik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Jens Lambrecht
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
- Vorlesungsumdrucke der Robotik-Vorlesungen - Umdrucke zum Robotik-Praktikum			

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

Robotics Lab	3,0	Internship	german
Literature			
Die Studierenden besitzen nach Durchführung der Versuche im Roboterlabor ein vertieftes Verständnis des in den Robotikvorlesungen erworbenen Stoffes und sollten somit in der Lage sein, praktische Probleme im industriellen Umfeld zu lösen.			

Robotics Lab	1,0	Colloquium	german

Title	Real-Time Computer Graphics		
Number	4216290	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Martin Eisemann
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	english german		

Contents

Objective qualification

Literature

- Frank Nielsen: Visual Computing. Charles River Media, 2005.

- Tomas Akenine-Möller, Eric Haines, Naty Hoffman: Real-Time Rendering. Third Edition. A K Peters, 2008.

- Edward Angel, Dave Shreiner: Interactive Computer Graphics. A Top-Down Approach with Shader-based OpenGL. sixth edition. Addison-Wesley, 2011.

↑

Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language

	4,0	Lecture/Exercise	english german
Literature			
- Frank Nielsen: Visual Computing. Charles River Media, 2005. - Tomas Akenine-Möller, Eric Haines, Naty Hoffman: Real-Time Rendering. Third Edition. A K Peters, 2008. - Edward Angel, Dave Shreiner: Interactive Computer Graphics. A Top-Down Approach with Shader-based OpenGL. sixth edition. Addison-Wesley, 2011.			

	2,0	Exercise	english german
Literature			
s. Modulhandbuch			

Title	Computer Graphics - Introduction		
Number	4216300	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Marcus Magnor
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement	1 course achievement: regular successful participation in the exercises (at least 50% of the homework assignments must be passed).		
Examination language	german		

Contents

- Fundamentals of digital image generation
- Physical laws of light transport
- Human visual perception
- 3D geometry and transformations
- Ray tracing approach
- Acceleration structures
- Material and reflection models
- Fundamentals of image signal processing

Objective qualification

After completing this module, students possess fundamental knowledge of the theoretical and practical foundations of computer graphics. Using the ray tracing approach as an example, a range of fundamental topics in image synthesis are explained both theoretically and practically. Students are able to understand all components of a ray tracer and to develop their own ray tracer.

Literature

- James Foley, AndriesVan Dam, et al., Computer Graphics: Principles and Practice, 2. Ausgabe, Addison-Wesley, 2009

- Peter Shirley: Realistic Ray-Tracing. AK Peters, 2009

- Peter Shirley, Steve Marschner: Fundamentals of Computer Graphics. AK Peters/CRC Press, 2009.

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
	4,0	Lecture/Exercise	german

Literature

- Peter Shirley: Realistic Ray-Tracing . AK Peters, 2009
- James Foley, Andries Van Dam, et. Al., Computer Graphics: Principles and Practice. Addison-Wesley, 2009
- Frank Nielsen, Visual Computing, Charles River Media, 2005
- Steven J. Gortler, Foundations of 3D Graphics, Mit Pr, 2012
- John F. Hughes, Computer Graphics: Principles and Practice, Addison-Wesley, 2009

Title	Computer Graphics Lab		
Number	4216250	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Marcus Magnor
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	english german		
Contents			
Objective qualification			
Literature			
Weiterführende Literatur je nach gewähltem Themengebiet			

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

Computer Graphics - Practical course	4,0	Internship	english ger-man

Literature

J. Neider and T. Davis and M. Woo, OpenGL Programming Guide: The Official Guide to Learning OpenGL, Addison- Wesley, Reading Mass.,2003,fourth edition, version 1.4
Microsoft, The DirectX Software Development Kit, SDK

Weiterführende Literatur je nach gewähltem Themengebiet

Title	Computer Vision and Machine Learning		
Number	4216330	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Marcus Magnor
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 exam: written exam, 90 minutes or oral exam, 30 minutes or Take-Home-Exam.		
Course achievement	1 study achievement: 50% of the exercises must be passed		
Examination language	english german		

Contents

- Feature Detectors and Descriptors
- Object Detectio
- Matting
- Image Compositing and Editing
- Dense Correspondences
- Motion Capture
- Cameracalibration
- Epipolar Geometry
- Stereo and Multi-View Reconstruction
- Cameras and Scanner
- Machine Learning for Computer Vision Problems

Objective qualification

Upon successful completion of this module, students will have a basic understanding of how to develop complex computer vision applications. They are able to analyze computer vision problems and to design and implement appropriate solutions.

Literature

- Radke: Computer Vision for Multimedia, Cambridge University Press
- Szeliski: Computer Vision - Algorithms and Applications, Springer Verlag
- Goodfellow et al.: Deep Learning - Das umfassende Handbuch, mitp

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Computer Vision und Machine Learning	4,0	Lecture/Exercise	english german
Literature			
- Radke: Computer Vision for Multimedia, Cambridge University Press - Szeliski: Computer Vision - Algorithms and Applications, Springer Verlag - Goodfellow et al.: Deep Learning - Das umfassende Handbuch, mitp			
	2,0	Exercise	english german

Title	Physics-Based Modeling and Simulation		
Number	4216270	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Marcus Magnor
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	Prior to taking this module, the students should successfully complete the module “Computergraphik – Grundlagen”. Additionally, it is encouraged to have programming skills in C/C++.		
Expected performance/ Type of examination	1 Exam: Written exam, 90 minutes or oral exam, 30 minutes or Take-Home-Exam.		
Course achievement	1 Non-graded work: 50% of the exercises have to be passed		
Examination language	english german		

Contents

- Rigid body dynamics
- Newtonian mechanics
- Differential equations
- Numerical analysis
- Particle systems
- Matrix optics
- Optics in participating media
- Interference phenomena

Objective qualification

After successful completion of the module, students will be familiar with the basics of the physically-based simulation techniques used in computer graphics. This course explains the fundamental physics-based approaches for the simulation of dynamic processes. Moreover, it also covers the laws of light propagation, using both radiation and wave optics.

Literature

- Dieter Meschede, Gerthsen Physik, 23. Auflage, Springer, 2006

- Dev Ramtal, Adrian Dobre: Physics for Flash, Games, Animation, and Simulations. Springer Science and Business Media, 2011.

- Kenny Erleben, Jon Sporring, Knud Henriksen, Henrik Dohlmann:Physics-based Animation. Charles River Media, 2005.

- Frank Nielsen, Visual Computing, Charles River Media, Graphics Series, 2005

Further references will be announced in the course.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	english german

Title			
Number	4216000020	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Martin Eisemann
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	C++/Python und mindestens eines der folgenden Module: Digitale Bildverarbeitung, Computer Vision and Machine Learning, Echtzeit-Computergraphik, Computergraphik Grundlagen or equivalent lectures.		
Expected performance/ Type of examination			
Course achievement	1 study achievement: Software and program development. The deliverables consist of the well commented source code with all required project files. In addition, a written documentation of the research project work is required. Upon successful completion of the research project, a certificate of achievement will be issued.		
Examination language	german		

Contents

The module consists of a practical research project in the field of computer vision. The student conducts a larger practical research project on her/his own.
• Individual or larger tasks from the field of visual computing (computer vision, computer graphics, visualization, visual synthesis).
• Alternatively, a sequence of tasks to cover a specific topic area.

Objective qualification

Upon successful completion of this module, students are able to analyze and practically work on a precisely defined and delimited scientific research project.

Literature

• Radke: Computer Vision for Multimedia, Cambridge University Press
• Szeliski: Computer Vision - Algorithms and Applications, Springer Verlag
• Pharr et al.: Physically-based Rendering
• Goodfellow et al.: Deep Learning - Das umfassende Handbuch, mitp

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Internship	german

Title	Advanced Practical Aspects of Computer Science		
Number	4216000040	**Module version**	
Shorttext		**Language**	german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Marcus Magnor
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		

Contents

In this course, interested Master students will learn the advanced use of software tools that are widely used in the professional world.

These include
- programming in C++ (incl. usage of external software libraries)
- code generator tools make, cmake und qmake
- debugger gdb (incl. graphical user interface)
- profiler gprof-valgrind
- UML-Tool Visio
- Versioning software snv
- documentation in doxygen
- development and prototyping in Matlab
- KI coding tools

The selection of topics thus includes the most common tools in practical computer science.
During the practical course, the individual software tools are introduced. Using short exercises, the Master's students can learn how to use each of the software tools.
The colloquium takes place after the practical part.
In preparation for the colloquium, every Master's student creates and documents a small software project. In this process, it is required to apply the skills learned during the course. During the colloquium, the Master students present their projects to other fellow students in an oral presentation.

Objective qualification

Upon completion of the module, Master students are able to work with the software tools commonly used in the professional world. The necessary skills are acquired both in isolation (practical training) and in combination (colloquium). Aside from this obvious benefit of qualifying for the job market, students in the Master's program are prepared for further practical work during their studies.

Literature

To be announced based on the topic

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Advanced Practical Aspects of Computer Science	2,0	Internship	german
Advanced Practical Aspects of Computer Science	2,0	Lecture	german

Title	Visual Computing		
Number	4216000000	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Martin Eisemann
Workload (h)	150		
Class attendance (h)	45	**Self studying (h)**	105
Compulsory requirements			
Expected performance/ Type of examination	1 exam: written exam or exam+, 90 minutes or oral exam, 30 minutes, or Implementation and documentation of a computer/software program, or oral presentation, or portfolio, or take-home exam		
Course achievement	1 study achievement: successful participation in homework		
Examination language	english german		

Contents
Hot topics in the field of Visual Computing
Objective qualification
Upon successful completion of this module, students will have in-depth knowledge on the newest developments and research trends in the area of Visual Computing. They are able to analyze respective problems and to design and implement appropriate solutions.
Literature
On demand

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
	4,0	Lecture/Exercise	english german

Title	Health-Enabling technologies A		
Number	4217000150	**Module version**	V1
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Thomas Deserno
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	graded work: written exam, 90 minutes, or oral exam, 30 minutes, or Portfolio or Take-Home-Exam.		
Course achievement			
Examination language	english		

Contents

- Healthcare delivery with respect to specific diseases.
- Sensors and data analytics
- Architecture of appropriate information systems
- Evaluation and future perspectives of HET-based healthcare
- Ethical, regulatory and social aspects of HET

Objective qualification

Passing this module, the students are able to name different health enabling technologies (HET) and explain their ethical, regulatory and social aspects. The students can use methods and tools to build HET systems.

Literature

- Bardram JE, Mihailidis A, Wan D (Hrsg.). Pervasive Computing in Healthcare. Boca Raton, FL: CRC Press; 2006.

- Haux R, Koch S, Lovell NH, Marschollek M, Nakashima N, Wolf KH. Health-Enabling and Ambient Assistive Technologies: Past, Present, Future. Yearb Med Inform. 2016: S76-91.

- Öberg A, Togawa T, Francis A. Spelman FA (Hrsg.). Sensors in Medicine and Health Care (eBook). Weinheim: Wiley-VCH; 2006.

- van Hoof, J, Demiris, G, Wouters, EJM (Hrsg.). Handbook of Smart Homes, Health Care and Well-Being. Heidelberg: Springer: 2017.

- Ligges U. Programmieren mit R. Statistik und ihre Anwendungen. Springer-Verlag Berlin, 3. Auflage 2008; ISBN-10: 3540799974, ISBN-13: 978-3540799979

- Wollschläger D. Grundlagen der Datenanalyse mit R: Eine anwendungsorientierte Einführung. Springer-Verlag, Berlin, 3. Auflage 2015; ISBN-10: 3662455064, ISBN-13: 978-3662455067

- Beckerman AP, Childs DZ, Petchey OL. Getting Started with R: An Introduction for Biologists. Oxford University Press, 2. Edition 2017; ISBN-10: 0198787847, ISBN-13: 978-0198787846

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Health-enabling technologies A	2,0	Lecture	english
Literature			
- Bardram JE, Mihailidis A, Wan D (Hrsg.). Pervasive Computing in Healthcare. Boca Raton, FL: CRC Press; 2006. - Haux R, Koch S, Lovell NH, Marschollek M, Nakashima N, Wolf KH. Health-Enabling and Ambient Assistive Technologies: Past, Present, Future. Yearb Med Inform. 2016: S76-91. - Öberg A, Togawa T, Francis A. Spelman FA (Hrsg.). Sensors in Medicine and Health Care (eBook). Weinheim: Wiley-VCH; 2006. - van Hoof, J, Demiris, G, Wouters, EJM (Hrsg.). Handbook of Smart Homes, Health Care and Well-Being. Heidelberg: Springer: 2017. - Ligges U. Programmieren mit R. Statistik und ihre Anwendungen. Springer-Verlag Berlin, 3. Auflage 2008; ISBN-10: 3540799974, ISBN-13: 978-3540799979 - Wollschläger D. Grundlagen der Datenanalyse mit R: Eine anwendungsorientierte Einführung. Springer-Verlag, Berlin, 3. Auflage 2015; ISBN-10: 3662455064, ISBN-13: 978-3662455067 - Beckerman AP, Childs DZ, Petchey OL. Getting Started with R: An Introduction for Biologists. Oxford University Press, 2. Edition 2017; ISBN-10: 0198787847, ISBN-13: 978-0198787846			
	2,0	Exercise	english

Title	Selected Topics of Representation and Analysis of Medical Data		
Number	4217000180	**Module version**	V1
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Thomas Deserno
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or portfolio or Take-Home-Exam.		
Course achievement			
Examination language	english		

Contents

Objective qualification

Literature

1. Medical Informatics, e-Health: Fundamentals and Applications. Editors: Venot, Alain, Burgun, Anita, Quantin, Catherine. Springer, 2014

2. Bulletin of the World Health Organization: Special issue on eHealth. http://www.who.int/bulletin/volumes/90/5/en/

3. Atlas of eHealth country profiles 2013: eHealth and innovation in women's and children's health. http://apps.who.int/iris/bitstream/10665/112761/1/9789241507288_eng.pdf

4. Global eHealth – Measuring Outcomes: Why, What, and How. http://www.ehealth-connection.org/files/conf-materials/Global%20eHealth%20-%20Measuring%20Outcomes_0.pdf

5. Telemedicine and E-Health Services, Policies, and Applications: Advancements and Developments by Joel J. P. C. Rodrigues (Instituto de Telecomunicações, University of Beira Interior, Portugal), Isabel de la Torre Díez (University of Valladolid, Spain) and Beatriz Sainz de Abajo (University of Valladolid, Spain). IGI Global, 2012

6. National eHealth Strategy Toolkit. World Health Organization and International telecommunication Union, Geneva, 2012. https://www.itu.int/pub/D-STR-E_HEALTH.05-2012

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
International perspectives in eHealth	3,0	Lecture	english

Title	Selected Topics in Health Information Systems		
Number	4217820	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Thomas Deserno
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	graded work: written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	english german		

Contents

There is a rapid change in methodology and assessment of current techniques for medical data analytics, in particular using deep learning. Therefore, the content of this module reflects the actual technologies and will be announced shortly before the module starts.

Objective qualification

The students will learn about recent trends and technologies to represent and analyze medical data. They will further learn how to cope with such topics by applying appropriate tools and scientific methodology.

Literature

IMIA Yearbook of Medical Informatics [erscheint jährlich]

Weitere Literatur wird jeweils aktuell bekannt gegeben

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

	3,0	Lecture/Exercise	english ger-man
Literature			
IMIA Yearbook of Medical Informatics [erscheint jährlich] Weitere Literatur wird jeweils aktuell bekannt gegeben			

Title	Selected Topics in Virtual Medicin		
Number	4217000160	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Thomas Deserno
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or term Paper or presentation or creation and documentation of computer programs or experimental work or portfolio or Take-Home-Exam.		
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			

- Riener, R., Harders, M.(2012): Virtual reality in medicine. London: Springer. ISBN-13: 978-1447140108.

- Rouse, W.B., Boff, K.R.(2005): Organizational Simulation. Hoboken: John Wiley & Sons. ISBN-13: 978-0471739449.

- Schwarz, J.(2017): 3D-Visualisierung der Anatomie und Funktion der unteren Extremitäten: Anatomische Darstellung im Zeichen moderner Animationstechnik. Saarbrücken: AV Akademikerverlag. ISBN-13: 978-3330504325.

- Parisi, T.(2016): Learning virtual reality: developing immersive experiences and applications for desktop, web, and mobile. Beijing, Boston: O'Reilly. ISBN-13: 978-1491922804.

- Parisi, T.(2014): Programming 3D Applications with HTML5 and WebGL 3D Animation and Visualization for Web Pages. Beijing, Boston: O'Reilly Media. ISBN-13: 9351105237.

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
	3,0	Lecture/Exercise	german

Literature

- Riener, R., Harders, M.(2012): Virtual reality in medicine. London: Springer. ISBN-13: 978-1447140108. - Rouse, W.B., Boff, K.R.(2005): Organizational Simulation. Hoboken: John Wiley & Sons. ISBN-13: 978-0471739449. - Schwarz, J.(2017): 3D-Visualisierung der Anatomie und Funktion der unteren Extremitäten: Anatomische Darstellung im Zeichen moderner Animationstechnik. Saarbrücken: AV Akademikerverlag. ISBN-13: 978-3330504325. - Parisi, T.(2016): Learning virtual reality: developing immersive experiences and applications for desktop, web, and mobile. Beijing, Boston: O'Reilly. ISBN-13: 978-1491922804. - Parisi, T.(2014): Programming 3D Applications with HTML5 and WebGL 3D Animation and Visualization for Web Pages. Beijing, Boston: O'Reilly Media. ISBN-13: 9351105237.

Title	Bioinformatics and Biostatistics 2		
Number	4217000040	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Tim Kacprowski
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	english german		
Contents			
Objective qualification			
Literature			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	english german
	2,0	Exercise	english german

Title	Biomedical Image and Signal Analysis		
Number	4217000120	**Module version**	V1
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Deserno
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	graded work: written exam (90 minutes) or oral exam (30 minutes) or experimental work or Portfolio or Take-Home-Exam.		
Course achievement			
Examination language	english		

Contents

Using examples from ECG, X-ray imaging, magnetic resonance imaging and optical imaging systems we explain the general methods in medical signal and image processing. The methods are categorized according to their general properties, and the pros and cons of the manifold of methods is discussed using these categories. Systematic evaluation of signal and image analytics with and without ground truth is also addressed in this module.

Objective qualification

Passing this module, the students can classify and compare different methodologies for medical signal and image acquisition. They can differ and compare linear with non-linear filtering and analyze electrocardiography (ECG) data into their components. They can segment medical images in two and three dimensions and are able to apply model-based approaches for image and signal analytics.

Literature

- Lehmann, T.M., Oberschelp, W., Pelikan, E., Repges, R.(1997): Bildverarbeitung für die Medizin: Grundlagen, Modelle, Methoden, Anwendungen. Springer-Verlag, Berlin. ISBN-13: 978-3540614586.

- Deserno, T.M.(Ed). (2011): Biomedical Image Processing. Springer-Verlag Berlin Heidelberg. ISBN-13: 978-3642267307.

- Handels, H.(2009):Medizinische Bildverarbeitung: Bildanalyse, Mustererkennung und Visualisierung für die computergestützte ärztliche Diagnostik und Therapie. 2. Auflage. Vieweg & Teubner Verlag. ISBN-13: 978-3835100770.

- Süße, H., Rodner, E.(2014): Bildverarbeitung und Objekterkennung: Computer Vision in Industrie und Medizin. Springer Vieweg. ISBN-13: 978-3834826053.

- Dougherty, G.(2009): Digital Image Processing for Medical Applications. Cambridge University Press. ISBN-13: 978-0521181938.

- Burger, W., Burge, M.J. (2015): Digitale Bildverarbeitung: Eine algorithmische Einführung mit Java.3. Auflage. Springer-Vieweg. ISBN-13: 978-3-642-04604-9.

- Jähne, B.(2012): Digitale Bildverarbeitung und Bildgewinnung. 7. Auflage. Springer-Verlag Berlin. ISBN-13: 978-3642049514.

- Broeke, J., Mateos Perez, J.M., Pascau, J.(2015): Image Processing with ImageJ. 2. Edition. Packt Publishing. ISBN-13: 978-1785889837.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Biomedical Image and Signal Analysis	4,0	Lecture/Exercise	english

Literature

- Lehmann, T.M., Oberschelp, W., Pelikan, E., Repges, R.(1997): Bildverarbeitung für die Medizin: Grundlagen, Modelle, Methoden, Anwendungen. Springer-Verlag, Berlin. ISBN-13: 978-3540614586. - Deserno, T.M.(Ed). (2011): Biomedical Image Processing. Springer-Verlag Berlin Heidelberg. ISBN-13: 978-3642267307. - Handels, H.(2009):Medizinische Bildverarbeitung: Bildanalyse, Mustererkennung und Visualisierung für die computergestützte ärztliche Diagnostik und Therapie. 2. Auflage. Vieweg & Teubner Verlag. ISBN-13: 978-3835100770. - Süße, H., Rodner, E.(2014): Bildverarbeitung und Objekterkennung: Computer Vision in Industrie und Medizin. Springer Vieweg. ISBN-13: 978-3834826053. - Dougherty, G.(2009): Digital Image Processing for Medical Applications. Cambridge University Press. ISBN-13: 978-0521181938. - Burger, W., Burge, M.J. (2015): Digitale Bildverarbeitung: Eine algorithmische Einführung mit Java.3. Auflage. Springer-Vieweg. ISBN-13: 978-3-642-04604-9. - Jähne, B.(2012): Digitale Bildverarbeitung und Bildgewinnung. 7. Auflage. Springer-Verlag Berlin. ISBN-13: 978-3642049514. - Broeke, J., Mateos Perez, J.M., Pascau, J.(2015): Image Processing with ImageJ. 2. Edition. Packt Publishing. ISBN-13: 978-1785889837.

Title	Health Infomation Systems B		
Number	4217000090	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Deserno
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or term Paper or presentation or creation and documentation of computer programs or experimental work or portfolio or Take-Home-Exam.		
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
- Winter,A.; Haux, R. et.al.: Health Information Systems: Architectures and Strategies. Springer Verlag, 2011. - IMIA Yearbook of Medical Informatics (erscheint jährlich) - weitere aktuelle Literatur wird im Rahmen der Vorlesung bekanntgegeben			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

Health Infomation Systems B	2,0	Lecture	german
Literature			
- Winter,A.; Haux, R. et.al.: Health Information Systems: Architectures and Strategies. Springer Verlag, 2011. ISBN-13: 978-1849964401 - IMIA Yearbook of Medical Informatics (erscheint jährlich) - weitere aktuelle Literatur wird im Rahmen der Vorlesung bekanntgegeben			

	2,0	Exercise	german

Title	Network Biology		
Number	4217000200	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Tim Kacprowski
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: written exam, 90 minutes, or oral exam, 30 minutes or Take-Home-Exam.		
Course achievement	1 non-graded work: 50% of exercises must be passed		
Examination language	english		

Contents

- Introduction graph theory
- Biological networks
- Biological network databases
- Statistical network analysis
- Graph algorithms
- Graph-based machine learning

Objective qualification

After successful completion of this module, students will
have a basic understanding of graph theory and its applications for the
analysis of biomedical data. They will be able to use network biology tools and
critically assess network analyses. They will be capable to devise new
graph-based strategies for the analysis of biomedical data.

Literature

wird noch bekanntgegeben

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

Network Biology	4,0	Lecture/Exercise	english
Literature			
to be announced			

	2,0	Exercise	english

Title	Virtual Medicine		
Number	4217000170	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Deserno
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or term Paper or presentation or deveplopment and documentation of computer programs or experimental work or portfolio or Take-Home-Exam.		
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			

- Parisi, T.(2016): Learning virtual reality: developing immersive experiences and applications for desktop, web, and mobile. Beijing, Boston: O'Reilly. ISBN-13: 978-1491922804.

- Parisi, T.(2014): Programming 3D Applications with HTML5 and WebGL 3D Animation and Visualization for Web Pages. Beijing, Boston: O'Reilly Media. ISBN-10: 9351105237.

- Riener, R., Harders, M.(2012): Virtual reality in medicine. London: Springer. ISBN-13: 978-1447140108.

- Rouse, W.B., Boff,K.R.(2005): Organizational Simulation. Hoboken: John Wiley & Sons. ISBN-13: 9780471739449.

- Schwarz, J.(2017): 3D-Visualisierung der Anatomie und Funktion der unteren Extremität: Anatomische Darstellung im Zeichen moderner Animationstechnik. Saarbrücken: AV Akademikerverlag. ISBN-13: 9783330504325.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Lecture/Exercise	german
Literature			
- Riener, R., Harders, M.(2012): Virtual reality in medicine. London: Springer. ISBN-13: 978-1447140108. - Rouse, W.B., Boff,K.R.(2005): Organizational Simulation. Hoboken: John Wiley & Sons. ISBN-13: 9780471739449. - Schwarz, J.(2017): 3D-Visualisierung der Anatomie und Funktion der unteren Extremität: Anatomische Darstellung im Zeichen moderner Animationstechnik. Saarbrücken: AV Akademikerverlag. ISBN-13: 9783330504325.			
	1,0	Exercise	german

Title	Automotive Software Engineering		
Number	4220000060	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Thüm
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	Basic knowledge of software engineering is required. It is recommended that students have previously taken Software Engineering 1 and Software Engineering 2.		
Expected performance/ Type of examination	1 Examination: Exam or exam+ (90 minutes), oral exam or oral exam+ (20 minutes), or take-home exam		
Course achievement	1 Study achievement: Solving of lecture-relevant practical tasks		
Examination language	english german		

Contents

This module covers methods, processes, and technologies in automotive software engineering. The concepts focus on the automotive sector, but related aspects of mobility as well as other safety-critical and embedded software systems (e.g., rail transport, aviation, or industrial automation) are also addressed.

- Fundamentals and framework conditions of software development in the automotive sector
- Electronic control units and software architectures for embedded and distributed systems
- Communication systems and software platforms for vehicles (e.g., AUTOSAR)
- Requirements management, model-based development, and software development processes
- Configuration and variability management
- Quality assurance, verification, validation, and testing
- Functional safety and cybersecurity
- Software updates and product lifecycle management
- Assisted and autonomous systems
- Tools, methods, and case studies from industrial practice

Objective qualification

After completing this module, students will have an understanding of the methods and technologies used to develop complex software for mobility solutions, particularly in the automotive sector. Students will be able to analyze such software systems, select appropriate architectures and development processes, and apply methods of requirements management, model-based development, variant management, and quality assurance. In addition, students will be familiar with current developments, tools, and industrial practices and will be able to assess their suitability for different applications.

Literature

Ian Sommerville: Software Engineering. 10. Aufl. Pearson, 2018, ISBN 978-3-86894-344-3.Jörg Schäuffele, Thomas Zurawka: Automotive Software Engineering. 7. Aufl., Springer Vieweg Wiesbaden, 2024.Olaf Kin-

del, Mario Friedrich: Softwareentwicklung mit AUTOSAR. Grundlagen, Engineering, Management für die Praxis, dpunkt-Verlag, 2009.Miroslaw Staron: Automotive Software

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Automotive Software Engineering	4,0	Lecture/Exercise	english german

Title	Constraint Solving		
Number	4220000040	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Thüm
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 Examination: Exam or exam+ (90 minutes), oral exam or oral exam+ (20 minutes) or take-home exam		
Course achievement	1 study achievement: Passing practical tasks		
Examination language	english german		

Contents

- Deeper understanding of satisfiability (SAT) solving
- Deeper understanding of propositional logic
- Different logic dialects, such as constraint programming or SMT
- Different logical problems, such as model counting
- Application scenarios for constraint solving
- Reducing problems in practice to constraint solving

Objective qualification

The students learn to recognize application scenarios of learned techniques in practice.
The students learn to evaluate the suitability of different approaches for a given problem setting and select promising solution.
The students should acquire a basic understanding of the underlying techniques.

Literature

Daniel Kroening, Ofer Strichman: Decision Procedures - An Algorithmic Point of View, Springer Verlag, 10. Auflage, IBSN 978-3-662-50496-3
Armin Biere, Marijn Heule, Hans van Maaren, Toby Walsh: Handbook of Satisfiability, 2. Auflage, 2021, IOS Press, ISBN 978-1-64368-160-3

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title	Managing Industrial Software Developments		
Number	4220420	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Softwaretechnik und Fahrzeuginformatik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Thomas Thüm
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	graded work: oral exam, 30 minutes, or written exam, 90 minutes or Take-Home-Exam.		
Course achievement			
Examination language	english		

Contents

- Industrial Information Management
- Product Software
- General conditions for SW production in a company - tasks of project management
- SW development projects
- Process models
- Planning and execution of development projects
- Software quality and assessment
- Company knowledge and maturity-models
- Example application from the area of parallel computer software

Objective qualification

After completing the module, students have an overview of professional industrial management of development projects using software development as an example. They have basic knowledge of project-, requirements-, quality-, and configuration- management, as well as the organizational interaction of large industrial structures. They know the most important process-, quality- and maturity- models and can apply them. Building on the fundamentals, the application in everyday industrial life is demonstrated using illustrative examples.

Literature

- Hindel, B.; Hörmann, K.; Müller, M.; Schmied, J.: „Basiswissen Software-Projektmanagement“; dpunkt Verlag, Heidelberg (2004)

- Messnarz, R.; Tully, C.: „Better Software Practice for Business Benefit – Principles and Experience“; IEEE Computer Society, Los Alamitos (1999)

- Wallmüller, E.: „Software-Qualitätsmanagement in der Praxis“; Hanser Verlag; München u.a. (2001)

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Lecture/Exercise	english

Title	Automotive Software Engineering Laboratory		
Number	4220350	**Module version**	
Shorttext		**Language**	german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Thüm
Workload (h)	60		
Class attendance (h)	56	**Self studying (h)**	4
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement	1 Coursework: Software development. Assessment of skills and commitment by the supervisor.		
Examination language	german		

Contents

- Paradigms of system and software engineering
- Modelling
- Frameworks
- Software/system architectures
- Patterns in software/system development
- Technical tools
- Practical application of the concepts learned

Objective qualification

After completing this module, students will have a deeper understanding of the development of complex software systems in the automotive sector. They will have practical experience in carrying out software development projects in the automotive environment and ensuring the quality of the results. They will be able to understand the task at hand, translate it into a software/system design, implement it and test it.

Literature

The literature sources vary according to the topic.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

Automotive Software Engineering Laboratory	3,0	Internship	german
	1,0	Colloquium	german

Title	Software Engineering and Machine Learning		
Number	4220000050	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Thüm
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	Basic knowledge in Software Engineering and Machine Learning		
Expected performance/ Type of examination	1 graded work: Exam or exam+ (90 minutes), oral exam or oral exam+ (20 minutes) or take-home exam		
Course achievement	1 course achievement: Solving of lecture-relevant term paper		
Examination language	english german		

Contents

Two developments are profoundly changing almost all areas of industry and research:
1. Software is playing an increasingly important role. Research can only be reproduced if the software works. Many traditional companies (e.g., car manufacturers) are evolving into software companies, as an ever-increasing proportion of innovations are created in software. 2. Machine learning is fundamentally changing how software works and how it is developed. Machine learning is increasingly being used in research and industry, often achieving better results than traditional approaches. Software development itself is partially automated with the help of machine learning.

The aim of the course is to understand the interactions between software engineering and machine learning. Students should learn about the risks and opportunities and understand them through practical application. Overall, the course is divided into the following areas:
1. Fundamentals of software engineering and machine learning: What are the challenges for each?
2. Machine learning for software engineering: How can machine learning be used to improve software engineering? In which development phases can it be used, and with which methods? What scientific findings are available so far regarding its use?
3. Software engineering for machine learning: How can software engineering principles be used to improve machine learning developments? What challenges do machine learning applications present compared to traditional software, and how can these be addressed? What scientific findings are available so far regarding its use?

Objective qualification

Literature

Ian Sommerville: Software Engineering. 10. Aufl. Pearson, 2018, ISBN 978-3-86894-344-3.
Haykin, Simon: Neural networks and learning machines, Prentice Hall, 2008

Molnar, C. (2025). Interpretable Machine Learning: A Guide for Making Black Box Models Explainable (3rd ed.)
Kalech, Meir and Abreu, Rui and Last, Mark. Artificial Intelligence Methods for Software Engineering, WORLD SCIENTIFIC, 2021
There will be further literature presented in the lecture, as this research area and the application of its findings is fast-changing. Partially, primary literature will be used.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Software Engineering and Machine Learning	4,0	Lecture/Exercise	english german

Title	Software in Safety-Critical Systems		
Number	4220320	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Thomas Thüm
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	german		

Contents

The lecture explains the concepts of safety and safety-related software, with practical examples illustrating the consequences of faulty behaviour in safety-related systems. It then discusses measures based on CENELEC standards that contribute to achieving high software quality, with a particular focus on analysis and quality assurance tools.

Objective qualification

After completing this module, students will have a deeper understanding of safety standards, basic concepts and principles of safety-related systems, the specific aspects of developing software for safety-related systems, selection criteria for suitable architectures, the use of model-based development in a safety-related environment, and the fundamentals of railway safety technology.

Literature

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Software in safety-relevant systems	3,0	Lecture/Exercise	german

Title	Software Product Lines		
Number	4220000020	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Thüm
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	Basic knowledge of logic (in particular propositional logic) and software engineering (in particular process models, UML class diagrams, design patterns) as well as programming experience (e.g., in Java) are required.		
Expected performance/ Type of examination	1 graded work: Written exam+ (90 minutes) or oral exam+ (20 minutes)		
Course achievement	1 non-graded work: Solve exercises relevant to the lecture		
Examination language	english german		

Contents

Modern software often must be available on many platforms and adapted to many different user and customer needs. This applies to system software (e.g., operating systems), application software (e.g., word processing and games) and complex cyber-physical systems (e.g., automobiles). The resulting variety of configurations poses challenges for the development, testing, and maintenance of such systems. The course teaches, among other things, how the configurability of systems can be modeled, which implementation techniques allow extensible and configurable software to be developed, and which strategies can still be used for meaningful testing despite an exponential number of variants.

The course includes the following contents:
- Introduction to software variability and inherent challenges
- Modeling and analysis of the desired variability
- Implementing variability at runtime (e.g., configuration options) and at compile time (e.g., clone-and-own)
- Implementation of software product lines:
  - Implementing features using conditional compilation (e.g., preprocessors and build systems).
  - Modular implementation of features (e.g., components, services and plug-ins)
  - Limitations of object orientation and extensions of object orientation (e.g. feature modules, aspects)
  - Design patterns for software variability
- Process models for the use and development of software product lines
- Problems and dealing with feature interactions
- Methods for static and dynamic quality assurance of software product lines
- Current topics from research and practice

Objective qualification

Students are able to
- identify the limitations of traditional programming techniques regarding the development of variable software.
- describe modeling, analysis and configuration of variability in software product lines.

- apply different implementation techniques for the development of software product lines.
- evaluate the suitability of presented programming techniques for different development scenarios.
- explain quality assurance techniques for software product lines and the associated challenges.

Literature

- Feature-Oriented Software Product Lines - Concepts and Implementation; Sven Apel, Don Batory, Christian Kästner, Gunter Saake; Springer, 2013
- Mastering Software Variability with FeatureIDE; Jens Meinicke, Thomas Thu#m, Reimar Schröter, Fabian Benduhn, Thomas Leich, Gunter Saake; Springer, 2017

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Software Product Lines	4,0	Lecture/Exercise	english german

Title	Software Quality Assurance		
Number	4220000070	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Thüm
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	Basic knowledge of software engineering is required. It is recommended that students have previously taken Software Engineering 1 and Software Engineering 2.		
Expected performance/ Type of examination	1 Examination: Exam or exam+ (90 minutes), oral exam or oral exam+ (20 minutes), or take-home exam		
Course achievement	1 Study achievement: Solving of lecture-relevant practical tasks		
Examination language	english german		

Contents

The goal of this course is to examine and apply advanced concepts for analyzing and improving the quality of software projects.
The course focuses, among other things, on the following topics in the areas of constructive, analytical, and organizational quality assurance:
- Processes for the efficient development and management of software projects
- Development approaches for correct and maintainable software, such as test-driven development and design-by-contract
- Efficient software generation through model-driven development and AI-based systems
- Dynamic software testing, such as regression testing, combinatorial testing, fuzzing, and GUI testing
- Static analysis of software, such as symbolic execution, program slicing, and model checking

Objective qualification

Students should understand how the studied techniques for analyzing and improving software quality work.
Students should be able to identify practical applications for these techniques.
Students should be able to weigh the advantages and disadvantages of these techniques for individual software projects and, based on this assessment, select appropriate solutions.

Literature

Ian Sommerville: Software Engineering. 10. Aufl. Pearson, 2018, ISBN 978-3-86894-344-3.Daniel Galin: Software Quality: Concepts and Practice. John Wiley & Sons, 2018, ISBN 978-1119134527.Khorikov, Vladimir: Unit testing principles, practices, and patterns. Simon and Schuster, 2020, ISBN 978-1617296277.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Software Quality Assurance	4,0	Lecture/Exercise	english german

Title	Advanced Software Engineering		
Number	4220370	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Thüm
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	graded work: software development. Assessment of skills and effort by the supervisor or Take-Home-Exam.		
Course achievement			
Examination language	english german		

Contents

Paradigms of software engineering (OO, components, …)

- Modelling
- Frameworks
- Component technologies
- Software/System architectures
- Patterns of software development
- Technical Tools
- Practical application of learned concepts

Objective qualification

After completing this module, the students have a profound comprehension in developing complex software systems. They gained practical experience in running software development projects and quality assurance of the results. They are capable of understanding the task, convert it in a software architecture, implementing the architecture, and testing the whole system.

Literature

Project-specific

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Internship	english german

Title	Selected Topics of System Software 1		
Number	4223000030	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Christian Mengert-Dietrich
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 minutes) or oral exam (30 minutes) or term paper or presentation or creation and documentation of computer programs or experimental work or portfolio or take-home exam.		
Course achievement	At least 50 percent of the exercises must be passed.		
Examination language	english german		
Contents			
New Topics in Computer Networks			
Objective qualification			
On completion of this module, the students have a deep understanding of recent advances and research trends in the area of system software.			
Literature			
References will be announced in the course			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	english german

Title	Selected Topics of System Software 2		
Number	4223000060	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Christian Mengert-Dietrich
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement	1 non-graded exam: oral exam (20 minutes) or term paper or presentation or creation and documentation of computer programs or experimental work or portfolio or take-home exam.		
Examination language	english german		
Contents			
New Topics in Computer Networks			
Objective qualification			
On completion of this module, the students have a deep understanding of recent advances and research trends in the area of system software.			
Literature			
References will be announced in the course			

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	english german

Title	Selected Topics of System Software 3		
Number	4223000050	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Christian Mengert-Dietrich
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement	1 non-graded exam: oral exam (20 minutes) or term paper or presentation or creation and documentation of computer programs or experimental work or portfolio or take-home exam.		
Examination language	english german		
Contents			
New Topics in Computer Networks			
Objective qualification			
On completion of this module, the students have a deep understanding of recent advances and research trends in the area of system software.			
Literature			
References will be announced in the course			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	english german

Title	Operating System Construction 1		
Number	4223000010	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Christian Mengert-Dietrich
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	In addition to this module, there is the "Practical course in operating system construction for multi-core systems". It is recommended to listen to both modules at the same time.		
Expected performance/ Type of examination	1 graded exam: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement	1 non-graded work: All assigned exercise tasks must be passed		
Examination language	german		

Contents

The module teaches the conceptual foundations and important techniques required for building an operating system. At the same time, basics from the operating system area such as interrupts, synchronization and scheduling, which should be largely known from other courses, are repeated and deepened.

- Basics of operating system development
- Interrupts (hardware, software, synchronization)
- Computer architecture from the OS point of view (e.g. IA-32)
- Coroutines and program threads
- Scheduling
- Operating system architectures
- Thread synchronization
- Device drivers
- Interprocess communication

The course itensely discusses the construction of an single-core operating system.

Objective qualification

Students who have successfully completed the module will be able to:

- Explain the start-up process of a computing system and describe the challenges in software development for “bare metal”.
- Outline and analyze the processes and strategies of interrupt handling in hardware and software, especially in multi-core systems.

- Distinguish different types of control flows and interrupt synchronization methods in operating systems.
- Identify basic synchronization problems and develop countermeasures, including coordination and synchronization of threads.
- Compare and characterize various driver models and basic operating system architectures.
- Explain and implement paradigms of interprocess communication in operating systems.
- Identify and resolve race conditions between concurrent threads.
- Develop synchronization mechanisms at the thread level and integrate device drivers into operating system architectures.
- Develop higher-level synchronization constructs from basic primitives.
- Cooperatively work in small groups, present and reflect on decisions, and constructively deal with errors and misdirections.

Literature

- Wolfgang Maurer: Linux Kernelarchitektur. Konzepte, Strukturen und Algorithmen von Kernel 2.6, Hanser (2005)
- Marshal Kirc McKusick: The Design and Implementation of the FreeBSD Operating System, Addision Wesley (2014)
- Pavel Yosifovich: Windows Internals, Part 1 und Part 2, Microsoft Press (2016).

Remark

In addition to this module, there is the "Practical course in operating system construction for multi-core systems". It is recommended to listen to both modules at the same time.

Current information on the course can be found on the institute's website: https://ibr.cs.tu-bs.de/vss/p/V_BSB1

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Operating System Construction 1	4,0	Lecture/Exercise	german

Literature

- Wolfgang Maurer: Linux Kernelarchitektur. Konzepte, Strukturen und Algorithmen von Kernel 2.6, Hanser (2005)
- Marshal Kirc McKusick: The Design and Implementation of the FreeBSD Operating System, Addision Wesley (2014)
- Pavel Yosifovich: Windows Internals, Part 1 und Part 2, Microsoft Press (2016)

Title	Operating System Construction 2		
Number	4223000020	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Christian Mengert-Dietrich
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	It is recommended to take one of the Operating System Construction 1 modules beforehand.		
Expected performance/ Type of examination			
Course achievement			
Examination language	german		

Contents

Objective qualification

Literature

- Wolfgang Maurer: Linux Kernelarchitektur. Konzepte, Strukturen und Algorithmen von Kernel 2.6, Hanser (2005)
- Marshal Kirc McKusick: The Design and Implementation of the FreeBSD Operating System, Addision Wesley (2014)
- Pavel Yosifovich: Windows Internals, Part 1 und Part 2, Microsoft Press (2016

↑

Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language

Operating System Construction 2	4,0	Lecture/Exercise	german
Literature			
• Wolfgang Maurer: Linux Kernelarchitektur. Konzepte, Strukturen und Algorithmen von Kernel 2.6, Hanser (2005) • Marshal Kirc McKusick: The Design and Implementation of the FreeBSD Operating System, Addision Wesley (2014) • Pavel Yosifovich: Windows Internals, Part 1 und Part 2, Microsoft Press (2016)			

Title	Cloud Computing		
Number	4223000070	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Christian Mengert-Dietrich
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement	non-graded work: The exercises must be passed at 50 percent.		
Examination language	english german		

Contents

Objective qualification

Literature

* A view of cloud computing
M. Armbrust, A. Fox, R. Griffith, A. D. Joseph, R. Katz, A. Konwinski, G. Lee, D. Patterson, A. Rabkin, I. Stoica, and M. Zaharia. A view of cloud computing.
Communication of the ACM, 53(4):50-58, 2010.
Cloud computing: An overview M. Creeger.

* Cloud computing: An overview.Queue, 7(5):3-4, 2009. Advisor-Creeger, Mache.

Further literature can be found on http://www.ibr.cs.tu-bs.de/courses/

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language

	2,0	Lecture	english german
	2,0	Exercise	english german

Title	Practical Course Operating System Construction for Multi-Core Systems		
Number	4223000000	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Christian Mengert-Dietrich
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	This module is complementary to the module "Operating System Construction 1". It is recommended to listen to both modules at the same time.		
Expected performance/ Type of examination			
Course achievement	1 non-graded work: All assigned exercise tasks must be passed		
Examination language	german		

Contents

The objective of the course is to impart crucial techniques required for the construction of a multicore operating system.

Objective qualification

Students who have successfully completed the module can:

- Outline and analyze the processes and strategies of interrupt handling in multi-core systems.
- Identify multi-core concurrency synchronization issues and develop countermeasures, including the coordination and synchronization of threads.
- Recognize challenges in implementing multicore operating systems and develop solutions for inter-process, inter-core, and interrupt synchronization.
- Detect and resolve race conditions between concurrent threads and processors.
- Develop complex multi-core synchronization constructs from basic primitives.
- Work cooperatively in small groups, present decisions, reflect on them, and constructively deal with errors and misdirections.

Literature

- Wolfgang Maurer: Linux Kernelarchitektur. Konzepte, Strukturen und Algorithmen von Kernel 2.6, Hanser (2005)
- Marshal Kirc McKusick: The Design and Implementation of the FreeBSD Operating System, Addision Wesley (2014)
- Pavel Yosifovich: Windows Internals, Part 1 und Part 2, Microsoft Press (2016).

Remark

This module is complementary to the module "Operating System Construction 1". It is recommended to listen to both modules at the same time.
Current information on the course can be found on the institute's website: https://ibr.cs.tu-bs.de/vss/p/V_BSB1.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Practical Course Operating System Construction for Multi-Core Systems	4,0	Internship	german

Literature

- Wolfgang Maurer: Linux Kernelarchitektur. Konzepte, Strukturen und Algorithmen von Kernel 2.6, Hanser (2005)
- Marshal Kirc McKusick: The Design and Implementation of the FreeBSD Operating System, Addision Wesley (2014)
- Pavel Yosifovich: Windows Internals, Part 1 und Part 2, Microsoft Press (2016)

Title	Algorithm Engineering		
Number	4227170	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Sandor Fekete
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement	1 Coursework: 50% of the exercises must be passed		
Examination language	german		

Contents

- Runtime of algorithms
- Theoretical and practical aspects of algorithm development
- Various case studies

Objective qualification

Graduates of this module understand the necessity and justification of algorithm engineering. They have mastered the most important techniques for analysing theoretical and practical runtime and for tuning algorithms.

Literature

Algorithms and Data Structures - The Basic Toolbox von Kurt Mehlhorn und Peter Sanders, 2008. (Mehr zu Beginn der Vorlesung!)

↑

Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Algorithm Engineering	1,0	Lecture	german

	1,0	Exercise	german
	1,0	Exercise, small group	german

Title	Advanced Algorithms Lab		
Number	4227000040	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Sandor Fekete
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
projektspezifisch			

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Internship	german
Literature			
projektspezifisch			

Title	Approximation Algorithms		
Number	4227270	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	every 2 years in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Sandor Fekete
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	graded work: written exam (120 minutes) or oral exam (30 minutes) minutes) or Take-Home-Exam. The form of the examination depends on the number of participants and will be announced at the beginnung of the lecture.		
Course achievement	non-graded work: 50% of the exercises must be passed		
Examination language	english german		

Contents

- A basic introduction to NP-completeness and approximation
- Approximation for vertex and set cover
- Packing problems
- Tour problems and variations
- Current research problems

In the context of various problems, a wide spectrum of techniques and concepts will be provided.

Objective qualification

Participants know the necessity and role of approximation algorithms. They can master the most important techniques for analysis and complexity of approximation algorithms for designing, including the validity of upper and lower bounds.

Literature

- Vijay V. Vazirani: Approximation Algorithms. 1st edition. Springer Verlag, 2001.

- Dorit Hochbaum: Approximation Algorithms for NP-hard Problems. Course Technology Inc, 1996.

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Approximation Algorithms	3,0	Lecture/Exercise	english german
Literature			
- Vijay V. Vazirani: Approximation Algorithms. 1st edition. Springer Verlag, 2001. - Dorit Hochbau: Approximation Algorithms for NP-hard Problems. Course Technology Inc, 1996.			
	1,0	Exercise, small group	english german

Title	Selected Topics of Algorithms		
Number	4227200	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Sandor Fekete
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or presentation (30 minutes) or Take-Home-Exam.		
Course achievement	1 Coursework: 50% of the exercises must be successfully completed.		
Examination language	english		

Contents

This course focusses on advanced algorithmic techniques and their applications in real life. The focus lies on recent research topics in the algorithms field.

Prior knowledge of basic algorithms and datastructures is beneficial, but not neccessary. We will (re-) introduce all concepts in class.

We will speak English in class. Students are encouraged (but not required) to use English in exercises and exams as well.

Objective qualification

Graduates of this module will have in-depth knowledge of algorithmic methods. They will be able to analyse abstract algorithmic problems and classify them according to their complexity. They will recognise deeper connections between different algorithmic structures.

Literature

Nach jeweiligem aktuellen Themenfokus; wird rechtzeitig bekannt gegeben.

↑

Related courses			
Rules for the choice of courses			
The small exercise is an facultative offer.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	english
	1,0	Exercise	english
	1,0	Exercise, small group	english

Title	Selected Topics of Graph Algorithms		
Number	4227210	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Sandor Fekete
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: written exam, 90 minutes, or oral exam, 30 minutes or Take-Home-Exam.		
Course achievement	1 non-graded work: 50% of the homework must have been successfully completed		
Examination language	english		

Contents

This course focusses on advanced algorithmic techniques and their applications in real life. The focus lies on recent research topics in the algorithms field.

Prior knowledge of basic algorithms and datastructures is beneficial, but not neccessary. All concepts will be (re-) introduced in class.

We will speak English in class. Students are encouraged (but not required) to use English in exercises and exams as well.

Objective qualification

Graduates of this module will have in-depth knowledge of algorithmic methods. They will be able to analyse abstract algorithmic problems and classify them according to their complexity. They will recognise deeper connections between different algorithmic structures.

Literature

Nach jeweiligem aktuellen Themenfokus; wird rechtzeitig bekannt gegeben.

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Graphs, Geometry, and Algorithms	3,0	Lecture/Exercise	english

Title	Combinatorial Algorithms		
Number	4227110	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Mathematische Optimierung
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Sandor Fekete
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (120 minutes) or oral exam (30 minutes) or Take-Home-Exam. The form of the examination depends on the number of participants and will be announced at the beginnung of the lecture.		
Course achievement	1 Coursework: 50% of the exercises must be passed		
Examination language	english		

Contents

This course focusses on advanced algorithmic techniques and combinatorial structures. Based on the theory of matroids, we will gently touch the topics of other algorithm courses (esp. Netzwerk- and Approximationsalgorithmen, and Mathematische Methoden) and discuss links between them. We will further explore these connections, revealing common underlying combinatorial structures.

Prior knowledge from some of the aforementioned courses is beneficial, but not neccessary. We will (re-) introduce all concepts in class.

We will speak English in class. Students are encouraged (but not required) to use English in exercises and exams as well.

Objective qualification

Graduates of this module will have mastered advanced methods of algorithmics. They will be able to analyse abstract algorithmic problems and classify them according to their complexity. They will recognise deeper connections between different algorithmic structures.

Literature

Nach jeweiligem aktuellen Themenfokus; wird rechtzeitig bekannt gegeben.

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	english
	1,0	Exercise	english

Title	Computational Geometry		
Number	4227250	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Sandor Fekete
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	graded work: written exam (120 minutes) or oral exam (30 minutes). The form of the examination depends on the number of participants and will be announced at the beginnung of the lecture.		
Course achievement	nongraded work: 50% of the exercises must be passed		
Examination language	english german		

Contents

* Geometric problems and data structures
* Convex hulls
* Nearest neighbors
* Voronoi diagrams
* Triangulations
* Location problems
* Tour problems
* Case studies from research

Objective qualification

Students who complete the module are familiar with basic modeling of geometric algorithms. They are able to classify the algorithmic difficulty of geometric problems and formulate appropriate objectives. They are proficient in various solution techniques and can also develop algorithmic methods for problems not previously considered. They have an overview of the practical relevance of problems and problem solutions.

Literature

Computational Geometry: Algorithms and Applications
Mark de Berg, Marc van Krevel, Mark Overmars, Otfried Schwarzkopf
Springer Verlag, 2nd edition (2000)

Algorithmische Geometrie
Rolf Klein
Springer, Heidelberg, 2005.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Computational Geometry	3,0	Lecture/Exercise	english
Literature			
Computational Geometry: Algorithms and Applications Mark de Berg, Marc van Krevel, Mark Overmars, Otfried Schwarzkopf Springer Verlag, 2nd edition (2000) Algorithmische Geometrie Rolf Klein Springer, Heidelberg, 2005.			
Computational Geometry	1,0	Exercise, small group	english
Literature			
Computational Geometry: Algorithms and Applications Mark de Berg, Marc van Krevel, Mark Overmars, Otfried Schwarzkopf Springer Verlag, 2nd edition (2000) Algorithmische Geometrie Rolf Klein Springer, Heidelberg, 2005.			

Title	Geometric Algorithms		
Number	4227220	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Sandor Fekete
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement	1 Coursework: 50% of homework assignments must have been successfully completed.		
Examination language	english		

Contents

This course focuses on advanced algorithmic techniques and their applications in real life. Prior knowledge of basic (geometric) algorithms and datastructures is beneficial.

Objective qualification

Graduates of this module have in-depth knowledge of algorithmic methods.
They can analyse abstract algorithmic problems and classify their complexity. They recognise deeper connections between different algorithmic structures.

Literature

- de Berg, M., Cheong, O., van Kreveld, M., Overmars, M.: Algorithms and Applications. 3. ed. Published by Springer Verlag, 2008.

- S. L. Devadoss, J. O'Rourke: Discrete and Computational Geometry. 1.edition. Published by Princeton University Press, 2011.

↑

Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language

	3,0	Lecture/Exercise	english

Literature

- de Berg, M., Cheong, O., van Kreveld, M., Overmars, M.: Algorithms and Applications. 3. ed. Published by Springer Verlag, 2008.

- S. L. Devadoss, J. O'Rourke: Discrete and Computational Geometry. 1.edition. Published by Princeton University Press, 2011.

Title	Mathematical Methods in Algorithms		
Number	4227190	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Sandor Fekete
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: 120 minutes or oral exam, 30 minutes or Take-Home-Exam. The form of the examination depends on the number of participants and will be announced at the beginnung of the lecture.		
Course achievement	1 non-graded work: 50% of the exercises must be passed		
Examination language	english		

Contents

Topics:
- Basic issues of algorithmics: (models, solutions, bounds, ...)
- Introduction to the theory of linear optimization
- Primal simplex algorithm,
- initial solution, degeneracy, finiteness of the simplex algorithm
- Introduction to the implementation of the simplex algorithm
- Interpretation of duality in applications
- Application of linear optimization to solve discrete optimization problems

Objective qualification

Qualification Objectives:

After completing the module, students possess the ability for mathematical modeling in the context of algorithmic optimization problems. They understand the underlying theories, in particular linear optimization and the primal simplex algorithm. In addition, students possess the ability to implement and apply the optimization algorithms covered and can analyze the complexity of optimization algorithms.

Literature

- V. Chvatal, Linear Programming

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Mathematical Methods in Algorithms	3,0	Lecture/Exercise	english
Literature			
A. Schrijver, Theory of Linear and Integer Programming, Wiley, 1998. V. Chvatal, Linear Programming, Freeman, New York, 1983. B. Korte, J. Vygen, Combinatorial Optimization, Springer, 2002.			
Mathematical Methods in Algorithms	1,0	Exercise, small group	english
Literature			
A. Schrijver, Theory of Linear and Integer Programming, Wiley, 1998. V. Chvatal, Linear Programming, Freeman, New York, 1983. B. Korte, J. Vygen, Combinatorial Optimization, Springer, 2002.			

Title	Online algorithms		
Number	4227260	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	every 2 years in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Sandor Fekete
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	graded work: written exam (120 minutes) or oral exam (30 minutes) or Take-Home-Exam. The form of the examination depends on the number of participants and will be announced at the beginnung of the lecture.		
Course achievement	non-graded work: 50% of the exercises must be passed		
Examination language	english german		

Contents

- Competitive Analysis
- Self-Organizing Data Structures
- Distributed Paging
- Online Scheduling
- Robot Motion Planning (Exploration, Search)
- Online Packing

Objective qualification

Participants know the necessity and role of algorithms with incomplete information. They can master the most important techniques for analysis and complexity of online algorithms, in particular how to establish upper and lower bounds for competitive factors.

Literature

- Allan Borodin und Ran El-Yaniv. Online Computation and Competitive Analysis. Reissue edition. Cambridge University Press, 2005.

- Amos Fiat und Gerhard Woeginger. Online Algorithms. Springer Verlag, 1998.

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	english
	1,0	Exercise	english
	1,0	Exercise, small group	english

Title	Distributed Algorithms		
Number	4227160	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Sandor Fekete
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (120 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement	1 Coursework: 50% of the exercises must be passed		
Examination language	german		

Contents

- Models for distributed algorithms
- Broadcast and convergecast
- Tree constructions
- Maximum independent sets
- Colouring problems
- Clustering problems
- Case studies from current research problems

Objective qualification

Graduates of this module understand the necessity and justification of distributed algorithms. They have mastered the most important techniques for analysing and designing distributed algorithms.

Literature

Distributed Algorithms. Nancy Lynch
Distributed Computing: A Locality-Sensitive Approach. David Peleg

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture/Exercise	german
Literature			
Nancy Lynch: Distributed Algorithms. Morgan Kaufmann Publishers. David Peleg: Distributed Computing - A Locality-Sensitive Approach. SIAM. Dorothea Wagner und Roger Wattenhofer: Algorithms for Sensor and Ad Hoc Networks, Advanced Lectures. Springer Verlag.			
	1,0	Exercise, small group	german
Literature			
Nancy Lynch: Distributed Algorithms. Morgan Kaufmann Publishers. David Peleg: Distributed Computing - A Locality-Sensitive Approach. SIAM. Dorothea Wagner und Roger Wattenhofer: Algorithms for Sensor and Ad Hoc Networks, Advanced Lectures. Springer Verlag.			

Title	Advanced Artificial Intelligence 1		
Number	4229000020	**Module version**	
Shorttext		**Language**	english
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Michel Besserve
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 examination: written exam, 90 minutes or oral exam, 30 minutes or take-home exam		
Course achievement	1 academic achievement: 50% of the exercises must be passed		
Examination language	english		
Contents			
Objective qualification			
After successfully completing this module, students have acquired expertise in some of the current advanced topics in AI.			
Literature			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	english

Title	Advanced Artificial Intelligence 2		
Number	4229000030	**Module version**	
Shorttext		**Language**	english
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Michel Besserve
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 examination: written exam, 90 minutes or oral exam, 30 minutes or take-home exam		
Course achievement	1 academic achievement: 50% of the exercises must be passed		
Examination language	english		
Contents			
Objective qualification			
After successfully completing this module, students have acquired expertise in some of the current advanced topics in AI.			
Literature			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	english

Title	Applied Bioinformatics for Sequence Analysis		
Number	4298020	**Module version**	V3
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Alice McHardy
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (120 minutes) or Take-Home-Exam.		
Course achievement	1 non-graded work: participation in the practical course		
Examination language	english		

Contents

Concepts, methods and application of sequence analysis in bioinformatics: - Bioinformatics databases - Statistical analysis in bioinformatics - Machine Learning in Bioinformatics - Quality control - Molecular biological methods for sequencing - Evaluation of various sequencing data (genomics, transcriptomics, metagenomics, …)

Objective qualification

Upon completion of the module, students will have a comprehensive understanding of high-throughput methods for (re)sequencing genomes and their analysis. In addition, methods for the visualization of results and quality control as well as for the evaluation of various sequencing data (genomics, transcriptomics, metagenomics, ...) will be taught. In the practical course, data analysis for biological interpretation of the results is performed using an example data set.

Literature

Es gibt pro Vorlesung 1-2 Fachartikel zu den jeweiligen Themen.

siehe hierzu:
https://www.nature.com/articles/nrg.2016.49 ;
https://www.nature.com/articles/s41576-019-0150-2

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Applied Bioinformatics for Sequence Analysis	2,0	Lecture	english
Literature			
General overview: https://www.nature.com/articles/nrg.2016.49 ; https://www.nature.com/articles/s41576-019-0150-2 Additionally, one or two scientific articles per topic, no books			
	2,0	Practical exercise	english

Title	Cryptology 1		
Number	4229100	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Anwendungssicherheit
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Martin Johns
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	german		

Contents

- Introduction
- Discrete logarithms and corresponding methods
- Cryptography with elliptic curves
- Factorisation and corresponding methods
- Lattice-based methods
- Quantum algorithms
- Post-quantum cryptography
- Outlook

Objective qualification

After completing the module, students will have in-depth knowledge of asymmetric cryptography. They will be able to explain the underlying algorithms and assess their security against attack methods. They will be able to assess the threat to current asymmetric methods posed by quantum computers and explain alternative methods.

Literature

- Baumslag, Fine, Kreuzer, Rosenberger. A Course in Mathematical Cryptography. De Gruyter 2015
- Buchmann. Einführung in die Kryptographie. Springer 2008
- Daemen, Rijmen. The Design of Rijndael. Springer 2002
- von zur Gathen: CryptoSchool. Springer 2015
- Lipton, Regan. Quantum Algorithms via Linear Algebra. MIT Press 2014
- Schneier. Applied Cryptography. Wiley & Sons, 1995
- Stinson, Paterson. Cryptography - Theory and Practice (4th Ed.). CRC Press 2019

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
	2,0	Lecture	german

Literature

- Baumslag, Fine, Kreuzer, Rosenberger. A Course in Mathematical Cryptography. De Gruyter 2015
- Buchmann. Einführung in die Kryptographie. Springer 2008
- Daemen, Rijmen. The Design of Rijndael. Springer 2002
- von zur Gathen: CryptoSchool. Springer 2015
- Lipton, Regan. Quantum Algorithms via Linear Algebra. MIT Press 2014
- Schneier. Applied Cryptography. Wiley & Sons, 1995
- Stinson, Paterson. Cryptography - Theory and Practice (4th Ed.). CRC Press 2019

	1,0	Exercise	german

Title	Cryptology 2		
Number	4229110	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Anwendungssicherheit
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Martin Johns
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	german		

Contents

- Introduction
- Symmetric methods and the Advanced Encryption Standard
- Differential cryptanalysis
- Random numbers
- Hash functions
- Homomorphic encryption
- Outlook

Objective qualification

After completing the module, students will have in-depth knowledge of symmetric cryptographic methods and will be able to perform differential cryptanalysis. They will be familiar with the cryptographic view of randomness and methods for the secure generation of random numbers. They will be able to explain the cryptographic properties of hash functions and their dependencies and name methods for constructing hash functions. They will be able to explain the basics of homomorphic encryption.

Literature

- Baumslag, Fine, Kreuzer, Rosenberger. A Course in Mathematical Cryptography. De Gruyter 2015
- Buchmann. Einführung in die Kryptographie. Springer 2008
- Daemen, Rijme. The Design of Rijndael. Springer 2002
- von zur Gathen: CryptoSchool. Springer 2015
- Lee, Sasaki, Sakiyama. Security of Block Ciphers. Wiley-IEEE Press 2016
- Schneier. Applied Cryptography. Wiley & Sons, 1995
- Stinson, Paterson. Cryptography - Theory and Practice (4th Ed.). CRC Press 2019

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Lecture/Exercise	german

Title	Machine Learning for Data Science		
Number	4229000050	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Michel Besserve
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	The lectures and exercises require a good command of the knowledge from Bachelor level “Linear Algebra” and “Analysis” courses, and a background knowledge on probability theory and the python programming language is recommended.		
Expected performance/ Type of examination	1 examination: written exam, 90 minutes or oral exam, 30 minutes or take-home exam		
Course achievement	1 academic achievement: 50% of the exercises must be passed		
Examination language	english german		

Contents

- Supervised Learning Algorithms
- Model Selection
- Unsupervised Learning Algorithms
- Deep Neural network architectures for data science
- Self-supervised learning and foundation models
- Uses and limitations of ML in data science projects

Objective qualification

After successfully completing this module, students should be able to
- understand and correctly apply basic concepts of machine learning algorithm design,
- master elementary tools for analyzing the performance of machine learning approaches,
- identify the most suited ML approaches for a particular application.

Literature

- Machine Learning, A Probabilistic Perspective, Murphy, 2012
- Deep Learning, Goodfellow et al., 2016
- Mathematics for Machine Learning, Deisenroth et al., 2020

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Machine Learning for Data Science	3,0	Lecture/Exercise	english

Title	Computational Methods in Bionics 1		
Number	2514600	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät Fakultät für Maschinenbau
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Thomas Vietor
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	Basic knowledge of differential calculus, basic understanding of biological and physical connections.		
Expected performance/ Type of examination	1 examination element: oral exam (30 min)		
Course achievement			
Examination language	german		

Contents

- Bionics as a science (definition, idea, goals, qualifications, structures)
- Social Systems (the biological foundation of social communities, system dynamics, agents, swarms)
- Biological principles of the evolution (history, terms, biological principle)
- Conventional methods of optimization (indirect methods, direct methods)
- Bionic methods of optimization (evolutionary algorithms, examples: evolution strategies, example: genetic algorithms, evolutionary programming, simulated annealing, particle swarm optimization)
- Neuronal networks (biological principle of neuronal networks, pattern recognition, regulation)

Objective qualification

The students are capable of: - describing bionic as an engineering science method - naming and describing the principles of biological mechanisms - applying descriptions of social systems and behavior towards economic-technical simulation systems - systemizing methods of optimization in the form of indirect, direct and bionic methods based on examples - describing and explaining the bionic methods of optimization trough the biological example, in an information technological manner - name and explain the structure and usage of neuronal networks - applying the studied principles of the approaches of bionics towards computational methods and being able to point them out in examples

Literature

- Nachtigall, W.: Bionik, Springer-Verlag, Berlin (1998)
- Beyer, H.-G.: The Theory of Evolution Strategies, Springer-Verlag, Berlin, Heidelberg (2001)
- Forrester, J. R.: Urban Dynamics, Pegasus Communications, Waltham (1969)
- Rechenberg, I.: Evolutionsstrategie '94, Frommann-Holzboog-Verlag, Stuttgart (1994)
- Rojas, R.: Theorie der neuronalen Netze, Springer-Verlag Berlin (1996)
- Schwefel, H.-P.: Evolution and Optimum Seeking, Verlag Wiley & Sons, New York (1995)

Remark

The lecture will be read in English if necessary.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Advanced Computer Architecture		
Number	2416520	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Computer Engineering
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Rolf Ernst Prof. Dr. Selma Saidi
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	oral exam (20 min)		
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
- J. L. Hennessy & David A. Patterson, "Computer Architecture - A Quantitative Approach (4th rev. Edition)", Academic Press, ISBN 978-0123704900 - additional materials during lectures			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Low-Power Embedded Systems		
Number	2416000000	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Datentechnik und Kommunikationsnetze
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Andres Gomez
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Written (90 min) or oral exam (30 min)		
Course achievement			
Examination language	english		

Contents

- An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. For example, they are part of industrial machines, agricultural and process industry devices, automobiles, medical equipment, cameras, household appliances, airplanes, sensor networks, internet-of-things, as well as mobile devices.
- The focus of this lecture is on the design of low-power embedded systems using formal models and utilizing the latest micro-architectural features for improved performance and energy efficiency, with practical examples using C/C++.

Objective qualification

The students
- gain an understanding of specific requirements, issues, and performance evaluations of low-power embedded system applications.
- make design decisions with deep knowledge of the inherent cost-versus-performance trade-offs in low-power, resource-constrained systems.
- apply the principles of real-time operating systems and scheduling theory to design efficient applications with shared resources.
- analyze different architectures, evaluate their hardware-software interface and memory architecture and different optimization techniques for microcontrollers, such as DSP extensions to the instruction set architecture.

Literature

- Edward A. Lee and Sanjit A. Seshia: Introduction to Embedded Systems, A Cyber- Physical Systems Approach, Second Edition, MIT Press, ISBN 978- 0-262-53381-2, 2017.
- P. Marwedel: Embedded System Design, Springer, ISBN 978- 3-030-60909-2, 2021.
- G.C. Buttazzo: Hard Real- Time Computing Systems. Springer Verlag, ISBN 978- 1-4614-0676-1, 2011.

- M. Wolf: Computers as Components – Principles of Embedded System Design. Morgan Kaufman Publishers, ISBN 978-0-128-05387-4, 2016.
- Avelino J. Gonzalez: Computer Programming in C for Beginners, Springer, ISBN 978-3-030-50752-7, 2020.
- Joseph Yiu. The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors. Newnes, 2013.

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Low-Power Embedded Systems	2,0	Lecture	english

Literature

- Edward A. Lee and Sanjit A. Seshia: Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, MIT Press, ISBN 978- 0-262-53381-2, 2017.
- P. Marwedel: Embedded System Design, Springer, ISBN 978- 3-030-60909-2, 2021.
- G. C. Buttazzo: Hard Real-Time Computing Systems. Springer Verlag, ISBN 978- 1-4614-0676-1, 2011.
- M. Wolf: Computers as Components – Principles of Embedded System Design. Morgan Kaufman Publishers, ISBN 978-0-128-05387-4, 2016.
- Avelino J. Gonzalez: Computer Programming in C for Beginners, Springer, ISBN 978-3-030-50752-7, 2020.
- Joseph Yiu. The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors. Newnes, 2013.

Low-Power Embedded Systems	1,0	Exercise	english

Literature

- Edward A. Lee and Sanjit A. Seshia: Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, MIT Press, ISBN 978- 0-262-53381-2, 2017.
- P. Marwedel: Embedded System Design, Springer, ISBN 978- 3-030-60909-2, 2021.
- G. C. Buttazzo: Hard Real-Time Computing Systems. Springer Verlag, ISBN 978- 1-4614-0676-1, 2011.
- M. Wolf: Computers as Components – Principles of Embedded System Design. Morgan Kaufman Publishers, ISBN 978-0-128-05387-4, 2016.
- Avelino J. Gonzalez: Computer Programming in C for Beginners, Springer, ISBN 978-3-030-50752-7, 2020.
- Joseph Yiu. The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors. Newnes, 2013.

Title	Computer Architecture 2 - Embedded Systems		
Number	2416060	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Selma Saidi
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	oral exam (30 minutes)		
Course achievement			
Examination language	german		

Contents

Specification of digital systems (FSM, statecharts, SDF, ...)

Architectural principles for embedded systems, examples (microcontrollers, digital signal processors)

Implementation:
- Automated circuit synthesis
- Optimising compilers for embedded architectures
- Scheduling in real-time operating systems

Objective qualification

Students will gain an in-depth understanding of the architecture and design of embedded systems. The focus is on formal fundamentals, systematic contexts, algorithms and methods. After completing the module, students will be able to model a given application and specify an adapted computer architecture by means of a hardware-software co-design.

Literature

#- lecture notes
- W. Wolf, Computers As Components
- Principles of Embedded Computing System Design, Morgan Kaufmann Publishers, ISBN 978-0123743978

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Lecture	german
	1,0	Exercise	german

Title	Cryptology Design Fundamentals		
Number	2416570	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Wael Adi
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
# Skript: W. Adi, Grundlagen des kryptographischen Systementwurfs (2008) # Cryptography: Theory and Practice, Von Douglas Robert Stinson,Edition 3, CRC Press, 2006, ISBN 1584885084, 9781584885085 # Cryptography and Network Security: Principles and Practice, Von William Stallings, Edition: 4, Prentice Hall, 2006, ISBN 0131873164, 9780131873162			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

	2,0	Lecture	german
Literature			
- Cryptography: An Introduction (3rd Edition), by Nigel Smart - Introduction to Modern Cryptography: Principles and Protocols by: J. Katz, Y. Lindell, CRC Press 2007, 2014 - Cryptography Theory and Practice, Second edition by D. Stinson. Chapman & Hall /CRC, 2002 - Reference book: Free on the web: Handbook of Applied Cryptography[EXTERNAL] by A. Menezes, P. Van Oorschot, S. Vanstone. Kostenlos!			

	1,0	Exercise	german
Literature			
- Cryptography: An Introduction (3rd Edition), by Nigel Smart - Introduction to Modern Cryptography: Principles and Protocols by: J. Katz, Y. Lindell, CRC Press 2007, 2014 - Cryptography Theory and Practice, Second edition by D. Stinson. Chapman & Hall /CRC, 2002 - Reference book: Free on the web: Handbook of Applied Cryptography[EXTERNAL] by A. Menezes, P. Van Oorschot, S. Vanstone. Kostenlos!			

Title	Neuromorphic Computing & Engineering		
Number	2420000010	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für CMOS Design
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Thomas Kämpfe
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Oral exam (30 min)		
Course achievement			
Examination language	english		

Contents

Neuromorphic computing is an approach which is inspired by the structure and function of human brains. Neuromorphic computers are based on Silicon devices which use physical artificial neurons and synapses to apply computations. In recent times, the term neuromorphic has been used to describe analog, digital, mixed-mode analog/digital VLSI, and software systems that implement models of neural systems. The implementation of neuromorphic computing on the hardware level can be realized by oxide-based resistive or ferro-electric memristors.

The lecture presents the principles of biological computation and their implementation in hardware. Basic building blocks of neuromorphic technology are presented. The implications for the development of novel information processing technologies are outlined.

Objective qualification

After successfully completing the module, students will have understand the principles of biological computation. They will know how to implement them in hardware. They will have basic skills in applying neuromorphic engineering.

Literature

- Neuromorphic Computing for Computer Scientists
- Shih-Chii Liu. Event-Based Neuromorphic Systems. 2014 Wiley Print ISBN:9780470018491, DOI:10.1002/9781118927601
- Z. Sun et al. A full spectrum of computing-in-memory technologies. Nature Electronics 2023, 6, 823-835. https://www.nature.com/articles/s41928-023-01053-4
- C. Schuman et al. Opportunities for neuromorphic computing algorithms and applications. Nature Computational Science 2022, 2, 10-19 https://www.nature.com/articles/s43588-021-00184-y

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
Neuromorphic Computing & Engineering	2,0	Lecture	english

Literature

- Neuromorphic Computing for Computer Scientists
- Shih-Chii Liu. Event-Based Neuromorphic Systems. 2014 Wiley Print ISBN:9780470018491, DOI:10.1002/9781118927601
- Z. Sun et al. A full spectrum of computing-in-memory technologies. Nature Electronics 2023, 6, 823-835. https://www.nature.com/articles/s41928-023-01053-4
- C. Schuman et al. Opportunities for neuromorphic computing algorithms and applications. Nature Computational Science 2022, 2, 10-19 https://www.nature.com/articles/s43588-021-00184-y

Neuromorphic Computing & Engineering	1,0	Exercise	english

Literature

- Neuromorphic Computing for Computer Scientists
- Shih-Chii Liu. Event-Based Neuromorphic Systems. 2014 Wiley Print ISBN:9780470018491, DOI:10.1002/9781118927601
- Z. Sun et al. A full spectrum of computing-in-memory technologies. Nature Electronics 2023, 6, 823-835. https://www.nature.com/articles/s41928-023-01053-4
- C. Schuman et al. Opportunities for neuromorphic computing algorithms and applications. Nature Computational Science 2022, 2, 10-19 https://www.nature.com/articles/s43588-021-00184-y

Title	Computer Lab Pattern Recognition		
Number	2424000020	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Nachrichtentechnik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Tim Fingscheidt
Workload (h)			
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement	Development and documentation of a computer / software program		
Examination language	english german		

Contents

The course consists of hands-on programming tasks that are solved by the participants and subsequently evaluated in a semi-automated way. In total, seven units from the sub-fields (i) basics of hands-on application of machine learning methods, (ii) image processing (computer vision) and (iii) time series analysis have to be completed. The seven units are:

- Interactive introduction to Python fundamentals using Jupyter notebooks, fundamentals of data processing, preparation and visualization.
- Use of single-layer machine learning models to solve a two-class problem: Support vector machines (based on libsvm) and neural networks. Splitting and use of datasets, application of appropriate metrics for evaluation, use of high-level machine learning libraries such as Sci-Kit-Learn
- Use of deep neural networks to solve a multi-class classification problem, introduction to recognized academic datasets such as MNIST and CIFAR-10, introduction to the use of deep learning libraries PyTorch and Tensorflow, usage and adaptation of pre-trained models
- Use of convolutional neural networks to solve more challenging image processing problems such as semantic segmentation and depth estimation, use of regularization methods in training
- Use of diverse cost functions to optimize neural networks, implementation of generative models such as Generative Adversarial Networks (GANs)
- Use of recurrent neural networks to solve problems based on time series data, application of concepts for anomaly detection
- Use of recurrent neural networks for speech processing, e.g., for noise reduction, analysis of neural networks with respect to their complexity (FLOPs, number of parameters)

Six out of the seven units have to be successfully passed for the entire computer lab module to be passed, among these unit 4 (convolutional neural networks) and unit 7 (recurrent neural networks in speech processing).

Objective qualification

In this course, students acquire the competencies to independently select and apply appropriate machine learning and deep learning methods for complex problems. The students ...
- ... master the programming language Python as well as the basics of the deep learning libraries PyTorch and Tensorflow.
- ... evaluate the effectiveness of simple machine learning models and neuronal networks for classification and regression problems.
- ... evaluate the quality of deep learning models on appropriate data (sub)sets with meaningful metrics
- ... know and use different types of neural networks for problems in the areas of image processing, time series processing and generative problems
- ... know and use different strategies for data preprocessing and data augmentation
- ... know and use different training and regularization methods for the optimization of neural networks
- ... evaluate the complexity of a neural network on the basis of various parameters

Literature

- Christopher M. Bishop, Nasser M. Nasrabadi, “Pattern Recognition and Machine Learning”, Springer 2006
- Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, MIT Press 2016

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Computer Lab Pattern Recognition	3,0	Internship	english german

Literature

- Christopher M. Bishop, Nasser M. Nasrabadi, “Pattern Recognition and Machine Learning”, Springer 2006
- Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, MIT Press 2016

Computer Lab Pattern Recognition	1,0	Colloquium	english german

Literature

- Christopher M. Bishop, Nasser M. Nasrabadi, “Pattern Recognition and Machine Learning”, Springer 2006
- Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, MIT Press 2016

Title	AI Engineering		
Number	2424000050	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Nachrichtentechnik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Tim Fingscheidt
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements	Basic knowledge (in theory and practice) in machine learning is required, e.g. from- Mustererkennung / Pattern Recognition (2424102) und im Computerlabor Mustererkennung (2424133).		
Expected performance/ Type of examination	Written exam (120 min) or roal exam (30 min)		
Course achievement	Lab work		
Examination language	english		

Contents

- Foundation Models
- Prompt Engineering
- Retrieval-Augmented Generation
- Agents
- Finetuning
- Legal and Ethical Aspects
- Building Applications with Foundation Models

Objective qualification

Students are able to explain the structure, functionality, and application of foundation models (large, generally pre-trained AI models) and describe their core components such as tokenization, embeddings, transformer architectures, and training procedures. They can apply methods such as prompt engineering, retrieval-augmented generation, finetuning, and agent systems to adapt AI models to specific tasks. Furthermore, they are able to analyze technical concepts, select appropriate tools, and design and evaluate AI applications while considering legal and ethical frameworks. In the accompanying lab sessions, students implement and experiment with the presented methods in practice, thereby deepening their understanding through hands-on experience.

Literature

- Lecure slides

- Publications on key technologies

- C. Huyen: „AI Engineering“, O‘Reilly Media, 2025

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
AI Engineering	2,0	Lecture	english
Literature			
- Vorlesungsfolien - Publikationen zu Schlüsseltechnologien - C. Huyen: „AI Engineering“, O‘Reilly Media, 2025			
Computer Lab AI Engineering	2,0	Internship	english
Literature			
- Lecure slides - Publications on key technologies - C. Huyen: „AI Engineering“, O‘Reilly Media, 2025			

Title	Deep Learning Lab		
Number	2424590	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Tim Fingscheidt
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement	Development and documentation of a computer / software program		
Examination language	german		
Contents			
Objective qualification			
Literature			
- R.O. Duda, P.E. Hart, D.G. Stork: Pattern Classification, Wiley, 2001 - C.M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006 - I. Goodfellow, Y. Bengio, A. Courville: Deep Learning, MIT Press, 2016			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

	3,0	Internship	german
Literature			
- R.O. Duda, P.E. Hart, D.G. Stork: Pattern Classification, Wiley, 2001 - C.M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006 - I. Goodfellow, Y. Bengio, A. Courville: Deep Learning, MIT Press, 2016			

	1,0	Colloquium	german
Literature			
- R.O. Duda, P.E. Hart, D.G. Stork: Pattern Classification, Wiley, 2001 - C.M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006 - I. Goodfellow, Y. Bengio, A. Courville: Deep Learning, MIT Press, 2016			

Title	Pattern Recognition		
Number	2424570	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Tim Fingscheidt
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	Oral exam (30 min) or written exam (90 min)		
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
- R.O. Duda, P.E. Hart, D.G. Stork: Pattern Classification, Wiley, 2001 - C.M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006			
Remark			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

	2,0	Lecture	english german
Literature			
- R. O. Duda, P. E. Hart, D. G. Stork: Pattern Classification, Wiley, 2001 - C. M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006			

	2,0	Seminar	english german
Literature			
- Vorlesungsfolien - R. O. Duda, P. E. Hart, D. G. Stork: Pattern Classification, Wiley, 2001 - C. M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006			

Title	Spoken Language Processing		
Number	2424540	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Tim Fingscheidt
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	Oral exam 30 minutes or written exam 90 minutes (depending on number of participants)		
Course achievement			
Examination language	english		

Contents

-Basics of speech production and perception
-Feature extraction
-Hidden Markov models
-Acoustic models and language models
-Automatic speech recognition
-Spoken language systems

Objective qualification

Literature

- Lecture slides
- X. Huang, A. Acero, H.-W. Hon: Spoken Language Processing, Prentice Hall, 2001
- B. Pfister, T. Kaufmann: Sprachverarbeitung, Springer, 2008
- A. Wendemuth: Grundlagen der Stochastischen Sprachverarbeitung, Oldenbourg, 2004
- E.G. Schukat-Talamazzini: Automatische Spracherkennung, Vieweg, 1995
- G.A. Fink: Mustererkennung mit Markov-Modellen, Teubner, 2003
- L. Rabiner, B.-H. Juang: Fundamentals of Speech Recognition, Prentice Hall, 1993
- K. Fukunaga: Statistical Pattern Recognition, Academic Press, 1990

Remark

This module from the master's program is also suitable for bachelor students. Basic knowledge of digital signal processing, as e.g. acquired in the module digital signal processing, facilitates the understanding of this lecture. Basic knowledge of probability calculus will also be expected.

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
	2,0	Lecture	english

Literature

- X. Huang, A. Acero, H.-W. Hon: Spoken Language Processing, Prentice Hall, 2001
- B. Pfister, T. Kaufmann: Sprachverarbeitung, Springer, 2008
- A. Wendemuth: Grundlagen der Stochastischen Sprachverarbeitung, Oldenbourg, 2004
- E.G. Schukat-Talamazzini: Automatische Spracherkennung, Vieweg, 1995
- G.A. Fink: Mustererkennung mit Markov-Modellen, Teubner, 2003
- L. Rabiner, B.-H. Juang: Fundamentals of Speech Recognition, Prentice Hall, 1993
- K. Fukunaga: Statistical Pattern Recognition, Academic Press, 1990

	2,0	Seminar	english

Literature

- X. Huang, A. Acero, H.-W. Hon: Spoken Language Processing, Prentice Hall, 2001
- B. Pfister, T. Kaufmann: Sprachverarbeitung, Springer, 2008
- A. Wendemuth: Grundlagen der Stochastischen Sprachverarbeitung, Oldenbourg, 2004
- E.G. Schukat-Talamazzini: Automatische Spracherkennung, Vieweg, 1995
- G.A. Fink: Mustererkennung mit Markov-Modellen, Teubner, 2003
- L. Rabiner, B.-H. Juang: Fundamentals of Speech Recognition, Prentice Hall, 1993
- K. Fukunaga: Statistical Pattern Recognition, Academic Press, 1990

Interdisciplinary elective field Advanced Industrial Management

Title	Digitalisation in the Automotive Industry		
Number	2523270	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Werkzeugmaschinen und Fertigungstechnik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Christoph Herrmann
Workload (h)	150		
Class attendance (h)	30	**Self studying (h)**	120
Compulsory requirements			
Expected performance/ Type of examination	written exam (120 min)		
Course achievement			
Examination language	german		

Contents

- Overview Automotive industry
- Change of values from vehicle ownership to mobility
- Digital Natives as employees and customers
- Overview of corporate architectures of the automotive industry
- Overview of the relevant digitalization technologies
- Vision / Outlook 2030
- Procedure for digitization
- Change of corporate culture
- Design Thinking and Agile Requirements for IT
- Cloud and Microservices
- Application examples
- Future trends and outlook

Objective qualification

Students
#

- are able to derive the challenges of change and its consequences for the automotive industry using practical case studies and empirical research #
- can assess the transformation of the automotive industry from vehicle manufacturer to mobility service provider by dealing with new technologies and related fields of application #
- are able to name various technologies and transfer their application to the automotive industry based on theories and best practices #
  develop an awareness of new technologies in the automotive sector and an understanding of digitalisation as a driver of transformation based on presented future trends #
- are able to design different application scenarios by means of the transformation drivers

Literature
• Winkelhake, U.: Die digitale Transformation der Automobilindustrie: Treiber # Roadmap # Praxis. Berlin: Springer Vieweg 2017. • Wedeniwski, S.: Mobilitätsrevolution in der Automobilindustrie. Berlin: Springer Vieweg 2015. • Wayner, P.: Future Ride. 99 Ways the Self-Driving, Autonomous Car Will Change Everything from Buying Groceries to Teen Romance to Turning Ten to Having a Heart Attack ... to Simply Getting From Here to There. Amazon Digital Services LLC 2015.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	1,0	Exercise	german
	2,0	Lecture	german

Title	Energy Efficiency in Production Engineering		
Number	2522930	**Module version**	v2
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Werkzeugmaschinen und Fertigungstechnik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Christoph Herrmann
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	written exam+ (120 min) or oral exam+ (30 min)		
Course achievement	presentation and/or written report in the context of a teamproject (On application, the result of the course achievement is taken into account in the assessment of the written examination+ or of the oral examination+, respectively, and can account maximum 20% of the respective grade.)		
Examination language	english		

Contents

- Background and methods for the holistic planning, design and development of sustainable production systems
- Definition of the term and origin of sustainability in production
- Technologies and procedures for industrial data acquisition
- Energetic evaluation of production processes on the basis of various key figures
- Data analysis of production processes using Sankey diagrams in theory and practice
- Analysis of production processes based on an (energy) value stream analysis
- Analysis of the different levels of consideration of factories (production processes, technical building equipment, building envelope) and relevant material, energy and information flows
- Guest lectures from industry on relevant topics of sustainable production systems
- Gaining knowledge about energy flexibility in production
- Practice-oriented application of various methods to increase energy efficiency in the IWF's learning factory

Objective qualification

The students...

- ... explain the planning, design and development of sustainability-oriented production systems in different contexts
- ... assess different strategies (e.g. efficiency strategy) and principles (e.g. avoidance principle) of sustainable development in defined use cases on a laboratory scale
- ... evaluate existing production systems in economic, ecological and social dimensions
- ... are able to illustrate the results of various efficiency strategies to non-experts and to apply relevant assumptions, restrictions and framework conditions correctly
- ... design their own research questions within the team project, evaluate experiments and derive a presentation of the results of the research

- ... organize themselves in a team project and gain experience in relevant soft skills such as teamwork, communication and presentation skills
- ... analyze sustainability-oriented production systems within a given topic
- ... are able to select relevant fields of action and measures for sustainable production

Literature

Vorlesungsskript "Energy Efficiency in Production Engineering" mit ausführlichen Quellenangaben für das Selbstudium

Herrmann, Christoph: Ganzheitliches Life Cycle Management, Berlin 2009

Dyckhoff, H. (2000): Umweltmanagement # Zehn Lektionen in umweltorientierter Unternehmensführung, Berlin: Springer-Verlag Berlin Heidelberg, 2000.

Günther, H.-O.; Tempelmeier, H. (2005): Produktion und Logistik. 6., verb. Aufl., [Hauptbd.], Berlin: Springer-Verlag Berlin Heidelberg, 2005.

Eversheim, W.; Schuh, G. (1999): Gestaltung von Produktionssystemen, VDI-Buch Nr. 3, Berlin: Springer-Verlag Berlin Heidelberg, 1999.

Remark

The course "Energy Efficiency in Production Engineering" is targeted in particular at students of mechanical engineering, industrial engineering, sustainable energy engineering, technology-oriented management, environmental engineering and other related courses.
This lecture is held in English.

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Related courses

Rules for the choice of courses

Both courses have to be attended.

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	2,0	Lecture	english
	1,0	Team Project	english

Title	Environmental and Sustainability Management in Industrial Application		
Number	2522950	**Module version**	v2
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Werkzeugmaschinen und Fertigungstechnik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Christoph Herrmann
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	It is recommended to complete the module "Total Life Cycle Management" in the previous winter semester. However, this is not a mandatory requirement for participation.		
Expected performance/ Type of examination	written exam+ (120 min) or oral exam+ (30 min)		
Course achievement	presentation and/or written report in the context of a teamproject (On application, the result of the course achievement is taken into account in the assessment of the written examination+ or of the oral examination+, respectively, and can account maximum 10% of the respective grade.)		
Examination language	english		

Contents

Requirements for companies from the perspective of sustainable development. Concept of Planetary Boundaries. Indicators of ecological limits, such as biodiversity loss, air pollution or the nitrogen cycle. Two central pillars for companies: Governance and leadership. Existing regulations, laws and standards such as ISO 26000 (Guide to Corporate Social Responsibility) or ISO 14001 (Environmental Management System Standard). Unique selling points to differentiate the company from its competitors. Various methods for sustainability strategies, such as materiality analysis. Indicators and measures regarding product policy, environmental communication, corporate social responsibility or external certifications.

Objective qualification

After completing the module "Environmental and Sustainability Management in Industrial Application" students are able to

- systematically analyse companies with regard to environmental and sustainability risks and to derive sustainability strategies for companies based on this analysis.
- apply suitable methods to identify the relevant environmental and sustainability aspects within the life cycle of a product and to derive requirements for companies.
- identify suitable measures to implement these requirements within a company organization.
- apply expertise on various topics of environmental and sustainability management within the framework of a case study.
- lead well-founded discussions on environmental and sustainability issues and to formulate sustainability strategies developed in a heterogeneous team.

Literature

Literature will be announced in the course.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	english
	1,0	Team Project	english

Title	Factory Planning		
Number	2522960	**Module version**	v2
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Werkzeugmaschinen und Fertigungstechnik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Christoph Herrmann
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	written exam+ (120 min) or oral exam+ (30 min)		
Course achievement	presentation and/or written report in the context of a teamproject (On application, the result of the course achievement is taken into account in the assessment of the written examination+ or of the oral examination+, respectively, and can account maximum 20% of the respective grade.)		
Examination language	german		

Contents

- Future of Factories
- Constituting elements of a factory
- Planning process
- Choice of location
- General building development
- Building structure planning
- Organizational structures of manufacturing
- Material flow and material handling
- Layout planning
- Planning of technical buidling services (TBS)
- Detailed planning of the production
- Sustainable operation of the factory
- Digitalization of the factory

Objective qualification

Students
#
- are able to describe and explain current trend, challenges and requirements of the factories using selected case studies #
- are able to categorize different factory planning cases, factory types, factory strategies and factory levels on the basis of socio-technical dimensions and analyze the effects on the factory planning process #
- are able to solve relevant planning and design tasks with reference to the VDI guideline 5200 #
- are able to independently select suitable tools, methods and models based on standard procedures (z. e.g. according to the VDI factory planning reference process) #
- are able to use methods and tools to design a factory structure and factory organization #
- are able to derive the effects of changed conditions for existing factories by tuning and adapting

Literature
1. Wiendahl H-P, Reichardt J, Nyhuis P (2014): Handbuch Fabrikplanung: Konzept, Gestaltung und Umsetzung wandlungsfähiger Produktionsstätten. München: Carl Hanser 2. Schenk M, Wirth S, Müller E (2014): Fabrikplanung und Fabrikbetrieb: Methoden für die wandlungsfähige, vernetzte und ressourceneffiziente Fabrik. 2. Aufl. Berlin: Springer Vieweg

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Factory Planning with Laboratory		
Number	2522970	**Module version**	v2
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Werkzeugmaschinen und Fertigungstechnik
Hours per Week / ECTS	5 / 7,0	**Module owner**	Prof. Dr. Christoph Herrmann
Workload (h)	210		
Class attendance (h)	70	**Self studying (h)**	140
Compulsory requirements			
Expected performance/ Type of examination	written exam+ (120 min) or oral exam+ (30 min)		
Course achievement	2 course achievements: 1. presentation and/or written report in the context of a teamproject (On application, the result of the course achievement is taken into account in the assessment of the written examination+ or of the oral examination+, respectively, and can account maximum 20% of the respective grade.) 2. protocol and presentation of the laboratory experiments		
Examination language	german		

Contents

- Future of Factories
- Constituting elements of a factory
- Planning process
- Choice of location
- General building development
- Building structure panning
- Organizational structures of manufacturing
- Material flow and material handling
- Layout planning
- Planning of technical buidling services (TBS)
- Detailed planning of the production
- Sustainable operation of the factory
- Digitalization of the factory
- Introduction to virtual factory planning
- Introduction to different digital planning tools
- Applying planning tools in a practice setting

Objective qualification

Students
#
- are able to describe and explain current trend, challenges and requirements of the factories using selected case studies #
- are able to categorize different factory planning cases, factory types, factory strategies and factory levels on the basis of socio-technical dimensions and analyze the effects on the factory planning process #

- are able to solve relevant planning and design tasks with reference to the VDI guideline 5200 #
- are able to independently select suitable tools, methods and models based on standard procedures (z. e.g. according to the VDI factory planning reference process) #
- are able to use methods and tools to design a factory structure and factory organization #
- are able to derive the effects of changed conditions for existing factories by tuning and adapting #
- have acquired extended knowledge about decision-making contexts in companies. #
- have their decision-making competence is strengthened by taking on different roles and experimenting with alternatives in the business games. #
- are able to transfer the experiences from the business games to real situations from everyday business life.

Literature

1. Wiendahl H-P, Reichardt J, Nyhuis P (2014): Handbuch Fabrikplanung: Konzept, Gestaltung und Umsetzung wandlungsfähiger Produktionsstätten. München: Carl Hanser
2. Schenk M, Wirth S, Müller E (2014): Fabrikplanung und Fabrikbetrieb: Methoden für die wandlungsfähige, vernetzte und ressourceneffiziente Fabrik. 2. Aufl. Berlin: Springer Vieweg

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	2,0	Lecture	german
	1,0	Exercise	german
Factory planning lab	2,0	Laboratory	german

Title	Production engineering for sustainable materials		
Number	2522000040	**Module version**	v2
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Werkzeugmaschinen und Fertigungstechnik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Christoph Herrmann
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements	none		
Recommended requirements	none		
Expected performance/ Type of examination	written exam+ (120 min) or oral exam+ (30 min)		
Course achievement	presentation and/or written report in the context of a teamproject (On application, the result of the course achievement is taken into account in the assessment of the written examination+ or of the oral examination+, respectively, and can account maximum 20% of the respective grade.)		
Examination language	english		

Contents

- Introduction to the current use of natural resources in an industrial context and presentation of related energy and material flows as well as political, social, technological and economic challenges
- Methods and tools for holistic, lifecycle assessment and increasing material efficiency in industrial value stream - Evaluation and classification of streams under ecological and economical aspects
- Overview of measures to reduce the energy consumption in each phase (e.g. raw material provisioning) and the entire life cycle
- Measures to reduce material losses in the material supply and product creation
- Drivers and opportunities to reduce material intensity (e.g., demand reduction, material and product substitution)
- Closed-loop approaches in product and material reuse and recycling (e.g. industrial metabolism, cradle-to-cradle)
- Areas of application and case studies
- Awareness of the ecological, economic and social relevance of global material flows for technical products from raw material extraction to recycling

Objective qualification

Students
#
- ...are able to classify the material flows for technical products in a global context and question the resulting consequences for the environment, economy and society #
- ... can analyse the process of raw material supply, processing, product manufacturing and use #
- ...are able to implement methods and tools (e.g. material flow analysis, life cycle assessment, life cycle costing) that enable a holistic, life cycle-oriented evaluation of material efficiency under different target sizes (ecological, economic, social) in the industrial value stream

- # ...can identify measures and approaches to increase material efficiency under the previously defined target variables and analyze which implementation challenges exist in the socio-economic and ecological environment #
- ...can identify the challenges associated with material substitution and argue why the entire product life cycle must be considered when choosing materials #
- ...can evaluate the ecological and economic relevance of the use of materials in technical products and services, identify key levers for improvement and anticipate potential implementation challenges

Literature

- Vorlesungsfolien (Powerpoint)
- Allwood J; Cullen J.: Sustainable Materials # With both eyes open
- Ashby, M. F.: Materials and the Environment # Eco-Informed Material Choice
- Herrmann C.: Ganzheitliches Life Cycle Management

Remark

This lecture and exercise will be held in English.

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Related courses

Rules for the choice of courses

The lecture or the written exam is an examination element and is graded. The exercise or case study work is a course achievement and must be documented.

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Production engineering for sustainable materials	1,0	Exercise	english
Production engineering for sustainable materials	2,0	Lecture	english

Title	Production Planning and Control		
Number	2523060	**Module version**	
Shorttext		**Language**	german
Frequency of offer		**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Werkzeugmaschinen und Fertigungstechnik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Christoph Herrmann
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 Examination element: written exam (120 min)		
Course achievement			
Examination language	german		

Contents

- Introduction to PPC
- Organization and flexibility of production networks
- Production Program Planning
- Production requirements planning
- In-house production planning and control
- Methods of the PPC
- External production planning and control
- Order Management
- PPC and ERP systems
- Innovations in the PPC

Objective qualification

Students # are able to explain the fundamental procedure for implementing and using ERP systems # are able to derive the essential advantages and disadvantages of the various methods of PPS on the basis of practical application examples # are able to evaluate and select suitable methods for specific applications in industrial practice using the relevant criteria # are able to evaluate the potentials of industry 4.0, by demonstrating the influences of a digital order processing process on PPS methods # are able to analyse the processes in companies on the basis of the target values of the PPS using suitable methods and derive improvements

Literature

- Luczak, H.; Eversheim, W.: Produktionsplanung und -steuerung: Grundlagen, Gestaltung und Konzepte. 2. Auflage. Berlin: Springer 2001.
- Kurbel, K.: Produktionsplanung und -steuerung im Enterprise Resource Planning und Supply Chain Management. 6. Auflage. München: Oldenbourg 2005.
- Lödding, H.: Verfahren der Fertigungssteuerung. Berlin: Springer 2005.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Interdisciplinary elective field Business Studies

Title	Orientation Management Control		
Number	2214170	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Controlling und Unternehmensrechnung
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Heinz Ahn
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	Basic knowledge of economics is a prerequisite for the module.		
Expected performance/ Type of examination	1 Klausur (90 min) oder 1 Take-at-Home-Exam		
Course achievement	for Organization, Governance, Education / MA Social Sciences instead of the examination performance: 1 written exam, 90 minutes or take-at-home exam		
Examination language	german		

Contents

Selected contents - depending on the respective current course:
- Effectiveness and efficiency measurement
- Performance indicators
- Budgeting systems
- Transfer pricing systems

Objective qualification

The students understand fundamental topics and methods of management control. Based on this, they are able to analyze related problems, critically evaluate proposed concepts, and soundly support respective decision-making in practice.

Literature

- Weber/Schäffer: Einführung in das Controlling, Stuttgart, aktuelle Auflage
- Ewert/Wagenhofer: Interne Unternehmensrechnung, Berlin et al., aktuelle Auflage
- Eisenführ/Weber/Langer: Rationales Entscheiden, Berlin et al., aktuelle Auflage

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Related courses			
Rules for the choice of courses			
In this module, the courses Coordination Instruments of Controlling (V2, Ü1) and Performance Measurement (V1) are compulsory. Optional colloquia and tutorials are voluntary.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Controlling coordination tools	2,0	Lecture/Exercise	german
Literature			
Ewert, R./Wagenhofer: Interne Unternehmensrechnung, Berlin et al., aktuelle Auflage			

Performance Analytics	2,0	Lecture	english german

Title	Specialisation Management Controlling		
Number	2214000000	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Controlling und Unternehmensrechnung
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Heinz Ahn
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 exam+ (30 min) or 1 take-home exam or 1 oral exam+ (20 min)		
Course achievement	1 presentation or 1 term paper or 1 presentation or 1 portfolio for Organisation, Governance, Education / MA Social Sciences instead of the examination additionally: 1 exam+ (30 min) or 1 take-home exam or 1 oral exam+ (20 min)		
Examination language	german		

Contents

Selected contents – depending on the respective current course:
- Management control in practice and research
- Controlling of risks and chances
- Project controlling

Effectiveness and efficiency analysis

Objective qualification

The students have a deeper understanding of actual topics and methods of management control. Based on this, they are able to analyze related problems, critically evaluate proposed concepts, and soundly support respective decision-making in practice. Furthermore, they are qualified to pursue academic work with the aim of writing a doctoral thesis.

Literature

- Weber/Schäffer: Einführung in das Controlling, Stuttgart, aktuelle Auflage
- Ewert/Wagenhofer: Interne Unternehmensrechnung, Berlin et al., aktuelle Auflage
- Eisenführ/Weber/Langer: Rationales Entscheiden, Berlin et al., aktuelle Auflage

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Related courses

Rules for the choice of courses

The module consists of two variants, one of which must be taken:

Variant A:
Current Topics in Controlling (VR3) and Advanced Performance Measurement (V1) are compulsory.
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Variant B:
Performance Analysis Projects is compulsory.
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Any colloquia and tutorials offered are voluntary in both variants.

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Advanced Performance Analytics	1,0	Lecture	english
Current topics in management accounting	2,0	Series of lectures	german

Literature

- Weber/Schäffer: Einführung in das Controlling, Stuttgart, aktuelle Auflage
- Ahn, H. (2003), Effektivitäts- und Effizienzsicherung - Controlling-Konzept und Balanced Scorecard, Frankfurt/M. et al.
- Ahn, H./Dyckhoff, H. (2004), Zum Kern des Controllings - Von der Rationalitätssicherung zur Effektivitäts- und Effizienzsicherung, in: Scherm/Pietsch (Hrsg.): Controlling - Theorien und Konzeptionen, München, S. 501-525

Actual Topics of Management Control	3,0	Series of lectures	german

Literature

- Weber, U./Schäffer, J. (2016), Einführung in das Controlling, Stuttgart
- Ahn, H. (2003), Effektivitäts- und Effizienzsicherung - Controlling-Konzept und Balanced Scorecard, Frankfurt/M. et al.
- Ahn, H./Dyckhoff, H. (2004), Zum Kern des Controllings - Von der Rationalitätssicherung zur Effektivitäts- und Effizienzsicherung, in: Scherm/Pietsch (Hrsg.): Controlling - Theorien und Konzeptionen, München, S. 501-525

Performance Analysis Projects	4,0	Series of lectures	german

Title	Orientation Data-Driven Enterprise		
Number	2218300	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Wirtschafts-informatik/Abt. Data-Driven Enterprise
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Frederik Möller
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 term paper & 1 presentation or 1 portfolio or 1 written exam (120 min) or 1 oral exam (30 minutes) or 1 term paper or 1 presentation or 1 take-at-home exam		
Course achievement			
Examination language	german		

Contents

In “Digital Business Engineering”, students acquire in-depth knowledge about the transformation of business models through a series of practical case studies and the strategic use of digital technologies and data. Business Engineering provides the theoretical framework. It offers a methodology for designing business models and is a model-driven and design-oriented approach to transforming companies. In the practical part of the course, students learn to apply various business engineering techniques (e.g. customer process modeling, information architecture design, SWOT analysis and more). The aim of the practical part is the independent (but guided) solving of a practical problem using the methods and techniques taught by the chair.

Objective qualification

After completing the module, students are able to apply business engineering techniques. Students will also be able to explain business engineering concepts and apply them to unfamiliar problems.

Literature

- OSTERWALDER, Alexander; PIGNEUR, Yves. Business model generation: a handbook for visionaries, game changers, and challengers. John Wiley & Sons, 2010.
- OSTERWALDER, Alexander; PIGNEUR, Yves; TUCCI, Christopher L. Clarifying business models: Origins, present, and future of the concept. Communications of the association for Information Systems, 2005, 16. Jg., Nr. 1,
- MÖLLER, Frederik, et al. Designing business model taxonomies–synthesis and guidance from information systems research. Electronic Markets, 2022, S. 1-26.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Digital Business Engineering	4,0	Lecture/Exercise	german

Literature

- OSTERWALDER, Alexander; PIGNEUR, Yves. *Business model generation: a handbook for visionaries, game changers, and challengers*. John Wiley & Sons, 2010.
- OSTERWALDER, Alexander; PIGNEUR, Yves; TUCCI, Christopher L. Clarifying business models: Origins, present, and future of the concept. *Communications of the association for Information Systems*, 2005, 16. Jg., Nr. 1,
- MÖLLER, Frederik, et al. Designing business model taxonomies–synthesis and guidance from information systems research. *Electronic Markets*, 2022, S. 1-26.

Digital Business Models and Sustainability	4,0	Lecture/Exercise	german

Literature

- Hahn, R. (2022). Sustainability management: Global perspectives on concepts, instruments, and stakeholders.
- Lüdeke-Freund, F., Carroux, S., Joyce, A., Massa, L., & Breuer, H. (2018). The sustainable business model pattern taxonomy—45 patterns to support sustainability-oriented business model innovation. Sustainable Production and Consumption, 15, 145-162.
- Osterwalder, A., & Pigneur, Y. (2010). Business model generation: a handbook for visionaries, game changers, and challengers (Vol. 1). John Wiley & Sons.
- Schaltegger, S., Lüdeke-Freund, F., & Hansen, E. G. (2016). Business models for sustainability: A co-evolutionary analysis of sustainable entrepreneurship, innovation, and transformation. Organization & environment, 29(3), 264-289.
- Schoormann, T., Stadtländer, M., & Knackstedt, R. (2021). Designing business model development tools for sustainability—a design science study. Electronic Markets, 1-23.

Title	Orientation Decision Support		
Number	2218220	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Dirk Mattfeld
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 exam (120 min) or 1 take-at-home exam		
Course achievement	only for Organisation, Governance, Education instead of the exam: 1 exam (120 min) or 1 take-at-home exam		
Examination language	german		

Contents

Selected contents - depending on the course selection:

Importance of information modelling for planning problems
Classification methods
Cluster analysis
Association analysis
Network models for route planning
Exciting trees, shortest paths
Round trip and route planning problems
Exact and heuristic methods for route planning

Objective qualification

Students have an insight into models and methods of data analysis and decision support. Students are able to map processes from the areas of mobility and transport in information and decision support models. They are familiar with algorithmic methods for analysing systems and generating recommendations for action.

Literature

- Vahrenkamp, R.; Mattfeld, D.C.: Logistiknetzwerke: Modelle für Standortwahl und Tourenplanung. Gabler, 2007.
- Berthold, M. et al: Guide to Intelligent Data Analysis
- Gabriel, R. et al: Computergestützte Informations- und Kommunikationssysteme in der Unternehmung. Technologien, Anwendungen, Gestaltungskonzepte. 2. Auflage. Springer, 2001.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Planning for Mobility and Transportation Purposes	2,0	Lecture	english
Literature			
• Mattfeld, D.; Vahrenkamp, R.: Logistiknetzwerke. Springer Gabler, 2014.			
Intelligent Data Analysis	2,0	Lecture	english
Literature			
• Hand, D.; Mannila, H.; Smyth, P.: Principles of Data Mining. MIT Press, 2001 • Berthold, M. R.; Borgelt, C.; Höppner, F.; Klawonn, F.; Silipo, R.: Guide to intelligent data analysis. Springer, 2020			

Title	Specialisation Decision Support		
Number	2218250	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Wirtschaftsinformatik - Lehrstuhl für Decision Support
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Dirk Mattfeld
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 exam (60 min) or 1 take-at-home exam (2.5 CP)		
Course achievement	Exercises (for the exercise(s)) (2.5 CP) only for Organisation, Governance, Education instead of the examination additionally 1 exam (60 min) or 1 take-at-home exam (2.5 CP)		
Examination language	german		

Contents

Selected content - depending on the course selection:

Business requirements for information systems in logistics and transport (ISLV)
Conception of ISLV
Functionality and examples of ISLV
Importance of information modelling for planning problems
Classification methods
Cluster analysis
Association analysis
Network models for route planning
Exciting trees, shortest paths

Objective qualification

Students have an in-depth understanding of the structure and design of information systems for mobility applications. The module enables students to transfer their basic knowledge of information systems for mobility applications to other domains. Through exercises, students consolidate the use of methods and models.

Literature

- Vahrenkamp, R.; Mattfeld, D.C.: Logistiknetzwerke: Modelle für Standortwahl und Tourenplanung. Gabler, 2007.
- Berthold, M. et al: Guide to Intelligent Data Analysis
- Gabriel, R. et al: Computergestützte Informations- und Kommunikationssysteme in der Unternehmung. Technologien, Anwendungen, Gestaltungskonzepte. 2. Auflage. Springer, 2001.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Data Driven Decision Making	2,0	Lecture	english
Literature			
• Mattfeld, D.; Vahrenkamp, R.: Logistiknetzwerke.Springer Gabler, 2014. • Berthold, M. R.; Borgelt, C.; Höppner, F.; Klawonn, F.; Silipo, R.: Guide to intelligent data analysis. Springer, 2020			
Data Driven Decision Making - Exercise	2,0	Exercise	german

Title	Orientation Services Management		
Number	2201000000	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Automobilwirtschaft und Industrielle Produktion - Lehrstuhl für Dienstleistungsmanagement
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. David Woisetschläger
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 portfolio or 1 take-home exam		
Course achievement	for Organization, Governance, Education / MA Social Sciences instead of the examination performance: 1 portfolio or 1 take-home exam		
Examination language	english german		

Contents

Contents - depending on the course selection:

Strategic Brand Management & Brand Strategy Bootcamp
Contents of the lecture include
- Brand understanding and the importance of brands
- Measurement of brand associations
- Secondary brand associations
- Instruments for building brand associations
- Brand strategy and positioning
- Brand architecture
- Measuring brand performance
- International brand management
- Internal brand management
- Organizational aspects of brand management
- Sectoral specialties in retail, industrial goods and the luxury sector.

Contents of the exercise are:
Working on a real practical problem in the field of brand management in cooperation with a company partner.

Business Model Innovation & Service Innovation
Contents of the lecture include:
- Relevance, importance and understanding of business model innovations
- Organizational success factors and barriers
- Transformation of existing business models
- Methods of business model innovation

- Building blocks of business model innovation and related methods
- Sectoral aspects such as innovation in mobility

Contents of the exercise are:
Application of service innovation methods on a practical example.

Customer Relationship Management & Customer Analytics
Contents of the lecture include:
- Relevance, importance and understanding of customer relationship management
- Theoretical foundations of CRM
- Target indicators of CRM
- Lifecycle perspective of the customer relationship
- Acquisition and new customer management
- Customer loyalty programs
- Types and management of switching barriers
- Customer evaluation and segmentation
- Expansion of customer relationships
- Complaint management
- Termination prevention and reactivation management
- Customer data and privacy

Contents of the exercise include learning and applying methods
- to calculate customer value
- to evaluate the customer relationship (e.g. satisfaction, loyalty, recommendation)
- to calculate customer churn or the probability of churn
- to evaluate the success of promotions and reactivation measures

Objective qualification

Depending on the selected courses:

After successful participation, students will have a basic understanding of brands and knowledge of which aspects play a role in branding. In addition, they will understand and be able to critically discuss how brands are developed and positioned and which instruments are suitable for this. They can argue on the basis of theory why certain brand-related measures can be expected to have an effect and have methodological knowledge in order to measure the brand and quantify influencing factors. Students will be able to formulate precise problems and research questions based on a complex practical issue in the field of brand management and develop a solution to the problem using the content and methods learned in the lecture.

After successful participation, students have a basic understanding of business model innovation and know which factors play a role in the development of business model innovations. In addition, they will understand and be able to critically discuss how innovations are developed and which methods are suitable for this. They can argue on the basis of theory why certain corporate measures can be expected to have an effect on the success of innovation and have methodological knowledge to develop, evaluate and critically reflect on business model innovations themselves. Students can formulate precise problems and research questions based on a complex practical issue in the field of innovation management and develop solutions to problems using the content and methods learned in the lecture and taught in the exercise.

Students have an understanding of issues that arise in the context of recording, designing and evaluating customer relationships. Based on the concepts and methods they have learned, students will be able to independently record, conceptually structure and analyze customer relationship management issues in various industry contexts. They have methodological and application knowledge for the qualitative and quantitative analysis of customer and company data required to answer customer relationship management tasks.

Literature

Strategic Brand Management & Brand Strategy Bootcamp
- Keller, Kevin L. und V. Swaminathan (2019): Strategic Brand Management - Building, Measuring, and Managing Brand Equity, 5th ed., Prentice Hall
- Supplementary journal paper per chapter
- Lecture notes for download.

- Supplementary information and literature as bibliography and/or download for the exercise.

Business Model Innovation & Service Innovation
- Textbooks and further literature will be announced in the lectures
- Supplementary literature (PDF documents, lecture notes for download)

Customer Relationship Management & Customer Analytics
- Kumar, V. and Werner Reinartz (2018): Customer Relationship Management: Concept, Strategy, and Tools, 3. ed., Springer.
- Textbooks and further literature will be announced in the lectures
- Supplementary literature (PDF documents, lecture notes for download)

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Related courses

Rules for the choice of courses

Students must choose a course from the following program:
- Strategic Brand Management & Brand Strategy Bootcamp
- Business Model Innovation & Service Innovation
- Customer Relationship Management & Customer Analytics

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Business Model Innovation: Concepts and Applications	4,0	Lecture/Exercise	english
Strategic Brand Management: Concepts and Applications	4,0	Lecture/Exercise	german
Customer Relationship Management and Customer Analytics	4,0	Lecture/Exercise	german

Title	Spezialisation Services Management		
Number	2201000020	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Automobilwirtschaft und Industrielle Produktion - Lehrstuhl für Dienstleistungsmanagement
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. David Woisetschläger
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 portfolio or 1 take-home exam		
Course achievement	for Organization, Governance, Education / MA Social Sciences instead of the examination performance: 1 portfolio or 1 take-home exam		
Examination language	english german		

Contents

Contents - depending on the course selection:

Strategic Brand Management & Brand Strategy Bootcamp
Contents of the lecture include
- Brand understanding and the importance of brands
- Measurement of brand associations
- Secondary brand associations
- Instruments for building brand associations
- Brand strategy and positioning
- Brand architecture
- Measuring brand performance
- International brand management
- Internal brand management
- Organizational aspects of brand management
- Sectoral specialties in retail, industrial goods and the luxury sector.

Contents of the exercise are:
Working on a real practical problem in the field of brand management in cooperation with a company partner.

Business Model Innovation & Service Innovation
Contents of the lecture include:
- Relevance, importance and understanding of business model innovations
- Organizational success factors and barriers
- Transformation of existing business models
- Methods of business model innovation

- Building blocks of business model innovation and related methods
- Sectoral aspects such as innovation in mobility

Contents of the exercise are:
Application of service innovation methods on a practical example.

Customer Relationship Management & Customer Analytics
Contents of the lecture include:
- Relevance, importance and understanding of customer relationship management
- Theoretical foundations of CRM
- Target indicators of CRM
- Lifecycle perspective of the customer relationship
- Acquisition and new customer management
- Customer loyalty programs
- Types and management of switching barriers
- Customer evaluation and segmentation
- Expansion of customer relationships
- Complaint management
- Termination prevention and reactivation management
- Customer data and privacy

Contents of the exercise include learning and applying methods
- to calculate customer value
- to evaluate the customer relationship (e.g. satisfaction, loyalty, recommendation)
- to calculate customer churn or the probability of churn
- to evaluate the success of promotions and reactivation measures

Objective qualification

Depending on the selected courses:

After successful participation, students will have a basic understanding of brands and knowledge of which aspects play a role in branding. In addition, they will understand and be able to critically discuss how brands are developed and positioned and which instruments are suitable for this. They can argue on the basis of theory why certain brand-related measures can be expected to have an effect and have methodological knowledge in order to measure the brand and quantify influencing factors. Students will be able to formulate precise problems and research questions based on a complex practical issue in the field of brand management and develop a solution to the problem using the content and methods learned in the lecture.

After successful participation, students have a basic understanding of business model innovation and know which factors play a role in the development of business model innovations. In addition, they will understand and be able to critically discuss how innovations are developed and which methods are suitable for this. They can argue on the basis of theory why certain corporate measures can be expected to have an effect on the success of innovation and have methodological knowledge to develop, evaluate and critically reflect on business model innovations themselves. Students can formulate precise problems and research questions based on a complex practical issue in the field of innovation management and develop solutions to problems using the content and methods learned in the lecture and taught in the exercise.

Students have an understanding of issues that arise in the context of recording, designing and evaluating customer relationships. Based on the concepts and methods they have learned, students will be able to independently record, conceptually structure and analyze customer relationship management issues in various industry contexts. They have methodological and application knowledge for the qualitative and quantitative analysis of customer and company data required to answer customer relationship management tasks.

Literature

Strategic Brand Management & Brand Strategy Bootcamp
- Keller, Kevin L. und V. Swaminathan (2019): Strategic Brand Management - Building, Measuring, and Managing Brand Equity, 5th ed., Prentice Hall
- Supplementary journal paper per chapter
- Lecture notes for download.

- Supplementary information and literature as bibliography and/or download for the exercise.

Business Model Innovation & Service Innovation
- Textbooks and further literature will be announced in the lectures
- Supplementary literature (PDF documents, lecture notes for download)

Customer Relationship Management & Customer Analytics
- Kumar, V. and Werner Reinartz (2018): Customer Relationship Management: Concept, Strategy, and Tools, 3. ed., Springer.
- Textbooks and further literature will be announced in the lectures
- Supplementary literature (PDF documents, lecture notes for download)

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Related courses

Rules for the choice of courses

Students must choose a course from the following program:
- Strategic Brand Management & Brand Strategy Bootcamp
- Business Model Innovation & Service Innovation
- Customer Relationship Management & Customer Analytics

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Business Model Innovation: Concepts and Applications	4,0	Lecture/Exercise	english
Strategic Brand Management: Concepts and Applications	4,0	Lecture/Exercise	german
Customer Relationship Management and Customer Analytics	4,0	Lecture/Exercise	german

Title	Orientation Finance		
Number	2215000040	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Finanzwirtschaft
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Marc Gürtler
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 written exam (120 min) or 1 oral exam (30 min) or 1 term paper or 1 presentation or 1 portfolio or 1 take-at-home exam		
Course achievement	for Organization, Governance, Education instead of the examination performance: 1 written exam (120 min) or 1 oral exam (30 min) or 1 term paper or 1 presentation or 1 portfolio or 1 take-at-home exam		
Examination language	german		

Contents

- Management of interest rate risk
- Management of stock price risk (portfolio management)
- Management of foreign exchange risk
- Management of credit risks in banks
- Valuation of financial instruments subject to risk

Objective qualification

Students have knowledge of the measurement, evaluation and management of financial risks and can apply this knowledge to issues faced by banks and insurance companies on the one hand and industrial companies on the other. In particular, students gain in-depth insights into the topics of “credit risks”, “interest rate risks”, “foreign exchange risks” and “stock price risks”.

Literature

- Gürtler (2013): Finanzwirtschaftliches Risikomanagement
- Breuer (2000): Unternehmerisches Währungsmanagement
- Breuer/Gürtler/Schuhmacher (2010): Portfoliomanagement I
- Breuer/Gürtler (2003): Internationales Management
- Hartmann-Wendels/Pfingsten/Weber (2007): Bankbetriebslehre

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Financial Risk Management	4,0	Lecture/Exercise	german
Literature			
vergleiche Homepage des Lehrstuhls			
Risk Management and Sustainability	4,0	Lecture/Exercise	german
Literature			
See the department’s website			

Title	Specialisation Finance		
Number	2215000030	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Finanzwirtschaft
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Marc Gürtler
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 written exam (120 min) or 1 term paper or 1 oral exam (30 min) or 1 presentation or 1 portfolio or 1 take-at-home exam		
Course achievement	for Organization, Governance, Education instead of the examination performance: 1 written exam (120 min) or 1 term paper or 1 oral exam (30 min) or 1 presentation or 1 portfolio or 1 take-at-home exam		
Examination language	german		

Contents

- Advanced methods and techniques of machine and statistical learning (e.g. tree-based methods, neural networks, support vector machines, cluster analysis, explainable artificial intelligence (AI))
- Application of the methods to forecasting and estimation problems in the financial sector
- Implementation of the methods, especially in the context of scientific case studies

Objective qualification

Students have the ability to use advanced methods of machine and statistical learning for forecasting and estimation problems in finance and to implement them in specific case studies using statistical software packages. Furthermore, students know the structured procedure that should be followed for implementation in the context of practical and scientific empirical projects.

Literature

- Gürtler (2013): Finanzwirtschaftliches Risikomanagement
- Wooldridge (2015): Introductory Econometrics – A Modern Approach
- von Auer (2011): Ökonometrie
- Brooks (2008): Econometrics for Finance
- Galeotti/Gürtler/Winkelvos (2013): Accuracy of Premium - Calculation Models for CAT Bonds – an Empirical Analysis
- Gürtler/Hibbeln (2013): Do Investors Consider Asymmetric Information in Pricing Securitizations?
- Gürtler/Hibbeln/Winkelvos (2016): The Impact of the Financial Crisis and Natural Catastrophes on CAT Bonds

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Related courses			
Rules for the choice of courses			
The course Machine Learning and Data Science in Finance is compulsory. The colloquium is voluntary.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Machine learning and data science in the financial sector	4,0	Lecture/Exercise	german
Literature			
See the department’s website			
Master’s Specialisation in Finance (Colloquium)	2,0	Colloquium	german

Title	Orientation Marketing		
Number	2221110	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Marketing und Innovation
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Christof Backhaus
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 exam (120 min) or 1 take-home exam		
Course achievement	for Organisation, Governance, Education / MA Social Sciences instead of the examination: 1 exam (120 min) or 1 take-home exam		
Examination language	english german		

Contents

Selected content - depending on the event selection:

Special features of international marketing
Consumer behaviour and organisational buying behaviour
Techniques of data collection and data analysis in marketing

Objective qualification

The aim of the orientation module Marketing is to give students the opportunity to expand their knowledge in a subject that is not one of their specialisations. After completing the module, students will have a sound knowledge of the following areas: 1. buyer behaviour and marketing research, 2. international marketing

Literature

- Zentes, J./Swoboda, B./Schramm-Klein, H. (2006): Internationales Marketing, München 2006
- Kroeber-Riel, W./Weinberg, P./Gröppel-Klein, A. (2008): Konsumentenverhalten, 9. Aufl., München 2008
- Fantapié Altobelli, C. (2007): Marktforschung, Stuttgart 2007
- Folienskripte

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Sustainability Transformation Management	2,0	Lecture	english
Consumer Behaviour	2,0	Lecture	german

Title	Orientation Marketing		
Number	2221110	**Module version**	V3
Shorttext		**Language**	english german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Marketing und Innovation
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Christof Backhaus
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 exam (120 min) or 1 take-home exam		
Course achievement	for Organisation, Governance, Education / MA Social Sciences instead of the examination: 1 exam (120 min) or 1 take-home exam		
Examination language	english german		

Contents

Selected content - depending on the event selection:

Special features of international marketing
Consumer behaviour and organisational buying behaviour
Techniques of data collection and data analysis in marketing

Objective qualification

The aim of the orientation module Marketing is to give students the opportunity to expand their knowledge in a subject that is not one of their specialisations. After completing the module, students will have a sound knowledge of the following areas: 1. buyer behaviour and marketing research, 2. international marketing

Literature

- Zentes, J./Swoboda, B./Schramm-Klein, H. (2006): Internationales Marketing, München 2006
- Kroeber-Riel, W./Weinberg, P./Gröppel-Klein, A. (2008): Konsumentenverhalten, 9. Aufl., München 2008
- Fantapié Altobelli, C. (2007): Marktforschung, Stuttgart 2007
- Folienskripte

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Consumer Behaviour	2,0	Lecture	german
Sales Management	2,0	Lecture	german
Literature			
• Johnston, Mark W. and Marshall, Greg W. (2021). Sales Force Management – Leadership, Innovation, Technology, 13th ed., New York: Routledge. • as well as further reading for the individual chapters, as listed in the course materials.			
Sales Management	2,0	Exercise	german
Literature			
• Johnston, Mark W. and Marshall, Greg W. (2021). Sales Force Management – Leadership, Innovation, Technology, 13th ed., New York: Routledge. • as well as further reading for the individual chapters, as listed in the course materials.			

Title	Specialisation Marketing		
Number	2221120	**Module version**	V3
Shorttext		**Language**	english german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Marketing und Innovation
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Christof Backhaus
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 exam (60 min) or 1 take-at-home exam (2.5 CP)		
Course achievement	1 written exam (60 min) or 1 exercise task or 1 take-at-home exam (for the exercise) (2.5 CP) for Organisation, Governance, Education / MA Social Sciences instead of the examination additionally: 1 exam (60 min) or 1 take-at-home exam (2.5 CP)		
Examination language	english german		

Contents

Selected contents - depending on the course selection:

Selected aspects of distribution management
Techniques of data collection and data analysis in marketing
In-depth study of selected marketing topics using case studies and exercises

Objective qualification

After completing this module, students have a sound knowledge of the areas of distribution management, international marketing, buyer behaviour and marketing research. They are able to think through, structure and solve marketing problems of various kinds.

Literature

- Zentes, J./Swoboda, B./Schramm-Klein, H. (2006): Internationales Marketing, München 2006
- Kroeber-Riel, W./Weinberg, P./Gröppel-Klein, A. (2008): Konsumentenverhalten, 9. Aufl., München 2008
- Fantapié Altobelli, C. (2007): Marktforschung, Stuttgart 2007
- Specht, G./Fritz, W. (2005): Distributionsmanagement, 4. Aufl., Stuttgart 2005
- Folienskripte

↑

Related courses			
Rules for the choice of courses			
Sales management and the exercise Sustainability Transformation Management are compulsory. The exercise Sales Management is voluntary and only for exam preparation. The order of the courses is arbitrary.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Sales Management	2,0	Lecture	german
Literature			
• Johnston, Mark W. and Marshall, Greg W. (2021). Sales Force Management – Leadership, Innovation, Technology, 13th ed., New York: Routledge. • as well as further reading for the individual chapters, as listed in the course materials.			
Exercise - Sustainability Transformation Management	2,0	Exercise	english
Sales Management	2,0	Exercise	german
Literature			
• Johnston, Mark W. and Marshall, Greg W. (2021). Sales Force Management – Leadership, Innovation, Technology, 13th ed., New York: Routledge. • as well as further reading for the individual chapters, as listed in the course materials.			

Title	Specialisation Marketing		
Number	2221120	**Module version**	V4
Shorttext		**Language**	english german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Marketing und Innovation
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Christof Backhaus
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 exam (60 min) or 1 take-at-home exam (2.5 CP)		
Course achievement	1 written exam (60 min) or 1 exercise task or 1 take-at-home exam (for the exercise) (2.5 CP) for Organisation, Governance, Education / MA Social Sciences instead of the examination additionally: 1 exam (60 min) or 1 take-at-home exam (2.5 CP)		
Examination language	english german		

Contents

Selected contents - depending on the course selection:

Selected aspects of distribution management
Techniques of data collection and data analysis in marketing
In-depth study of selected marketing topics using case studies and exercises

Objective qualification

After completing this module, students have a sound knowledge of the areas of distribution management, international marketing, buyer behaviour and marketing research. They are able to think through, structure and solve marketing problems of various kinds.

Literature

- Zentes, J./Swoboda, B./Schramm-Klein, H. (2006): Internationales Marketing, München 2006
- Kroeber-Riel, W./Weinberg, P./Gröppel-Klein, A. (2008): Konsumentenverhalten, 9. Aufl., München 2008
- Fantapié Altobelli, C. (2007): Marktforschung, Stuttgart 2007
- Specht, G./Fritz, W. (2005): Distributionsmanagement, 4. Aufl., Stuttgart 2005
- Folienskripte

↑

Related courses			
Rules for the choice of courses			
The lecture and exercise Sustainability Transformation Management are compulsory.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Sustainability Transformation Management	2,0	Lecture	english
Exercise - Sustainability Transformation Management	2,0	Exercise	english

Title	Orientation Production and Logistics		
Number	2220250	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Automobilwirtschaft und Industrielle Produktion - Lehrstuhl für Produktion und Logistik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Spengler
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 written exam 120 (min) or 1 take-at-home exam		
Course achievement	for Organization, Governance, Education / MA Social Sciences instead of the examination performance: 1 written exam 120 (min) or 1 take-at-home exam		
Examination language	english german		

Contents

Selected content - depending on course selection:

Production Facility Management:
The course “Production Facility Management” deals with various issues that arise in the context of production facility planning and operation. First of all, an overview is given of the tasks involved in the project management of a production facility construction project. Of particular relevance here is the interdisciplinary handling of such projects. A special focus is placed on investment and cost planning. Methods are taught with which economically relevant parameters can be estimated based on the technical planning in various project phases. Students are also taught methods for static and dynamic capacity planning. Finally, students are given an overview of configuration planning and maintenance.

Sustainability in Production and Logistics:
The course “Sustainability in Production and Logistics” teaches the main conditions and options to design a sustainable production and logistics system. The initial focus is laid on approaches for the static and dynamic modeling of energy and material flows as well as the design of disassembly and recycling processes. Within the subsequent sustainability assessment, approaches for an economic, environmental, and social assessment of products and processes are presented. This is followed by an introduction to multi-criteria decision-making, which enables the consideration of various sustainability aspects in the context of corporate decisions. The lecture is accompanied by interactive discussions and practical examples from various sectors, such as the steel industry or electromobility.

Operations Management in the Automotive Industry:
In the course "Operations Management in the Automotive Industry," students gain a detailed insight into the methods and concepts for planning and controlling automotive production. Students are introduced to

model-based planning approaches, enabling them to solve strategic (network planning), tactical (assembly line balancing), and operational (assembly line sequencing) problems within automotive production. Special focus is the development of mathematical planning models from Operations Management.

Supply Chain Management:
In the course “Supply Chain Management”, a model-based analysis of industrial supply chains is carried out. Special features of various industries such as the automotive, steel, and semiconductor industries are worked out and their effects on the supply chain are illustrated using the models presented. During the course, typical efficiency losses of industrial supply chains are discussed and approaches to maximize the efficiency of a supply chain are presented. Finally, a quantitative planning approach is presented that can be used to create distribution networks depending on product-specific requirements.

Objective qualification

In the "Production and Logistics" orientation, students are taught various quantitative and qualitative methods from Operations Management for evaluating, designing, planning, and controlling sustainable value creation networks. These methods are applied to practical production and logistics-related issues across various disciplines, such as process engineering, electrical engineering, electromobility, mechanical engineering, or the chemical industry.

Through the course, students are empowered to independently apply and develop quantitative and qualitative methods from Operations Management. Additionally, they are able to appropriately apply and adapt the learned methods in collaboration with different disciplines to address specific challenges.

Literature

Textbooks and further literature will be mentioned in the lectures.

↑

Related courses

Rules for the choice of courses

Production and Logistics A: Supply Chain Management + Operations Management in the Automotive Industry
Production and Logistics B: Asset Management + Sustainability in Production and Logistics

Students in the Master of Social Sciences can only choose option B.

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Sustainability in Production and Logistics	2,0	Lecture	german

Literature

- Baumast, A.; Pape, J. (2008): Betriebliches Umweltmanagement: Nachhaltiges Wirtschaften in Unternehmen, Eugen Ulmer: Stuttgart
- Deutsches Institut für Normung (2006): Umweltmanagement – Ökobilanz – Anforderungen und Anleitungen (ISO 14044:2006). Beuth-Verlag. Berlin. Ausgabedatum: 2006-10
- Erbguth, W.; Schlacke, S. (2010): Umweltrecht, Nomos: Baden-Baden
- Spengler, T. (1998): Industrielles Stoffstrommanagement, Erich Schmidt: Berlin
- Walther, G. (2010): Nachhaltige Wertschöpfungsnetzwerke – Überbetriebliche Planung und Steuerung von Stoffströmen entlang des Produktlebenszyklus, Gabler-Verlag: Wiesbaden.

Operations Management in the Automotive Industry	4,0	Lecture/Exercise	english

Literature

Examples:
- Meyr, H. (2004): Supply chain planning in the German automotive industry, in: OR Spectrum, Vol. 26, No. 4, pp. 447-470 (online available)
- Brabazon, P. G.; MacCarthy, B. (2004): Virtual-build-to-order as a mass Customization order fulfilment model, in: Concurrent Engineering Research and Applications, Vol. 12, No. 2, pp. 155-165 (online available)
- Boysen et al. (2007): A classification of assembly line balancing problems, in: European Journal of Operational Research, Vol. 183, No. 2, pp. 674-693 (online available)
- Boyer, K.; Leong, G. K. (1996): Manufacturing flexibility at the plant level, in: Omega, Vol. 24, No. 5, pp. 495-510.
- Fleischmann, B. et al. (2006): Strategic Planning of BMWs Global Production Network, in: Interfaces, Vol. 36, No. 3, pp. 194-208

Supply Chain Management	4,0	Lecture/Exercise	english

Literature

- Chopra, S./Meindl, P. (2016): Supply Chain Management – Strategy, Planning, and Operation. Pearson
- Shapiro, J. (2006): Modeling The Supply Chain, Duxbury/Thomson Learning
- Simchi-Levi, D./Kaminsky, P./Simchi-Levi, E. (2007): Designing and Managing the Supply Chain: Concepts, Strategies, and Case studies, McGraw-Hill/Irwin
- Stadtler, H./Kilger, C. (2007): Supply Chain Management and Advanced Planning, Springer

Production Facility Management	2,0	Lecture	german

Literature

- Bernecker (2013): Planung und Bau verfahrenstechnischer Anlagen: Projektmanagement und Fachplanungsfunktionen, 4. Auflage, Springer-Verlag, Berlin.
- Bronner (2001): Industrielle Planungstechniken: Unternehmens-, Produkt- und Investitionsplanung, Kostenrechnung und Terminplanung, Springer-Verlag, Berlin.
- Geldermann, Jutta (2014): Anlagen- und Energiewirtschaft – Kosten- und Investitionsschätzung sowie Technikbewertung von Industrieanlagen, Verlag Franz Vahlen, München.
- Günther, Hans-Otto; Tempelmeier, Horst (2016): Produktion und Logistik, 12. Auflage, Springer-Verlag, Berlin.
- Thonemann, Ulrich (2015): Operations Management – Konzepte, Methoden und Anwendungen, 3. Auflage, Pearson Studium, München.
- Birolini, Alessandro (2017): Reliability Engineering: Theory and Practice, 8. Auflage, Springer-Verlag, Berlin.
- Peters et al. (2003): Plant Design and Economics for Chemical Engineers, 5th Edition, McGraw-Hill, New York.

Exercise Supply Chain Management & Operations Management in the Automotive Industry	2,0	Exercise	english

Literature

Examples:
- Meyr, H. (2004): Supply chain planning in the German automotive industry, in: OR Spectrum, Vol. 26, No. 4, pp. 447-470 (online available)
- Brabazon, P. G.; MacCarthy, B. (2004): Virtual-build-to-order as a mass Customization order fulfilment model, in: Concurrent Engineering Research and Applications, Vol. 12, No. 2, pp. 155-165 (online available)
- Boysen et al. (2007): A classification of assembly line balancing problems, in: European Journal of Operational Research, Vol. 183, No. 2, pp. 674-693 (online available)
- Boyer, K.; Leong, G. K. (1996): Manufacturing flexibility at the plant level, in: Omega, Vol. 24, No. 5, pp. 495-510.
- Fleischmann, B. et al. (2006): Strategic Planning of BMWs Global Production Network, in: Interfaces, Vol. 36, No. 3, pp. 194-208

Exercise on asset management and sustainability in production and logistics	2,0	Exercise	german

Literature

- Bernecker (2013): Planung und Bau verfahrenstechnischer Anlagen: Projektmanagement und Fachplanungsfunktionen, 4. Auflage, Springer-Verlag, Berlin.
- Bronner (2001): Industrielle Planungstechniken: Unternehmens-, Produkt- und Investitionsplanung, Kostenrechnung und Terminplanung, Springer-Verlag, Berlin.
- Geldermann, Jutta (2014): Anlagen- und Energiewirtschaft – Kosten- und Investitionsschätzung sowie Technikbewertung von Industrieanlagen, Verlag Franz Vahlen, München.
- Günther, Hans-Otto; Tempelmeier, Horst (2016): Produktion und Logistik, 12. Auflage, Springer-Verlag, Berlin.
- Thonemann, Ulrich (2015): Operations Management – Konzepte, Methoden und Anwendungen, 3. Auflage, Pearson Studium, München.
- Birolini, Alessandro (2017): Reliability Engineering: Theory and Practice, 8. Auflage, Springer-Verlag, Berlin.
- Peters et al. (2003): Plant Design and Economics for Chemical Engineers, 5th Edition, McGraw-Hill, New York.

Title	Specialisation Production and Logistics		
Number	2220260	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Automobilwirtschaft und Industrielle Produktion - Lehrstuhl für Produktion und Logistik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Spengler
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 exam 120 (min) or 1 take-at-home exam (on the 2 lectures of the chosen combination)		
Course achievement	only for Organisation, Governance, Education instead of the exam: 1 exam 120 (min) or 1 take-at-home exam (on the 2 lectures of the chosen combination)		
Examination language	english german		

Contents

Selected content - depending on the course selection:

Plant management:
The course ‘Plant Management’ deals with various issues that arise in the context of plant planning and plant operation. Firstly, an overview is given of the tasks involved in the project management of a plant construction project. Of particular relevance here is the interdisciplinary handling of such projects. A special focus is placed on investment and cost planning. Methods are taught with which economically relevant parameters can be estimated on the basis of technical planning in various project phases. Students are also taught methods for static and dynamic capacity planning. Finally, students are given an overview of plant configuration planning and plant maintenance.

Sustainability in production and logistics:
In the course ‘Sustainability in Production and Logistics’, the relevant framework conditions and possibilities for designing sustainable production and logistics are taught. The focus is initially placed on approaches to static and dynamic modelling of energy and material flows as well as the design of dismantling and recycling. Within the subsequent sustainability assessment, approaches for an economic, ecological and social assessment of a product or process are presented. This is followed by an introduction to multi-criteria decision-making, which enables various aspects of sustainability to be taken into account when making business decisions. The lecture is accompanied by interactive discussions and application examples from various sectors, such as the steel industry or electromobility.

Operations Management in the Automotive Industry:
As part of the course ‘Operations Management in the Automotive Industry’, students gain a detailed insight into the methods and concepts for planning and controlling automotive production. Students learn about model-based planning approaches that enable them to solve strategic (network planning), tactical (assem-

bly line balancing) and operational (assembly line sequencing) problems in the context of automotive production. A particular focus is always on integrating the special technical challenges of the automotive industry into the respective planning approaches.

Supply Chain Management:
In the course ‘Supply Chain Management’, a model-based analysis of industrial supply chains is carried out. Special features of various industries such as the automotive, steel and semiconductor industries are analysed and their effects on the supply chain are illustrated using the models presented. During the course, typical efficiency losses of industrial supply chains are discussed and approaches to maximise the efficiency of a supply chain are presented. Finally, a quantitative planning approach is presented that can be used to create distribution networks depending on product-specific requirements.

Master's Colloquium - Production and Logistics:
In the Master's colloquium, students are given the opportunity to present and discuss their Master's and diploma theses.

Objective qualification

The Production and Logistics specialisation builds on the quantitative and qualitative methods of economics learned in the orientation. The methods learnt are extended and further methods are introduced. Furthermore, additional subject areas are addressed in which the methods are applied.

The course enables students to independently apply and develop quantitative and qualitative methods in economics. In addition, students will be able to apply and adapt the methods they have learnt in cooperation with different subject areas to the specific challenges of the subject.

Literature

Textbooks and further reading will be given in the lectures

↑

Related courses

Rules for the choice of courses

Depending on the chosen combination in the corresponding orientation, the following combinations are possible:

Production and Logistics A: Supply Chain Management + Operations Management in the Automotive Industry
(Orientation consisted of Production and Logistics B: Plant Management + Sustainability in Production and Logistics)

Production and Logistics B: Plant Management + Sustainability in Production and Logistics
(Orientation consisted of Production and Logistics A: Supply Chain Management + Operations Management in the Automotive Industry)

The colloquium is voluntary.

Compulsory attendance

Name of the course	SWS	Eventtype	Language

Sustainability in Production and Logistics	2,0	Lecture	german

Literature

- Baumast, A.; Pape, J. (2008): Betriebliches Umweltmanagement: Nachhaltiges Wirtschaften in Unternehmen, Eugen Ulmer: Stuttgart
- Deutsches Institut für Normung (2006): Umweltmanagement – Ökobilanz – Anforderungen und Anleitungen (ISO 14044:2006). Beuth-Verlag. Berlin. Ausgabedatum: 2006-10
- Erbguth, W.; Schlacke, S. (2010): Umweltrecht, Nomos: Baden-Baden
- Spengler, T. (1998): Industrielles Stoffstrommanagement, Erich Schmidt: Berlin
- Walther, G. (2010): Nachhaltige Wertschöpfungsnetzwerke – Überbetriebliche Planung und Steuerung von Stoffströmen entlang des Produktlebenszyklus, Gabler-Verlag: Wiesbaden.

	2,0	Colloquium	german

Operations Management in the Automotive Industry	4,0	Lecture/Exercise	english

Literature

Examples:
- Meyr, H. (2004): Supply chain planning in the German automotive industry, in: OR Spectrum, Vol. 26, No. 4, pp. 447-470 (online available)
- Brabazon, P. G.; MacCarthy, B. (2004): Virtual-build-to-order as a mass Customization order fulfilment model, in: Concurrent Engineering Research and Applications, Vol. 12, No. 2, pp. 155-165 (online available)
- Boysen et al. (2007): A classification of assembly line balancing problems, in: European Journal of Operational Research, Vol. 183, No. 2, pp. 674-693 (online available)
- Boyer, K.; Leong, G. K. (1996): Manufacturing flexibility at the plant level, in: Omega, Vol. 24, No. 5, pp. 495-510.
- Fleischmann, B. et al. (2006): Strategic Planning of BMWs Global Production Network, in: Interfaces, Vol. 36, No. 3, pp. 194-208

Production Facility Management	2,0	Lecture	german

Literature

- Bernecker (2013): Planung und Bau verfahrenstechnischer Anlagen: Projektmanagement und Fachplanungsfunktionen, 4. Auflage, Springer-Verlag, Berlin.
- Bronner (2001): Industrielle Planungstechniken: Unternehmens-, Produkt- und Investitionsplanung, Kostenrechnung und Terminplanung, Springer-Verlag, Berlin.
- Geldermann, Jutta (2014): Anlagen- und Energiewirtschaft – Kosten- und Investitionsschätzung sowie Technikbewertung von Industrieanlagen, Verlag Franz Vahlen, München.
- Günther, Hans-Otto; Tempelmeier, Horst (2016): Produktion und Logistik, 12. Auflage, Springer-Verlag, Berlin.
- Thonemann, Ulrich (2015): Operations Management – Konzepte, Methoden und Anwendungen, 3. Auflage, Pearson Studium, München.
- Birolini, Alessandro (2017): Reliability Engineering: Theory and Practice, 8. Auflage, Springer-Verlag, Berlin.
- Peters et al. (2003): Plant Design and Economics for Chemical Engineers, 5th Edition, McGraw-Hill, New York.

Supply Chain Management	4,0	Lecture/Exercise	english

Literature

- Chopra, S./Meindl, P. (2016): Supply Chain Management – Strategy, Planning, and Operation. Pearson
- Shapiro, J. (2006): Modeling The Supply Chain, Duxbury/Thomson Learning
- Simchi-Levi, D./Kaminsky, P./Simchi-Levi, E. (2007): Designing and Managing the Supply Chain: Concepts, Strategies, and Case studies, McGraw-Hill/Irwin
- Stadtler, H./Kilger, C. (2007): Supply Chain Management and Advanced Planning, Springer

Exercise Supply Chain Management & Operations Management in the Automotive Industry	2,0	Exercise	english

Literature

Examples:
- Meyr, H. (2004): Supply chain planning in the German automotive industry, in: OR Spectrum, Vol. 26, No. 4, pp. 447-470 (online available)
- Brabazon, P. G.; MacCarthy, B. (2004): Virtual-build-to-order as a mass Customization order fulfilment model, in: Concurrent Engineering Research and Applications, Vol. 12, No. 2, pp. 155-165 (online available)
- Boysen et al. (2007): A classification of assembly line balancing problems, in: European Journal of Operational Research, Vol. 183, No. 2, pp. 674-693 (online available)
- Boyer, K.; Leong, G. K. (1996): Manufacturing flexibility at the plant level, in: Omega, Vol. 24, No. 5, pp. 495-510.
- Fleischmann, B. et al. (2006): Strategic Planning of BMWs Global Production Network, in: Interfaces, Vol. 36, No. 3, pp. 194-208

Exercise on asset management and sustainability in production and logistics	2,0	Exercise	german

Literature

- Bernecker (2013): Planung und Bau verfahrenstechnischer Anlagen: Projektmanagement und Fachplanungsfunktionen, 4. Auflage, Springer-Verlag, Berlin.
- Bronner (2001): Industrielle Planungstechniken: Unternehmens-, Produkt- und Investitionsplanung, Kostenrechnung und Terminplanung, Springer-Verlag, Berlin.
- Geldermann, Jutta (2014): Anlagen- und Energiewirtschaft – Kosten- und Investitionsschätzung sowie Technikbewertung von Industrieanlagen, Verlag Franz Vahlen, München.
- Günther, Hans-Otto; Tempelmeier, Horst (2016): Produktion und Logistik, 12. Auflage, Springer-Verlag, Berlin.
- Thonemann, Ulrich (2015): Operations Management – Konzepte, Methoden und Anwendungen, 3. Auflage, Pearson Studium, München.
- Birolini, Alessandro (2017): Reliability Engineering: Theory and Practice, 8. Auflage, Springer-Verlag, Berlin.
- Peters et al. (2003): Plant Design and Economics for Chemical Engineers, 5th Edition, McGraw-Hill, New York.

Title	Orientation Information Management		
Number	2222310	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	2	**Institution**	Institut für Wirtschafts-informatik - Abteilung Service-Informationssy-steme
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Susanne Robra-Bissantz
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	The prerequisite for the module is basic knowledge in economics.		
Expected performance/ Type of examina-tion	1 assignment or 1 exam (120 min) or 1 portfolio or 1 take-at-home-exam or 1 exam+		
Course achievement	for Organisation, Governance, Education / MA Social Sciences instead of the exami-nation: 1 term paper or 1 exam (120 min) or 1 portfolio or 1 take-at-home exam		
Examination language	german		

Contents

Selected content – depending on the course selection:
- Servicification
- Role of IT in Service Processes
- Service Dominant Logic
- Digital Products
- Value in Interaction
- E-Services
- Service Design
- Service Ecosystems and Platforms
- Digital Economy
- Digital Management
- Cooperation and Collaboration
- Digital Collaboration

Objective qualification

Students understand the strategic relevance of information systems for companies in terms of operational tasks, people and technology. They are familiar with concepts for internal or inter-company IT-supported co-operation as well as their objectives and strategies in the context of strategic management. A possible spe-cialisation is the view of application systems as e-services.

Literature

Course materials are provided on Stud.IP, along with additional literature.

↑

Related courses			
Rules for the choice of courses			
Colloquium optional			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Digital Transformation: Collaborations	4,0	Lecture	german
Literature			
• Vorlesungsunterlagen zum Download • Weitere Literatur wird in der Veranstaltung bekannt gegeben			
Digital Transformation: Services	4,0	Lecture	german
Literature			
Vorlesungsunterlagen per Download, weitere Literatur wird in der Veranstaltung bekannt gegeben.			
	2,0	Colloquium	german

Title	Specialisation Information Management		
Number	2222000010	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Susanne Robra-Bissantz
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements	The module “Orientation Service Information Systems” must be successfully completed.		
Recommended requirements	The prerequisite for the module is basic knowledge in economics.		
Expected performance/ Type of examination			
Course achievement			
Examination language	german		

Contents

Selected content which students apply in a practical project building on the knowledge gained in the “Orientation Service Information Systems”:

- Servicification
- Role of IT in Service Processes
- Service Dominant Logic
- Digital Products
- Value in Interaction
- E-Services
- Service Design
- Service Ecosystems and Platforms
- Digital Economy
- Digital Management
- Cooperation and Collaboration
- Digital Collaboration

Objective qualification

Students understand the strategic relevance of information systems for companies in terms of operational tasks, people and technology. They are familiar with concepts for internal and/or inter-company IT-supported co-operation as well as their objectives and strategies in the context of strategic management. A possible specialisation is the view of application systems as e-services. Students acquire the technical and methodological knowledge and skills to develop, design, critically reflect on, present and at least partially technically implement strategically relevant IT-supported innovations for companies. Through project work, they are familiarised with working in teams and with modern media and are therefore able to apply their knowledge, make it sustainably accessible for themselves and expand it independently.

Literature

The course materials are available in Stud.IP; further reading can also be found there.

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Project	german
	2,0	Colloquium	german

Title	Orientation Management and Organisation Science		
Number	2223100	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Management
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Dietrich von der Oelsnitz
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 written exam (90 minutes) or 1 take-home exam		
Course achievement	For Organization, Governance, Education / MA Social Sciences instead of the exam: 1 written exam (90 minutes) or 1 take-home exam		
Examination language	german		

Contents

Depending on the chosen courses, practical and theoretical knowledge in the areas of organization and team management, as well as inter-organizational networks, are covered.

Objective qualification

After completing this module, students will have an in-depth understanding of the organization and processes within and between companies. They will learn how to systematically develop and maintain a company's knowledge base. Students will be able to explain the actions and behavior of organizational members and understand organizations as socio-technical systems.

Literature

- Oelsnitz, D. von der (2009): Die innovative Organisation, 2. Aufl., Stuttgart.
- Schulte-Zurhausen, M. (2005): Organisation, 4. Aufl., München.
- Schreyögg, G. (2008): Organisation, 5. Aufl., Wiesbaden.
- Stock-Homburg, R. (2008): Personalmanagement, Wiesbaden.
- Gemünden, H.G./Högl, M. (2005): Teamarbeit in innovativen Projekten, in: Högl, M./Gemünden, H.G. (Hrsg.): Management von Teams, 3. Aufl., Wiesbaden, S. 1-31.

↑

Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language

Organization	2,0	Lecture	german
Literature			
• Oelsnitz, D. von der (2009): Die innovative Organisation, 2. Aufl., Stuttgart. • Schulte-Zurhausen, M. (2005): Organisation, 4. Aufl., München • Schreyögg, G. (2008): Organisation, 5. Aufl., Wiesbaden.			

Team Management	1,0	Lecture	german
Literature			
• Stock-Homburg, R. (2008): Personalmanagement, Wiesbaden. • Gemünden, H.G./Högl, M. (2005): Teamarbeit in innovativen Projekten, in: Högl, M./Gemünden, H.G. (Hrsg.): Management von Teams, 3. Aufl., Wiesbaden, S. 1-31. • Oelsnitz, D. von der (2005): Kooperation: Entwicklung und Verknüpfung von Kernkompetenzen, in: Zentes, J./Swoboda, B./Morschett, D. (Hrsg.): Kooperationen, Allianzen und Netzwerke, 2. Aufl., Wiesbaden, S. 183-210.			

Team and Organizational Management	1,0	Exercise	german

		Colloquium	german

Organisation and Change	4,0	Lecture/Exercise	german
Literature			
• Oelsnitz, D. von der (2009): Die innovative Organisation, 2. Aufl., Stuttgart. • Schulte-Zurhausen, M. (2014): Organisation, 6. Aufl., München. • Schreyögg, G. (2024): Organisation, 7. Aufl., Wiesbaden.			

Title	Specialisation Management and Organisation Science		
Number	2223110	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Management
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Dietrich von der Oelsnitz
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	The module requires basic knowledge of business administration in the area of corporate management and organisation.		
Expected performance/ Type of examination	1 written Exam (90 min) or 1 take-at-home exam		
Course achievement	For Organisation, Governance, Education / MA Social Sciences instead of the examination: 1 written examination (90 minutes) or 1 take-at-home exam		
Examination language	german		

Contents

Depending on the chosen courses, practical and theoretical knowledge in the areas of organization, strategic knowledge management (including tools) and the management of teams and interorganizational networks are covered.

Objective qualification

After completing this module, students will have an in-depth understanding of the organization and processes within and between companies. They will learn how to systematically develop and maintain a company's knowledge base. Students will be able to explain the actions and behavior of organizational members and understand organizations as socio-technical systems.

Literature

- North, K.: Wissensorientierte Unternehmensführung, 4. Aufl., Wiesbaden 2005.
- Oelsnitz, D. von der/Hahmann, M.: Wissensmanagement, Stuttgart 2003.
- Probst, G./Raub, S./Romhardt, K.: Wissen managen, 5. Auflage, Wiesbaden 2006.
- Oelsnitz, D. von der (2005): Kooperation: Entwicklung und Verknüpfung von Kernkompetenzen, in: Zentes, J./ Swoboda, B./Morschett, D. (Hrsg.): Kooperationen, Allianzen und Netzwerke, 2. Aufl., Wiesbaden, S. 183-210

↑

Related courses			
Rules for the choice of courses			
Colloquium voluntary			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Networkmanagement	1,3	Lecture/Exercise	german
Literature			
Wird in der Vorlesung bekannt gegeben.			
Knowledge Management	2,0	Lecture/Exercise	german
Literature			
• North, K.: Wissensorientierte Unternehmensführung, 4. Aufl., Wiesbaden 2005. • Oelsnitz, D. von der/Hahmann, M.: Wissensmanagement, Stuttgart 2003. • Probst, G./Raub, S./Romhardt, K.: Wissen managen, 5. Auflage, Wiesbaden 2006.			
	1,0	Colloquium	german
Team and Alliance Management	4,0	Lecture/Exercise	german
Literature			
This will be announced during the lecture.			

Title	Orientation Business Creation and Succession		
Number	2225000030	**Module version**	
Shorttext		**Language**	english
Frequency of offer	every term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Marketing und Innovation
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Bastian Kindermann
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 Portfolio or 1 written exam (120 min) or 1 oral exam (30 min) or 1 term paper oder 1 presentation oder 1 term paper & 1 presentation oder 1 Take-at-Home-Exam		
Course achievement			
Examination language	english		

Contents

Principles of Strategy & Entrepreneurship
In our research-oriented master-level course “Principles of Strategy & Entrepreneurship”, we will explore core questions of strategic management and delve into the process of new venture creation.
The course covers seven main areas:
1. Foundations: Tracing the origins of the strategy concept
2. Strategy & economics: Exploring the influence of economics on the notion of strategy
3. Strategy making: Understanding different perspectives on the strategy formation process
4. Competitive strategies: Learning about strategy in competitive settings
5. Cooperative strategies: Examining strategy in cooperative settings
6. Strategic entrepreneurship: Getting familiarized with strategy perspectives on new venture creation
7. Digital strategy: Delving into digital platform strategies.

Strategic Innovation Management
The master-level course “Strategic Innovation Management” offers participants a holistic guideline through the process of innovation management. The course content spans topics such as strategy development, the creation of innovation-focused firm cultures and leadership, and the expansion into global markets. In addition, we will explore concrete innovation strategies related to open innovation and (digital) platforms.

Objective qualification

After completing this module, students will be able to understand the processes of strategy development and innovation management and implement them in established companies and start-ups. Students also learn which criteria to apply when choosing a suitable strategy and how they can drive innovation processes on this basis. These skills not only prepare participants for future research-related work (e.g. Master's theses, doctorates), but also for career opportunities in management consulting, strategy departments, corporate development, innovation departments and start-ups.

Literature

wird zu Beginn der Veranstaltung bekanntgegeben.

↑

Related courses			
Rules for the choice of courses			
1 course of your choice			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Principles of Strategy & Entrepreneurship	4,0	Lecture/Exercise	english
Literature			
will be announced at the beginning of the course			
Strategic Innovation Management	4,0	Lecture/Exercise	english
Literature			
will be announced at the beginning of the course			

Interdisciplinary elective field Communication Networks

Title	Advanced Topics in Mobile Radio Systems		
Number	2424510	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Thomas Kürner
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Oral exam (20 min) or written exam (90 min)		
Course achievement	Short presentation during exercise class		
Examination language	english		

Contents

- Current topics in mobile radio systemes
- Multi antenna systems (MIMO)
- OFDM-systems
- Ultra wide band communication
- mm-/sub-mm wave communication

Objective qualification

Students acquire in-depth knowledge in selected areas of mobile communications that are relevant to issues in research, development or implementation. After completing the module, students will be able to analyse current research contributions in the field of mobile communications, prepare and present them in a way that is understandable to third parties and use the findings for their own research activities.

Literature

- lecture notes
- A. Molisch, Wireless Communications, Addison-Wesley 2005
- S. Haykin, M. Moher, Modern Wirless Communications, Pearson 2005
- up-to-date magazine articles

Remark

The lecture comprises five independent parts; they might be replaced by further up-to-date parts.

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
	2,0	Lecture	english
Literature			
- Skript - A. Molisch, Wireless Communications, Addison-Wesley 2005 - S. Haykin, M. Moher, Modern Wireless Communications, Pearson 2005 - aktuelle Zeitschriftenaufsätze			

	1,0	Exercise	english
Literature			
siehe Vorlesung			

Title	Advanced Topics in Telecommunications		
Number	2416540	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Admela Jukan
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
# G. Camarillo, M. García-Martín, The 3G IP Multimedia Subsystem (IMS): Merging the Internet and the Cellular Worlds, John Wiley & Sons, 2004, ISBN: 978-0-470-87156-0 # F. Travostino, J. Membretti, G. Karmous-Edwards (Eds.), Grid Networks: Enabling Grids with Advanced Communication Technology, John Wiley & Sons, 2006, ISBN: 978-0-470-01748-7 # K. M. Sivalingam and T. Znati (Eds), Wireless Sensor Networks, Kluwer Academic Publishers, 2005, ISBN: 978-1-4020-7883-5			

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

	2,0	Lecture	english
Literature			
Include latest research papers, tutorials and industrial standards			

	1,0	Exercise	english
Literature			
Include latest research papers, tutorials and industrial standards			

Title	Information Technologies for Social Good		
Number	2416720	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Admela Jukan
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	oral exam (30 min) or written exam (90 min)		
Course achievement			
Examination language	english		

Contents

Disaster management of critical IT infrastructures
Prediction and information models for disaster management
Communication network systems for first responders
Bridging the digital divide
Low cost network systems for developing countries
Social networking for social good
IT systems to address climate change
Fundamentals of privacy and anonymity
Cryptography and privacy
Green farming
Smart farm animals
Technologies for domestic animals
Technologies for wild animals and preservation

Objective qualification

This class is designed for students who are interested in studying the successful deployments and the potential use of information technologies in various topics that are essential for social good, including but not limited to disaster management, broadband and digital divide, social resilience, privacy, environmental sustainability, and animal welfare.
After completion of this module the students own deep knowledge about topical research subjects in this area. They are able to analyze, assess and design upcoming systems and their respective components.

Literature

Selected scientific publications
Book: Advanced ICTs for Disaster Management and Threat Detection: Collaborative and Distributed Frameworks, Edited by Asimakopoulou, Eleana, IGI Press 2010.
Book: Smart Sensing Technology for Agriculture and Environmental Monitoring, Edited by Subhas Chandra, Springer 2012.

Book: More playful user interfaces, Interfaces that Invite Social and Physical Interactions, Edited by Anton Nijholt, Springer 2015.
Remark
Prerequisites: The students are expected to have already taken courses in networking and in particular in the architecture and protocols in the Internet, broadband networks, protocols and software engineering, as well as communication technologies, such as fiber, traditional wireline and wireless networks.

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	1,0	Exercise	english
	2,0	Lecture	english

Literature
Buch: Advanced ICTs for Disaster Management and Threat Detection: Collaborative and Distributed Frameworks, Edited by Asimakopoulou, Eleana, IGI Press 2010. Buch: Smart Sensing Technology for Agriculture and Environmental Monitoring, Edited by Subhas Chandra, Springer 2012. Buck: More playful user interfaces, Interfaces that Invite Social and Physical Interactions, Edited by Anton Nijholt, Springer 2015.

Title	Performance Evaluation of Communication Networks		
Number	2416580	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Admela Jukan
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 min) or oral exam (30 min), depending on number of participants		
Course achievement			
Examination language	german		

Contents

- Modeling of stochastic processes
- Theory of Markoff chains
- Processes and characteristics in communication systems
- Multiservice communication systems
- M/G/1 queueing systems and priorities
- Basics of stochastic simulation

Objective qualification

- Upon completion of this module, students will have a basic understanding of modeling stochastic processes in communication systems.
- Based on the introduced process characteristics, they are able to evaluate and compare systems, and to form their own models.

Literature

Lecture notes
L. Kleinrock, Queuing Systems - Volume I: Theory, John Wiley & Sons, New York, 1975, ISBN: 0-471-49110-1
A. Leon-Garcia: Probability and Random Processes for Electrical Engineering, Addison-Wesley, 1989, ISBN: 0-201-12906-X

Remark

Electrical Engineering: Knowledge of the content of the Statistics module is assumed.
Computer Science Minor: Recommended prior knowledge is provided in the Introduction to Stochastics module or Statistics module. Information Systems Engineering: knowledge of the content of the Statistics module is assumed.

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
	2,0	Lecture	german
Literature			
#Skript L. Kleinrock, Queuing Systems A. Leon-Garcia, Probability and Random Processes for Electrical Engineering			

	1,0	Exercise	german
Literature			
Skript L. Kleinrock, Queuing Systems A. Leon-Garcia, Probability and Random Processes for Electrical Engineering			

Title	Modelling and Simulation of Mobile Radio Systems		
Number	2424400	**Module version**	
Shorttext		**Language**	german
Frequency of offer		**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Kürner
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	oral exam (20 min) or written exam (90 min)		
Course achievement	Colloquium or lab journal		
Examination language	german		
Contents			
Objective qualification			
Literature			
Lecture notes M. C. Jeruchim, P. Balaban, K. S. Shanmugan, Simulation of Communication Systems - Modeling, Methodology and Techniques, Kluwer 2000 R. Vaughan, J. B. Andersen, Channels, Propagation and Antennas for Mobile Communications, IEE Electromagnetic Waves Series 2003 J. G. Proakis, M. Saleh, Grundlagen der Kommunikationstechnik, Pearson Studium, 2. Auflage, 2004 M. Pätzold, Mobilfunkkanäle - Modellierung, Analyse und Simulation, Vieweg 1999 O. Beucher, MATLAB und Simulink, Pearson 2002 M. Schiff, Introduction to Communications Simulation, Artech House 2006 P. Stoica, R. Moses, Spectral Analysis of Signals, Pearson 2005			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Laboratory	german
Literature			
siehe Vorlesung			
	2,0	Lecture	german
Literature			
Skript M.C.Jeruchim, P.Balaban, K.S.Shanmugan: Simulation of Communications - Modeling			

Title	Network Security		
Number	2416530	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Admela Jukan
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
# W. Adi, Vorlesungsfolien und Übungen. # William Stallings, Network Security Essentials: Applications and Standards, 3rd Edition, Prentice Hall, © 2007, ISBN-10: 0-13-238033-1 # Charlie Kaufman, Radia Perlman, Mike Speciner, Network Security: Private Communication in a Public World (2nd edition), Prentice Hall, 2002, ISBN-10: 0130460192			

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

	2,0	Lecture	german

Literature

- W. Adi, Vorlesungsfolien und Übungen. William Stallings, Network Security Essentials: Applications and Standards, 3rd Edition, Prentice Hall, © 2007, ISBN-10: 0-13-238033-1
- Charlie Kaufman, Radia Perlman, Mike Speciner, Network Security: Private Communication in a Public World (2nd edition), Prentice Hall, 2002, ISBN-10: 0130460192

	1,0	Exercise	german

Title	New Architecture and Protocols in Communication Networks		
Number	2416760	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Datentechnik und Kommunikationsnetze
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Admela Jukan
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 min) or oral exam (30 min)		
Course achievement			
Examination language	german		

Contents

- Introduction to broadband communication
- Broadband access networks
- Optical Networks
- Control and management of broadband networks
- Wireless broadband networks
- Applications of broadband networks

Objective qualification

After completing this module, students will have in-depth knowledge of architectures and signaling protocols of new architecture and protocols in advanced communication networks, including the access networks, core and backone networks, optical transport networks, wireless networks and virtual private networks, such as data center networks and campus networks. The fundamentals learned enable students to design, analyze and evaluate new protocols, services and network architectures.

Literature

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
Literature			
Include latest research papers, tutorials and industrial standards			
	1,0	Exercise	english german

Title	Planning of Terrestrial Radio Networks		
Number	2424410	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Kürner
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	Oral exam (20 minutes) or written exam (90 minutes)		
Course achievement	Colloquium or lab journal		
Examination language	german		

Contents

Introduction
Radio propagation models
Coverage planning
Planning cellular networks
General principles of cellular network planning
GSM radio network planning
UMTS radio network planning
Planning OFDMA networks

As part of the computer exercise, an introduction to the operation and handling of a radio planning tool

Objective qualification

After completing the module, students will have an understanding of the essential processes and interrelationships involved in planning terrestrial radio networks and will have acquired knowledge of the data required for this purpose and, in particular, the algorithms, models and methods used. They will be able to solve planning tasks independently using a radio planning tool.

Literature

- Lecture notes (German and Eglish)
- C. Lüders, Mobilfunksysteme, Vogel-Verlag 2001 #
- N. Geng, W. Wiesbeck, Planungsmethoden für die Mobilkommunikation, Springer-Verlag 1998
- J. Laiho, A. Wacker, T. Novosad, Radio Network Planning and Optimisation for UMTS, Wiley 2002

Remark

This Master's module is also suitable for Bachelor students.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Laboratory	german
Literature			
siehe Vorlesung			
	2,0	Lecture	german
Literature			
Skript in deutscher und englischer Sprache C.Lüders, Mobilfunksysteme, Vogel-Verlag 2001 N.Geng, W.Wiesbeck, Planungsmethoden für die Mobilkommunikation, Springer-Verlag 1998 J.Laiho, A.Wacker, T.Novosad, Radio Network Planning and Optimisation for UMTS, Wiley 2002			

Title	Self-Organizing Networks		
Number	2424580	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Thomas Kürner
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	oral exam (30 min) or written exam (90 min)		
Course achievement	Presentation in scope of exercise		
Examination language	english		

Contents

1 Motivation for SON
2 SON Overview
3 SON Functions (Self-Configuration, Self-Planning, Self-Healing, Self-Optimisation)
4 SON Operation
5 Cognitive Network Management

[Self-Organising Networks (Ü)]
(see also lecture)

The exercise takes place in the form of short presentations by the students, who present current topics in a short written report (in IEEE publication) and a 30-minute presentation.

Objective qualification

Students acquire in-depth knowledge in the areas of self-organisation and cognitive network management of mobile radio systems. After completing the module, students will be able to analyse current research contributions in the field of network management of future mobile radio systems, prepare and present them in a comprehensible way for third parties and use the findings for their own research activities.

Literature

S. Hamalainen, H- Sanneck, C. Sartori; LTE Self-Organising Networks (SON): Network Management Automation for Operational Efficiency, Wiley 2011

J. Ramiro, K. Hamied; Self-Organizing Networks (SON): Self-Planning, Self-Optimization and Self-Healing for GSM, UMTS and LTE

see lecture

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	english
Literature			
S. Hamalainen, H- Sanneck, C. Sartori; LTE Self-Organising Networks (SON): Network Management Automation for Operational Efficiency, Wiley 2011 J. Ramiro, K. Hamied; Self-Organizing Networks (SON): Self-Planning, Self-Optimization and Self-Healing for GSM, UMTS and LTE			
	1,0	Exercise	english
Literature			
siehe Vorlesung			

Interdisciplinary elective field Mechanical Engineering/Mechatronics

Title	Actuators		
Number	2538220	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Mikrotechnik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Andreas Dietzel
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	If you are particularly interested in microactuators, the modules Fundamentals of Microsystem Technology and Applications of Microsystem Technology (Master) are recommended. Please also note the introductory evening on the subject of microsystem technology and mechatronics. The students should have basic knowledge of electrical engineering and physics (at least school knowledge on advanced course level).		
Expected performance/ Type of examination	1 examination element: written exam (90 min) or oral exam (30 min)		
Course achievement			
Examination language	german		

Contents

The form of energy required to generate a mechanical output variable (= travel motion and force which can be transferred to another component) is used in this module to classify the actuator principles: Electrostatic, thermomechanical, electromagnetic, chemomechanical, etc. An actuator concept represents the concrete technical implementation of an actuator with a defined functional structure. Within the framework of the module, the function of an actuator is defined, a selection of the most important actuator principles is explained in detail and their implementation in a corresponding actuator concept is presented using examples (linear and rotary drives, actuators, valves, pumps, switches, relays, etc.). Microactuators are a focal point of the application examples.

Objective qualification

The students are able to distinguish a total of 12 different physical actuator principles with regard to their functionality and their application-specific properties and can draw conclusions about their possible applications. The students can define an actuator, describe the actuator principles and derive the factors influencing the actuator forces and actuator travel from the given mathematical equations. They are able to construct actuator concepts with a basic function (positioning movement). In addition, they can use the scaling laws to calculate how the power density and other characteristics of actuator principles behave when scaling and determine the consequences of this.

Literature

- S. Büttgenbach, I. Constantinou, A. Dietzel, M. Leester-Schädel, Case Studies in Micromechatronics, Springer 2020, ISBN 978-3-662-61319-1
- H. Janocha: Adaptronics and Smart Structures. Springer, 2nd ed. 2007, ISBN 3-540-71965-2
- H. Janocha: Aktoren; Grundlagen und Anwendung. Springer, 1992, ISBN 3-540-54707-X
- H. Janocha: Actuators, Springer, 2004, ISBN 3-540-61564-4
- Jendritza: Technischer Einsatz Neuer Aktoren. Expert Verlag, ISBN 3-8169-1235-4

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	2,0	Lecture	german
	1,0	Exercise	german

Title	Control Engineering 2		
Number	2539000030	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Intermodale Transport- und Logistiksysteme
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Jürgen Pannek
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 examination element: written exam (90 min) or oral exam (30 min)		
Course achievement			
Examination language	english		

Contents

- Design of complex control loops, substitute control loops, feedback, cascade control, feedforward control
- Multivariable systems, decoupling
- Nonlinear control systems, two- and three-point controllers
- State space description
- Time-optimal control systems
- Digital control systems

Objective qualification

After completing the lecture Control Engineering 2, the students have a sound basic knowledge in the field of linear control engineering and are familiar with some nonlinear methods and means of description from the field of nonlinear control engineering, as well as individual elements for the implementation of these methods. They have methodological knowledge for dealing with complex, networked systems and can apply the most important procedures for the description and control of such systems.

Literature

- Lunze, J.: Regelungstechnik 1: Systemtheoretische Grundlagen, Analyse und Entwurf einschleifiger Regelungen, Springer-Verlag, 2016, Berlin u.a., 11., überarbeitete und ergänzte Auflage, ISBN 978-3-662-52678-1
- Lunze, J.: Regelungstechnik 2: Mehrgrößensysteme, Digitale Regelung, Springer-Verlag, 2016, Berlin u.a., 9., überarb. Auflage, ISBN 978-3-662-52676-7
- Leonhard, W.: Einführung in die Regelungstechnik, Vieweg-Verlag, 1990, Braunschweig, 5. Auflage, ISBN 3-528-43584-4
- Schnieder, E.; Leonhard, W.: Aufgabensammlung zur Regelungstechnik, Vieweg-Verlag, 1983, Braunschweig, ISBN 3-528-03037-2

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

Title	Introduction to Metrology		
Number	2511360	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Produktionsmesstechnik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Rainer Tutsch
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	written exam, 150 minutes		
Course achievement			
Examination language	german		

Contents

Metrology in mechanical engineering, essential terms and definitions, traceability, SI units, labour agreements of the unity system, measuring signals and methods, measurement uncertainty and its causes, statistical methods in metrology (e.g. error propagation, linear regression, analysis of variance, t-test, chi-squared-test), handling of measurement signals, selected measuring tasks and concrete examples from industrial measurement technology.

Objective qualification

The students are familiar with the basics of measurement technology. That contains issues concerning preparations of the measurement and its realization as well as the evaluation and interpretation of the measured data.
The students are able to recognize and avoid or at least minimize possible error sources by understanding the interactions between measuring device, measuring object, environment and user. Beyond that, they can handle the measured data, in particular statistic methods enabling them to test the validity of data and to estimate a measurement uncertainty. Furthermore, the students get an overview of state-of-the-art metrology techniques determining variables in process monitoring and quality control.

Literature

1. P. Profos, T. Pfeifer (Hrsg.): Grundlagen der Meßtechnik. 5., überarb. Aufl., München [u.a.]: Oldenbourg, 1997, ISBN: 3-486-24148-6
2. H.-J. Gevatter, U. Grünhaupt: Handbuch der Mess- und Automatisierungstechnik in der Produktion, Springer Verlag, 2006, ISBN: 978-3-540-21207-2
3. Vorlesungsskript

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	1,0	Exercise	german
Literature			
Metrology in mechanical engineering, essential terms and definitions, traceability, SI units, labour agreements of the unity system, measuring signals and methods, measurement uncertainty and its causes, statistical methods in metrology (e.g. error propagation, linear regression, analysis of variance, t-test, chi-squared-test), handling of measurement signals, selected measuring tasks and concrete examples from industrial measurement technology.			
	2,0	Lecture	german

Title	Applied Electronics		
Number	2538000000	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Mikrotechnik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Andreas Dietzel
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	The students are picked up from school (physics) by their level of knowledge. At the beginning of the course, the school knowledge is repeated at the advanced level and is deepened and supplemented in the further course.		
Expected performance/ Type of examination	written exam (90 min) or oral exam (30 min)		
Course achievement			
Examination language	german		

Contents

Starting with an introduction to electronic components, linear networks are analyzed initially. Building on this, the field is expanded to include complex AC calculations, focusing on passive filters and resonant circuits. Furthermore, the construction and operation of semiconductor components such as diodes and transistors are introduced, along with their basic circuits. The emphasis on sensor technology covers various bridge circuits and signal amplification using operational amplifier circuits. This includes an in-depth discussion of key basic circuits such as inverting and non-inverting amplifiers, differentiators, and integrators. Finally, a brief introduction to digital circuitry is provided, using examples of logic components such as flip-flops and gates.

Objective qualification

Students are able to name and describe all basic passive electrical components and to design their application. With the help of the given mathematical equations they are able to design, calculate and evaluate basic electronic circuits, starting with linear networks, passive filters and resonant circuits, rectifier and transistor circuits up to operational amplifiers.

Literature

U. Tietze, Ch. Schenk: Halbleiterschaltungstechnik, Springer, 12. Aufl. 2002, ISBN 3-540-42849-6

R. Kories, H. Schmidt-Walter: Taschenbuch der Elektrotechnik, Verlag Harri Deutsch, 7. Aufl. 2006, ISBN 978-3-8171-1793-2

E. Hering, K. Bressler, J. Gutekunst: Elektronik für Ingenieure und Naturwissenschaftler, Springer, 5. Aufl. 2005, ISBN 978-3-540-24309-0

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Applied Electronics	2,0	Lecture	german
Applied Electronics	1,0	Exercise	german

Title	Finite Element Methods		
Number	2529310	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinen-bau
Module duration	1	**Institution**	Institut für Mechanik und Adaptronik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Markus Böl
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examina-tion	written exam (120 min) or oral exam (60 min) in groups		
Course achievement			
Examination language	german		

Contents

- strong/weak form, method of weighted residuals
- local/global shape functions
- 1D elements (beam elements)
- 2D elements (quadrilateral elements, triangular elements)
- Numerical integration
- assembly of element matrix and load vector
- Variational principles
- Modal analysis, numerical time integration schemes

Objective qualification

After completing the course attendees will be able to describe the basics of the finite element method and calculate deformations using the taught elements. Shape functions can be selected with regard to the mathematical problem. Students can solve engineering motivated problems of elastostatics and heat con-duction.

Literature

O.C. Zienkiewicz & R.L. Taylor, The Finite Element Method (2 volumes), Buttherworth / Heinemann, Oxford u.a., 2000

J. Fish & T. Belytschko, A First Course in Finite Elements, John Wiley & Sons Ltd, 2007

T.J.R. Hughes, The Finite Element Method, Dover Publications, 2000

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Modelling of Mechatronic Systems		
Number	2540310	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinen-bau
Module duration	1	**Institution**	Institut für Akustik und Dynamik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Michael Müller
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	Requirements: No special requirements		
Expected performance/ Type of examina-tion	Written exa (90 min) or oral exam (30 min)		
Course achievement			
Examination language	german		

Contents

Hamilton's Principle, Lagrange's equation of the second kind, Modeling of discrete mechanical systems, Analogies between mechanics and electrical systems, Modeling of discrete electrical systems, Modeling of mechatronic systems, actuators and sensors, Lagrange's equation of the first kind, constraint forces

Objective qualification

Students are able to apply a uniform approach to mathematically description of the dynamics of mechanical (multi-body) systems, electrical networks and mechatronic (electromechanical) systems. The use of different types of constraints can also be analysed and evaluated with regard to their solution behaviour. They can formulate and analyze equations of motion of selected mechatronic systems. They are thus able to indepen-dently develop and evaluate problem-adapted models for mechatronic problems.

Literature

- D. A. Wells, Lagrangian Dynamics, Schaum's Outlines, 1967
- R. H. Cannon, Dynamics of Physical Systems, Mc Graw Hill, 2003
- B. Fabian, Analytical System Dynamics, Springer, 2009

Remark

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Principles of Adaptronics		
Number	2510250	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Mechanik und Adaptronik
Hours per Week / ECTS	3 / 5,0	**Module owner**	
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	Technical mechanics, engineering mathematics, materials science, control engineering, functional materials for mechanical engineering		
Expected performance/ Type of examination	1 Examination element: written exam (120 min) or oral exam (30 min)		
Course achievement			
Examination language	german		

Contents

- Goals of adaptronics
- elements of adaptive structures and systems
- functional materials - electromechanical transducers
- functional materials - thermomechanical transducers
- integration of structural materials
- target field of shape control
- oscillations of discrete systems
- oscillations of continuous systems
- target field of vibration suppression
- basics of acoustics
- target field of sound reduction
- target field of integrated structure monitoring
- control principles of adaptive systems
- examples of applications.

Objective qualification

After completing the module, students will be able to describe the basic principles of multifunctional materials and their application.
Based on experimental investigations, discussion of the results and subsequent modelling, the ability to design adaptronic concepts and integrate them into mechanical structures emerges.
The students can explain the target fields of adaptronics - shape control, vibration suppression, sound reduction and structure monitoring - and design the first small applications.

Literature

- D. Jenditza et al; Technischer Einsatz Neuer Aktoren; expert Verlag, Renningen-Malmsheim; 1998; ISBN 3-8169-1589-2

- H. Janocha; Adaptronics and Smart Structures; Springer-Verlag, Berlin Heidelberg New York; 1999; ISBN 3-540-61484-2
- W. Elspass, M. Flemming; Aktive Funktionsbauweisen; Springer-Verlag, Berlin Heidelberg New York; 1998; ISBN 3-540-63743-5
- R. Gasch, K. Knothe; Strukturdynamik; Springer-Verlag, Berlin Heidelberg New York; 1989; ISBN 3-540-50771-X
- L. Cremer, M. Heckl; Körperschall; Springer-Verlag, Berlin Heidelberg New York; 1996; ISBN 3-540-54631-6
- H. Henn et al; Ingenieursakustik; Verlag Vieweg, Braunschweig Wiesbaden; 2001; ISBN 3-528-28570-2

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

Title	Simulation of Mechatronic Systems		
Number	2539000010	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Intermodale Transport- und Logistiksysteme
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Jürgen Pannek
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	Digital Tools, Modelling of Mechatronic Systems		
Expected performance/ Type of examination	1 examination achievement: written exam+ (90 min.) or oral examination+ (30 min)		
Course achievement	1 course achievement (facultative): Creation and documentation of a computer or software program (on application, the result of the course achievement can account for up to 20% of the grade of the written exam+/oral exam+) The application must be submitted to the examiner before the start of the exam+.		
Examination language	english		

Contents

- Elements of the simulation of dynamic systems
- mathematical methods linear, nonlinear systems
- numerical methods: eigenvalue calculation, numerical integration, sensitivity
- software methods: OOP (C++), program structures for simulation
- Windows with plot and other representations, animation

Objective qualification

After having successfully completed the lecture Simulation of Mechatronic Systems, students are able to define numerical methods for dynamical systems, transfer them to simulations and apply them. The students can specify and explain the parametrization and processing of results as well as the use of simulation in applications. In addition, they understand and are able to apply an agile software development process with object-oriented programming in C++. They can define requirements, derive test cases, automate testing and implement a continuous integration and development.

Literature

1. P. Deuflhard, D. Bornemann: Scientific computing with ordinary differential equations, 2012, Springer
2. M. Glöcker, Simulation mechatronischer Systeme - Grundlagen und technische Anwendung, 2014, Springer
3. B. Zeigler, Theory of Modeling and Simulation - Discrete Event & Iterative System Computational Foundations, Third edition, 2019, Elsevier

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	english
Literature			
A. Willms, C++, Einstieg für Anspruchsvolle, Addisson-Wesley R.Kaiser, C++ mit dem Borland C++Builder 2007 G. Wolmeringer, Coding for Fun, IT-Geschichte zum Nachprogrammieren, Galileo Computing			
	2,0	Exercise	english

Interdisciplinary elective field Mechanical Medicine

Title	Clinical Course 1		
Number	4217000050	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Deserno
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or term Paper or presentation or creation and documentation of computer programs or experimental work or portfolio or Take-Home-Exam.		
Course achievement			
Examination language	german		

Contents

Objective qualification

Literature

- Engberding R. Untersuchungstechniken in der Echokardiographie. Springer Verlag Berlin 1989; ISBN-10: 3540503277, ISBN-13: 978-3540503279

- Effert S, Hanrath P, Bleifeld W, Keutel J. Echokardiographie. Springer-Verlag Berlin, 1979; ISBN-10: 3540091661, ISBN 13: 978-3540091660

- Kunert M, Ulbricht L. Praktische Echokardiographie: Lehrbuch und DVD mit Video-Atlas. Deutscher Ärzte-Verlag, 3. Auflage: 2010; ISBN-10: 3769112636, ISBN-13: 978-3769112634

Roos-Pfeuffer B. Klinische Prüfung von Medizinprodukten: Ein Kommentar zu DIN EN ISO 14155. Beuth Verlag, 2015, ISBN-10: 3410241531, ISBN-13: 978-3410241539

Schumacher M. Methodik Klinischer Studien: Methodische Grundlagen der Planung, Durchführung und Auswertung (Statistik und ihre Anwendungen). Springer Verlag 2008, ISBN-10: 3540851356, ISBN-13: 978-3540851356

Gaus W, Chase D. Klinische Studien: Regelwerke, Strukturen, Dokumente, Daten. DVMD Verlag 2008, ISBN-10: 3833472227, ISBN-13: 978-3833472220

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
	2,0	Course	german

Literature

- Sucaet Y, Waelput W. Digital Pathology – Springer Briefs in Computer Science, Springer-Verlag, Berlin, 2014, ISBN-10: 3319087797, ISBN-13: 978-3319087795 - Pantanowitz L, Parwani A (eds). Digital Pathology. Verlag: ASCP Press. Juni 2017. ISBN-10: 0891896104, ISBN-13: 978-0891896104 - Kaplan KJ, Rao LKF (eds). Digital Pathology: Historical Perspectives, Current Concepts & Future Applications. Springer-Verlag, Berlin; 1st ed. 2016, ISBN-10: 9783319203782, ISBN-13: 978-3319203782 - Hufnagl P, Zwönitzer R, Haroske G. Bundesverband Deutscher Pathologen e.V. (eds). Leitfaden Digitale Pathologie in der Diagnostik – Befunderstellung an digitalen Bildern. Version 1.0, März 2018, https://www.pathologie.de/?eID=downloadtool&uid=1734 - Pathologie. Werner Böcker, Helmut Denk, Philipp U Heitz, Holger Moch, Gerald Höfler, Hans Kreipe (Herausgeber); 2012 | 5. Auflage ; Urban & Fischer in Elsevier (Verlag) 978-3-437-42384-0 (ISBN) - Neuropathology. Ellison D, Love S; Elsevier Ltd, Oxford; Auflage: 3rd Edition. (20. Dezember 2012) ISBN-10: 0723435154 ISBN-13: 978-0723435150 - ICD-11 for Mortality and Morbidity Statistics; WHO - WHO Classification of Tumours of the Digestive System 5th Edition, Volume 1

Sonography	1,0	Lecture	german

Literature

- Engberding R. Untersuchungstechniken in der Echokardiographie. Springer Verlag Berlin 1989; ISBN-10: 3540503277, ISBN-13: 978-3540503279

- Effert S, Hanrath P, Bleifeld W, Keutel J. Echokardiographie. Springer-Verlag Berlin, 1979; ISBN-10: 3540091661, ISBN 13: 978-3540091660

- Kunert M, Ulbricht L. Praktische Echokardiographie: Lehrbuch und DVD mit Video-Atlas. Deutscher Ärzte-Verlag, 3. Auflage: 2010; ISBN-10: 3769112636, ISBN-13: 978-3769112634

	1,0	Exercise	german

Title	Clinical Course 2		
Number	4217000060	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Thomas Deserno
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or term Paper or presentation or creation and documentation of computer programs or experimental work or portfolio or Take-Home-Exam.		
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			

- Kaplan, K. , Rao, L. (Eds.)(2016): Digital Pathology: Historical Perspectives, Current Concepts & Future Applications. Springer-Verlag. ISBN-13: 978-3319203782.

- Sucaet, Y., Waelput, W. (2014): Digital Pathology. Springer Verlag. ISBN-13: 978-3319087795.

- Pantanowitz, L. (Ed.) (2012): Pathology Informatics: Theory and Practice. American Society of Clinical Pathologists Press. ISBN-13: 978-0891895831.

- Wu, Q., Merchant, F., Castleman, K. (2008): Microscope Image Processing. Elsevier. ISBN-13: 978-0123725783.

- Sinard, J. (2006): Practical Pathology Informatics: Desmystifying informatics for the practicing anatomic pathologist. ISBN-13: 978-0387280578.

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
Robotic surgery	3,0	Lecture	german

Literature

1 Avgousti, S. et al. Medical telerobotic systems: current status and future trends. Biomed Eng Online 15, 96, doi:10.1186/s12938-016-0217-7 (2016).
2 Camarillo, D. B., Krummel, T. M. & Salisbury, J. K., Jr. Robotic technology in surgery: past, present, and future. Am J Surg 188, 2S-15S, doi:10.1016/j.amjsurg.2004.08.025 (2004).
3 Catchpole, K. R. et al. Diagnosing barriers to safety and efficiency in robotic surgery. Ergonomics 61, 26-39, doi:10.1080/00140139.2017.1298845 (2018).
4 George, L. C., O'Neill, R. & Merchant, A. M. Residency Training in Robotic General Surgery: A Survey of Program Directors. Minim Invasive Surg 2018, 8464298, doi:10.1155/2018/8464298 (2018).
5 Kearns, J. T. & Gundeti, M. S. Pediatric robotic urologic surgery-2014. J Indian Assoc Pediatr Surg 19, 123-128, doi:10.4103/0971-9261.136456 (2014).
6 Lanfranco, A. R., Castellanos, A. E., Desai, J. P. & Meyers, W. C. Robotic surgery: a current perspective. Ann Surg 239, 14-21, doi:10.1097/01.sla.0000103020.19595.7d (2004).
7 Mullen, M. G. et al. Declining Operative Experience for Junior-Level Residents: Is This an Unintended Consequence of Minimally Invasive Surgery? J Surg Educ 73, 609-615, doi:10.1016/j.jsurg.2016.02.010 (2016).
8 Tan, A. et al. Robotic surgery: disruptive innovation or unfulfilled promise? A systematic review and meta-analysis of the first 30 years. Surg Endosc 30, 4330-4352, doi:10.1007/s00464-016-4752-x (2016).
9 Wottawa, C. R. et al. Evaluating tactile feedback in robotic surgery for potential clinical application using an animal model. Surg Endosc 30, 3198-3209, doi:10.1007/s00464-015-4602-2 (2016).
10 Ahmad, N. et al. Ambulatory movements, team dynamics and interactions during robot-assisted surgery. BJU Int 118, 132-139, doi:10.1111/bju.13426 (2016).
11 PwC. What doctor? Why AI and robotics will define New Health. https://www.pwc.com/gx/en/industries/healthcare/publications/ai-robotics-new-health.html, 1-32 (2017).
12 Frost&Sullivan. Transforming healthcare through artificial intelligence systems. AI health and life sciences, 1-19 (2016).
13 Tiferes, J. et al. in Proceedings of the Human Factors and Ergonomics Society Annual Meeting Vol. 60 518-522 (SAGE Journals, 2016).
14 Vitiello, V., Lee, S. L., Cundy, T. P. & Yang, G. Z. Emerging robotic platforms for minimally invasive surgery. IEEE Rev Biomed Eng 6, 111-126, doi:10.1109/RBME.2012.2236311 (2013).

Title	Medical Methodology Course 1		
Number	4217000070	**Module version**	V1
Shorttext		**Language**	english german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Deserno
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	graded work: oral exam (30 minutes) or development and documentation of computer programs or Portfolio or Take-Home-Exam		
Course achievement			
Examination language	english german		

Contents

The module focus on several examples, all taken from IT-supported clinical research and medical trials.

Objective qualification

Passing this module, the students develop a fundamental understanding for methodological aspects of medical informatics. They can plan and conduct scientific studies and can develop novel research projects in the field of electronic health. The students can use, compare, and evaluate specific IT tools in medical informatics. They know about data privacy and security issues for medical data in Europe.

Literature

- Roos-Pfeuffer, B.: Klinische Prüfung von Medizinprodukten: Ein Kommentar zu DIN EN ISO 14155. Beuth Verlag, 2015. ISBN-13: 978-3410241539

- Schumacher, M.: Methodik Klinischer Studien: Methodische Grundlagen der Planung, Durchführung und Auswertung (Statistik und ihre Anwendungen). Springer Verlag, 2008. ISBN-13: 978-3540851356.

- Gaus, W., Chase, D.: Klinische Studien: Regelwerke, Strukturen, Dokumente, Daten. DVMD Verlag, 2008. ISBN-13: 978-3833472220

- Johner, C., Hölzer-Klüpfel, M., Wittorf, S.: Basiswissen Medizinische Software. Aus- und Weiterbildung zum Certified Professional for Medical Software. Dpunkt Verlag Heidelberg. 2. Auflage, 2015. ISBN-13: 978-3864902307.

- Schneider, UK: Sekundärnutzung klinischer Daten: Rechtliche Rahmenbedingungen. Medizinisch Wissenschaftliche Verlagsgesellschaft, 2015. ISBN-13: 978-3954661428.

- Jäschke, T. (Hrsg.): Datenschutz im Gesundheitswesen: Grundlagen, Konzepte, Umsetzung. Medizinisch Wissenschaftliche Verlagsgesellschaft, 2016. ISBN-13: 978-3954662210.

- IT-Reviewing Board der TMF (Hrsg.): IT-Infrastrukturen in der patientenorientierten Forschung. Aktueller Stand und Handlungsbedarf 2015. TMF, 2016. ISBN-13: 978-389838-7101.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Clinical Research Methodology	4,0	Lecture/Exercise	english german

Literature

• Roos-Pfeuffer B. Klinische Prüfung von Medizinprodukten: Ein Kommentar zu DIN EN ISO 14155. Beuth Verlag, 2015, ISBN-10: 3410241531, ISBN-13: 978-3410241539 • Schumacher M. Methodik Klinischer Studien: Methodische Grundlagen der Planung, Durchführung und Auswertung (Statistik und ihre Anwendungen). Springer Verlag 2008, ISBN-10: 3540851356, ISBN-13: 978-3540851356 • Gaus W, Chase D. Klinische Studien: Regelwerke, Strukturen, Dokumente, Daten. DVMD Verlag 2008, ISBN-10: 3833472227, ISBN-13: 978-3833472220 • Johner C, Hölzer-Klüpfel M, Wittorf S. Basiswissen Medizinische Software. Aus- und Weiterbildung zum Certified Professional for Medical Softare. Dpunkt Verlag Heidelberg, 2. Auflage 2015; ISBN-13: 978-3864902307 • Schneider UK. Sekundärnutzung klinischer Daten: Rechtliche Rahmenbedingungen. Medizinisch Wissenschaftliche Verlagsgesellschaft 2015; ISBN-13: 978-3954661428 • Jäschke T. (Hrsg). Datenschutz im Gesundheitswesen: Grundlagen, Konzepte, Umsetzng. Medizinisch Wissenschaftliche Verlagsgesellschaft 2016; ISBN-13: 978-3954662210 • IT-Reviewing Board der TMF (Hrsg). IT-Infrastrukturen in der patientenorientierten Forschung. Aktueller Stand und Handlungsbedarf 2015. TMF 2016; ISBN-13: 978-389838-7101

Title	Medical Methodology Course 2		
Number	4217000080	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Thomas Deserno
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or term Paper or presentation or deveplopment and documentation of computer programs or experimental work or portfolio or Take-Home-Exam.		
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
wird in der Lehrveranstaltung bekannt gegeben			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Smart Living	2,0	Lecture	german
Literature			
will be announced in the course			
Smart Living	1,0	Exercise	german

Interdisciplinary elective field Philosophy

Title	Formal Logic		
Number	4299800	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät Fakultät für Geistes- und Erziehungswissenschaften
Module duration	1	**Institution**	
Hours per Week / ECTS	2 / 4,0	**Module owner**	Prof. Dr. Nicole Karafyllis
Workload (h)	120		
Class attendance (h)	28	**Self studying (h)**	92
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or Take-Home-Exam.		
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
- Tugendhat, Ernst; Wolf, Ursula. Logisch-semantische Propädeutik. Reclam 1986. - Zoglauer, Thomas: Einführung in die formale Logik für Philosophen. Vandenhoeck & Ruprecht 2008 (4. Aufl.)			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

	2,0	Seminar	german

Literature

Primärliteratur:

- Beckermann, A., Einführung in die Logik. Berlin: de Gruyter 2014.
- Hardy, J. and Schamberger, C., Logik der Philosophie: Einführung in die Logik und Argumentationstheorie. UTB 2017.
- Tetens, H., Philosophisches Argumentieren: eine Einführung. München: C.H. Beck 2010.
- Tugendhat, E. und Wolf, U., Logisch-semantische Propädeutik, Stuttgart: 1983.
- Zoglauer, T., Einführung in die formale Logik für Philosophen. UTB, 2016.
- Wessel, H., Logik, Berlin, Logos-Verlag 1986.
- Aristoteles: Die Kategorien. Griechisch/Deutsch, herausgegeben und übersetzt von Ingo W. Rath. Stuttgart: Reclam 1998.

	2,0	Tutorial	german

Title	Philosophy for the Engineering Sciences (3)		
Number	4299720	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät Fakultät für Geistes- und Erziehungswissenschaften
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Nicole Karafyllis
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (20 minutes) or term Paper or term Paper (10-15 pages) or Take-Home-Exam.		
Course achievement			
Examination language	german		

Contents
Objective qualification
Literature
- Nagel, Thomas: Was bedeutet das alles? Eine ganz kurze Einführung in die Philosophie. Reclam 2010. - Hübner, Johannes: Einführung in die theoretische Philosophie. Metzler 2015.

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
	2,0	Lecture/Exercise	german

Title	Philosophy for the Engineering Sciences (4)		
Number	4299730	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät Fakultät für Geistes- und Erziehungswissenschaften
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Hans-Christoph Schmidt am Busch
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (20 minutes) or term Paper or term Paper (10-15 pages) or Take-Home-Exam.		
Course achievement			
Examination language	german		

Contents
Objective qualification
Literature
- Quante, Michael. Einführung in die Allgemeine Ethik. WBG 2013 (4. Aufl.). - Celikates, Robin; Gosepath. Stefan. Grundkurs Philosophie. Band 6. Reclam 2013.

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
	2,0	Seminar	german

	2,0	Block course	german

Literature

Primärliteratur:

- #Strawson, Peter F.: Freedom and Resentment/Freiheit und Groll. Englisch/Deutsch. Stuttgart: Reclam 2024.

Einführende Literatur:

- #Keil, Geert: Willensfreiheit und Determinismus. Stuttgart: Reclam. 2. Überarbeitete Auflage 2018;
- An der Heiden, Uwe/Schneider, Helmut (Hrsg.): Hat der Mensch einen freien Willen? Die Antworten der großen Philosophen. Stuttgart: Reclam 2007.

Weitere Literatur wird in der Veranstaltung bekannt gegeben.

	2,0	Lecture/Exercise	german

Interdisciplinary elective field Psychology

Title	Introduction to Psychology		
Number	17119920	**Module version**	2025
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Lebenswissenschaften
Module duration	1 Semester	**Institution**	Institut für Psychologie
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Mark Vollrath
Workload (h)	180		
Class attendance (h)	60	**Self studying (h)**	120
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
Wird in den Veranstaltungen bekannt gegeben.			

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	2,0	Lecture	german

Title	Introduction to Psychology		
Number	17119930	**Module version**	2025
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Lebenswissenschaften
Module duration	1 Semester	**Institution**	Institut für Psychologie
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Mark Vollrath
Workload (h)	180		
Class attendance (h)	60	**Self studying (h)**	120
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
Wird in den Veranstaltungen bekannt gegeben.			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	2,0	Lecture	german
Literature			
Wird in der Lehrveranstaltung bekannt gegeben.			

Title	Introduction to Psychology		
Number	17119940	**Module version**	2025
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Lebenswissenschaften
Module duration	1 Semester	**Institution**	Institut für Psychologie
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Mark Vollrath
Workload (h)	180		
Class attendance (h)	60	**Self studying (h)**	120
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
Wird in den Veranstaltungen bekannt gegeben.			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	2,0	Lecture	german

Interdisciplinary elective field Spaceflight Technology

Title	Spaceflight Propulsion		
Number	2514490	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Raumfahrtsysteme
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Simona Silvestri
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	A basic understanding of physical and mathematical relationships is recommended.		
Expected performance/ Type of examination	1 examination element: written exam (120 min) or oral exam (45 min)		
Course achievement			
Examination language	english		

Contents

- Functionality, performance, advanced state of construction, as well as the calculation and examination methods of chemical propulsion systems.
- Fundamentals of fluidstream, combustion and heat transfer in chemical rocket engines.
- Categorization and characterization of fuels (fuels and oxidizers) for solid, liquid and hybrid rocket engines.
- The main subsystems of a chemical rocket engine, for example, pressure gas-transport system, turbo pump units, injection systems for gaseous and liquid fuels, combustion chambers and outlet nozzles, ignition and cooling systems.
- Rules for safe handling of rocket propellants and experimental test systems.

Objective qualification

The students can describe the functioning of space propulsion and define advanced design methods. They are able to describe calculation and investigation methods and to explain their application. They can apply the fundamentals of fluid mechanics and calculate combustion and heat transfer processes. They learn to calculate the characteristic quantities of rocket engines and apply them to experimental techniques. They are able to design propulsion systems. They are capable of carrying out tests with chemical rocket engines, considering safety measures.

Literature

- George P. Sutton, Oscar Biblarz, Rocket Propulsion Elements, Wiley, 8 edition, February 2, 2010.
- Martin J. L. Turner, Rocket and Spacecraft Propulsion: Principles, Practice and New Developments, Springer Praxis Books / Astronautical Engineering, Springer, 3rd ed. edition, November 23, 2010.

- M. Chiaverini, Pennsylvania State University and K. Kuo, Fundamentals of Hybrid Rocket Combustion and Propulsion, Progress in Astronautics and Aeronautics, AIAA, 1st edition, March 15, 2007.

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Related courses			
Rules for the choice of courses			
Lecture and exercise must be occupied.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Spaceflight Propulsion	2,0	Lecture	english
Spaceflight Propulsion	1,0	Exercise	english

Title	Spaceflight Technology - Missions		
Number	2514040	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Raumfahrtsysteme
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Simona Silvestri
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	A basic understanding of physical and mathematical relationships is recommended.		
Expected performance/ Type of examination	1 examination element: Written exam (120 min) or oral exam (45 min)		
Course achievement			
Examination language	german		

Contents

- Basics of orbital mechanics: equation of motion and Kepler orbits, elliptical orbits, orbit transfers.
- Satellite orbits in space: launch sites and possible orbits, calculation of satellite ground tracks, types of satellite ground tracks.
- Perturbation theories of satellite orbits: perturbations due to perturbing forces components, method of varying the orbital elements as a function of time.
- Perturbations of satellites in Earth orbits: Earth's gravitational potential, technically relevant gravitational perturbations, aerodynamic perturbations, orbital lifetime, perturbation on the geostationary orbit, solar radiation pressure.

Objective qualification

Students can name the orbital elements and describe simple orbits. They can describe the orientation of these orbits in space depending on the launch site and explain the possible inclinations. They can apply this understanding to the calculation of the required launch azimuth taking into account the earth's rotation. They are able to analyze the ground-track of satellite orbits. They can assess the effects of perturbing accelerations on the temporal changes of the orbital elements. They are able to develop algorithms to take into account technically relevant orbit perturbations. The students have knowledge of the physical principles of earthbound satellite orbits under the influence of the most important perturbations. They are able to determine the influence of perturbing forces and uncertainties in the prediction of satellite orbits.

Literature

- D.G. King-Hele, Satellite Orbits in an Atmosphere: Theory and application, Springer, 1 edition (December 31, 1987), ISBN-10: 0216922526.
- Vladimir A. Chobotov, Orbital Mechanics (AIAA Education Series), AIAA (American Institute of Aeronautics & Ast, 3. edition (May 2002), ISBN-10: 1563475375.
- Pedro Ramon Escobal, Methods of Orbit Determination, Krieger Pub Co, 2nd edition (October 1976), ISBN-10: 0882753193.

- David A. Vallado, Fundamentals of Astrondynamics and Applications, Microcosm Press, Hawthorne, CA and Springer, New York, NY, 2007.
- Oliver Montenbruck, Eberhard Gill, Satellite Orbits - Models Methods Applications, Springer-Verlag, Berlin Heidelberg 2000.
- John P. Vinti, Orbital and Celestial Mechanics, in: Progress in Astronautics and Aeronautics, Vol. 177, American Institute of Aeronautics and Astronautics, 1998.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Solar System Space Missions		
Number	1521050	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Joachim Block
Workload (h)	150		
Class attendance (h)	28	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Oral exam (30 min) or written exam (90 min) at the end of the semester		
Course achievement			
Examination language	german		

Contents

The lecture is emphatically interdisciplinary and is aimed at students from various disciplines. It covers the history of the exploration of the solar system from its historical beginnings to the present day. The focus is on the expansion of the scientific world view through the rapid increase in knowledge about the planets, moons and small bodies of the solar system with the help of space probes. Theories and models dating back to the pre-space age are compared with the iteratively grown knowledge of the real nature of our cosmic environment. The dependence of this advancing knowledge on physical and technical prerequisites, such as the sensor technology on space probes or the achievable autonomy of on-board systems, is discussed, as is the prioritisation of mission objectives based on scientific and social paradigms. An important aspect is the impact that knowledge about our Earth as a habitable planet in this solar system has on human society's self-image. The lecture complements the course offered in the winter semester, Realisation of Large-Scale Physical Projects Using the Example of Space Missions.

Objective qualification

Upon completion of this module, students will have acquired knowledge of the physical and technical requirements for sensor technology on space probes and the achievable autonomy of on-board systems in space travel. The knowledge gained will enable them to understand the prioritisation of objectives for space missions.

Literature

Will be announced in the respective lecture at the begnning.

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
Solar System Space Missions	3,0	Lecture/Exercise	german

Literature

Larson, W. J., J. R. Wertz, Space Mission Analysis and Design, Kluwer, 1996.
Ley, W.; Wittmann, K.; Hallmann, W. (Hrsg.): Handbuch der Raumfahrttechnik. 3. völlig neubearb. Aufl., Hanser-Verlag, 2008
Harvey, B.: Europe´s Space Programme. To Ariane and Beyond. Springer-Verlag Berlin Heidelberg New York, 2003

Title	Spaceflight Technology - Space Debris		
Number	2514060	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Raumfahrtsysteme
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Simona Silvestri
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	Basic knowledge of the orbital mechanics is recommended.		
Expected performance/ Type of examination	1 examination element: written exam (120 min) or oral exam (45 min)		
Course achievement			
Examination language	german		

Contents

- Definition of the space debris environment
- space surveillance and debris measurements
- modeling of the current space debris environment
- debris collision fluxes on operational orbits
- long-term predictions of the debris environment
- debris mitigation measures and their effectiveness
- collision avoidance of trackable objects with spacecraft
- prediction of re-entries and of associated risks
- shielding technologies for hyper-velocity impacts
- meteoroid environment models for the Earth
- meteorite and near-Earth object risk assessment
- electrical propulsion & nuclear power sources

Objective qualification

Students can name the main sources of space debris objects and relate them to diameter classes. They are able to describe the most important observation methods and to explain the appropriate selection of sensors. They can apply the knowledge of orbital mechanics to the distribution of the object population on near earth orbits. They are able to describe the generation of space debris empirically and to analyze the debris distribution of individual orbital release events. They can assess the collision properties between particles and spacecraft. With the help of suitable software, they are able to carry out risk analyzes for satellite missions and to assess the impact of mitigation measures.

Literature

- Heiner Klinkrad (Space Debris Office, ESA/ESOC, Darmstadt), Space Debris - Models and Risk Analysis (engl.), Springer-Verlag Berlin-Heidelberg-New York, 2006, ISBN: 3-540-25448-X.

- Joseph A. Angelo, David Buden, Space Nuclear Power, Krieger Publishing Company (Oktober 1985), ISBN-10: 0894640003.
- Dan M. Goebel, Ira Katz, Fundamentals of Electric Propulsion: Ion and Hall Thrusters (Jpl Space Science and Technology), Wiley & Sons, (10. November 2008), ISBN-10: 0470429275.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Space Systems Practical Experience		
Number	2514650	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Raumfahrtsysteme
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Simona Silvestri
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	A basic understanding of physical and mathematical relationships is recommended.		
Expected performance/ Type of examination	1 examination element: completion report		
Course achievement	1 Course achievement: presentation (30 min)		
Examination language	german		

Contents

- Introduction to aerospace standards
- implementation of space projects
- project phases of space mission
- Definition of mission objectives and benefits
- Planning and design of space missions
- Trade-off studies
- Calculation and design of the selected systems
- System structure
- possibly procurement of coponents and / or prototyping system components
- Basics in Project Management
- Team work
- Communication and presentation techniques.

Objective qualification

Students can name important space standards. They are able to describe the management of space projects and to divide them into project phases. They can implement defined mission goals in the planning of space missions. They will be able to analyze alternative designs and assess their advantages and disadvantages. They can convert theoretical planning into practical application. They have knowledge of designing space systems. In teamwork, they will learn the elementary methods for realizing and organizing space projects in order to design a satellite system in its entirety. They are able to define the goals, use and mission of a space project taking into account the applicable standards.

Literature

- Wilfried Ley, Klaus Wittmann, Willi Hallmann. Handbuch der Raumfahrttechnik, Carl Hanser Verlag GmbH & Co. KG, Auflage: 4., aktualisierte Auflage (13. Januar 2011).

- Larson, W.J. [ed.], and J.R. [ed.] Microcosm Wertz. Space Mission Analysis and Design. Second Edition. United States: Microcosm, Inc., Torrance, CA (US), 1992.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	1,0	Lecture	german
	2,0	Exercise	german

Title	Implementation of scientific space projects and other large projects in physics		
Number	1521040	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Joachim Block
Workload (h)	150		
Class attendance (h)	28	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Oral exam (30 min) at the end of the semester		
Course achievement			
Examination language	english german		

Contents

The lecture is emphatically interdisciplinary and is aimed at students from various disciplines who are interested in how challenging scientific and technical issues can be practically addressed and solved through targeted large-scale research projects, under various social constraints. Space missions are a prime example of such large-scale projects and therefore form a key part of the lecture material. Based on a series of historical examples, the lecture shows how the aims, approach and overall management philosophy have changed significantly since the 1950s and how this reflects the changing social models and paradigm shifts. Comparisons are also made with two much older exploration projects (from antiquity and early modern times) in order to highlight similarities across different eras. Conversely, project management and control procedures that were originally developed only for space travel and only later transferred to Earth-based applications are also the subject of in-depth consideration.

Objective qualification

Upon completion of this module, students will have mastered the concepts and fundamentals of modern management philosophies in space travel. The knowledge they acquire will enable them to understand the project planning involved in space missions.

Literature

Will be announced in the respective lecture at the beginning.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Implementation of scientific space projects and other large projects in physics	2,0	Lecture	english german
Literature			
Larson, W. J., J. R. Wertz, Space Mission Analysis and Design, Kluwer, 1996. Ley, W.; Wittmann, K.; Hallmann, W. (Hrsg.): Handbuch der Raumfahrttechnik. 3. völlig neubearb. Aufl., Hanser-Verlag, 2008 Harvey, B.: Europe´s Space Programme. To Ariane and Beyond. Springer-Verlag Berlin Heidelberg New York, 2003			

Interdisciplinary elective field Signal Processing

Title			
Number	2424420	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Kürner
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	Oral exam (20 min) or written exam (120 min)		
Course achievement	Colloquium or lab journal		
Examination language	english german		

Contents

- Introduction
- Fundamentals of information theory
- Basics of channel coding
- Single-error-correcting block codes
- Block codes for correcting burst errors
- Convolutional codes
- Special coding techniques

Objective qualification

Upon completion of the module, students will have an understanding of the information-theoretical limits of data transmission and will have acquired knowledge of source and channel coding methods in theory and application. Students will be able to assess the performance of source and channel coding methods and construct simple codes.

Literature

Lecture notes
H.Rohling: Einführung in die Informations- und Codierungstheorie, Teubner
R.Togneri, C.J.S. deSilva: Fundamentals of Information Theory and Coding Design, Chapman&Hall/CRC
H.Schneider-Obermann: Kanalcodierung, Vieweg

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Coding Theory	2,0	Lecture	english german
Literature			
Vorlesungsskript H. Rohling: Einführung in die Informations- und Codierungstheorie, Teubner R. Togneri, C. J. S. de Silva: Fundamentals of Information Theory and Coding Design, Chapman&Hall/CRC H. Schneider-Obermann: Kanalcodierung, Vieweg			
Coding Theory	1,0	Exercise	english german
Literature			
siehe Vorlesung			
Computer exercise on Coding Theory	1,0	Laboratory	english german

Title	Digital Signal Transmission		
Number	2424660	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Nachrichtentechnik
Hours per Week / ECTS	6 / 8,0	**Module owner**	Prof. Dr. Eduard Jorswieck
Workload (h)	240		
Class attendance (h)	84	**Self studying (h)**	156
Compulsory requirements			
Expected performance/ Type of examination	Written exam (180 minutes) or oral exam (30 minutes), depending on number of participants		
Course achievement			
Examination language	german		

Contents

Part I:
- Deterministic signals in LTI systems
- Fourier transform
- Discrete signals and systems
- Correlation function of deterministic signals
- System theory of low-pass and band-pass systems

Part II:
- Statistical signal processing
- Multiplexing
- Binary transmission with low-pass signals
- Binary transmission with band-pass signals
- Digital modulation

Objective qualification

The students describe signal processing systems by their impulse response or transfer function. They know the fundamental principles of digital communications systems.

Literature

- Proakis, John G., and Masoud Salehi. Digital communications. Vol. 4. New York: McGraw-Hill, 2001.

Remark

First half of the summer semester: Digital Signal Transmission I, second half: Digital Signal Transmission II (4+2 SWS / week). Recommended Recommended prerequisite: module Fundamentals of Information Technology.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
Literature			
Ohm, Lüke: Signalübertragung, Springer-Verlag, ISBN 3-540-67768-2 Reimers: Digitale Fernsehtechnik, 2. Aufl., ISBN 3-540-60945-8			
	2,0	Lecture	german
Literature			
Ohm, Lüke: Signalübertragung, Springer-Verlag, ISBN 3-540-67768-2 Reimers: Digitale Fernsehtechnik, 2. Aufl., ISBN 3-540-60945-8			
	1,0	Exercise	german
Literature			
siehe Vorlesung			
	1,0	Exercise	german
Literature			
siehe Vorlesung			

Title	Speech Communication		
Number	2424500	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Tim Fingscheidt
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	oral exam (30 min) or written exam (90 min) (according to number of participants)		
Course achievement	Colloquium or laboratory protocol as proof of performance		
Examination language	english		

Contents

- Speech production
- Speech perception
- Linear prediction and speech modelling
- Speech coding
- Noise reduction
- Acoustic echo compensation

Objective qualification

After completing this module, students are capable of digital speech signal processing and can apply acquired knowledge of speech production and speech perception as well as algorithms and methods of speech enhancement, speech coding, speech transmission in mobile communication systems, and Voice over IP.

Literature

- Copies of lecture slides
- P.Vary u. R.Martin: Digital Speech Transmission, Wiley 2006

Remark

This module of the Master’s programme is also suited for Bachelor students.
Basic knowledge of digital signal processing, e.g., acquired through the module Fundamentals of Digital Signal Processing, facilitate comprehension of this lecture. Basic knowledge of probability calculus is also helpful.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	english
Literature			
Kopien der Vorlesungsfolien P.Vary u. R.Martin: Digital Speech Transmission, Wiley 2006			
	2,0	Laboratory	german
Literature			
siehe Vorlesung			

Elective field Mathematics

Title	Algorithmic Game Theory		
Number	1296290	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	irregular	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Studiendekan der Mathematik
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
Noam Nisan, Tim Roughgarden, Eva Tardos, Vijay V. Vazirani (Eds.), Algorithmic Game Theory, Cambridge University Press, 2007. Martin J. Osborne, An Introduction to Game Theory, Oxford University Press, 2004. Tim Roughgarden, Selfish Routing and the Price of Anarchy, MIT Press, 2005.			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

Algorithmic Game Theory	1,0	Exercise, small group	german

Algorithmic Game Theory	2,0	Lecture/Exercise	german

Title	Computational Statistics		
Number	1296000130	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Studiendekan der Mathematik
Workload (h)	150 h		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 Examination in the form of a written exam (90 minutes) or oral exam (20-30 minutes) as specified by the examiner. With the approval of the Mathematics Examination Board, the examiner may also choose a take-home exam as the form of examination. The lecturer will announce the exact examination modalities at the beginning of the course.		
Course achievement	1 Coursework in the form of homework assignments as specified by the examiner The exact examination procedures will be announced by the lecturer at the beginning of the course.		
Examination language	german		

Contents

- Fundamentals of statistical work, important one-dimensional discrete and continuous distributions
- Moment estimators and maximum likelihood method, unbiasedness, bias, consistency
- Confidence intervals
- Gaussian, t and binomial tests, type 1 and type 2 errors, goodness-of-fit functions, p-values
- Empirical distribution function, empirical quantiles, Monte Carlo simulation, inversion method
- Linear models: parameter estimation, best linear estimators, confidence intervals, testing linear hypotheses, analysis of variance
- Contingency tables, chi-square tests
- Logistic regression

Objective qualification

Technical/methodological skills

Students expand their understanding of basic knowledge in the field of stochastics and deepen the knowledge acquired in the fundamentals section. They learn about applications in the field of statistics through numerous examples. Students gain knowledge and understanding of different modelling techniques, their boundary conditions and limitations. They become familiar with fundamental statistical issues such as estimation, statistical testing, confidence intervals and regression analysis.

Social skills

Social skills are strengthened in particular through professional exchange among students, for example when working together to develop solution strategies, discussing mathematical concepts or cooperatively dealing with complex problems.

Personal skills

Students independently acquire new knowledge and perspectives and discuss mathematical content with others; they develop solutions in a focused, precise and goal-oriented manner. Students can train and improve their teamwork skills in homework assignments, compare the requirements of the module with their own prior knowledge and independently close any gaps in their knowledge, as well as reflect on their learning progress and adjust their learning behaviour if necessary.

Literature

- K. Behnen, G. Neuhaus, Grundkurs Stochastik, Springer-Verlag und PD-Verlag, 1995 und 2003
- P. J. Bickel, K. A. Doksum, Mathematical Statistics: Basic Ideas and Selected Topics, Prentice Hall, 2001
- H.-O. Georgii, Stochastik: Einführung in die Wahrscheinlichkeitstheorie und Statistik, De Gruyter Lehrbuch, 2009
- H. Dehling, B. Haupt, Einführung in die Wahrscheinlichkeitstheorie und Statistik, Springer-Verlag, 2004
- H. Pruscha, Angewandte Methoden der Mathematischen Statistik, Teubner Skripten zur Mathematischen Stochastik, 1996

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Related courses

Rules for the choice of courses

The module ‘Computational Statistics’ consists of a lecture and a tutorial. The ‘short tutorial’ is only compulsory if it is offered instead of the ‘long tutorial’.

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Computational Statistics	3,0	Lecture/Exercise	german
Computational Statistics	1,0	Exercise, small group	german
Introduction to Statistics	6,0	Lecture/Exercise	german

Title	Introduction to Quantum Information Theory		
Number	1294540	**Module version**	V3
Shorttext		**Language**	english german
Frequency of offer	every 2 years in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 6,0	**Module owner**	Studiendekan der Mathematik
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Recommended requirements	A basic knowledge of classical information theory is recommended		
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Examination language	english german		

Contents

- Vectors and Operators,
- States, Observables, Statistics,
- Composite Systems and Entanglement,
- Classical Entropy and Information,
- The Classical-Quantum Channel,
- Quantum Evolutions and Channels,
- Quantum Entropy and Information Quantities

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture

- acquainted with the basic objects, constructions, and mathematical theorems and their proofs of quantum information theory
- obtain an understanding of the similarities of, and the fundamental differences between, classical information theory and quantum information theory
- learn about applications of quantum information theory in quantum computing and communication.

Literature

- A. Holevo: Quantum Systems, Channels, Information, De Gruyter

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Introduction to Quantum Information Theory	3,0	Lecture/Exercise	english german
Introduction to Quantum Information Theory	1,0	Exercise, small group	german

Title	Linear and Combinatorial Optimization		
Number	1296000170	**Module version**	V1
Shorttext		**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	Studiendekan der Mathematik
Workload (h)	300		
Class attendance (h)	84	**Self studying (h)**	216
Compulsory requirements			
Recommended requirements	The contents of the basic modules ‘Analysis 1 and 2’ and ‘Linear Algebra’ are prerequisites.		
Expected performance/ Type of examination	1 examination in the form of a written exam (120 minutes) or oral exam (25-35 minutes) as specified by the examiner. With the approval of the Mathematics Examination Board, the examiner may also choose a take-home exam as the form of examination. The exact examination modalities will be announced by the lecturer at the beginning of the course.		
Course achievement	1 Coursework in the form of homework assignments as specified by the examiner The exact examination procedures will be announced by the lecturer at the beginning of the course.		
Examination language	german		

Contents

- Efficiently solvable combinatorial problems such as spanning trees, rivers, and matchings
- Basic concepts of polyhedron theory
- Simplex method
- Duality
- Solution of linear programs
- Basic concepts of complexity
- NP-hard combinatorial problems
- Selected applications

Objective qualification

Technical/methodological skills
Students understand the basic definitions, theorems, proofs, and solution methods for combinatorial optimization, linear programming, and complexity theory. They are also familiar with typical applications from economics and engineering and can model them, assess their complexity, and select or design suitable solution methods.

Social skills
Social skills are strengthened in particular through professional exchange among students, for example when working together to develop solution strategies, discussing mathematical concepts, or cooperatively dealing with complex problems.

Personal skills
Students independently acquire new knowledge and perspectives and discuss mathematical content with others; they develop solutions in a focused, precise, and goal-oriented manner. Students can train and

improve their teamwork skills in homework assignments, compare the requirements of the module with their own prior knowledge and independently close any gaps in their knowledge, reflect on their learning progress, and adjust their learning behavior if necessary
Literature
• V. Chvatal: Linear Programming, Freeman and Company, 1983 • W.J. Cook, W.H. Cunningham, W.R. Pulleyblank, and A. Schrijver, Combinatorial Optimization, John Wiley and Sons, 1998 • Korte/Vygen, Kombinatorische Optimierung, Springer, 2008 • Schrijver, Combinatorial Optimization, Springer, 2004

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Related courses			
Rules for the choice of courses			
The module “Linear and Combinatorial Optimization” consists of a lecture and a tutorial. The “short tutorial” is only compulsory if it is offered instead of the “long tutorial.”			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Linear and Combinatorial Optimization	6,0	Lecture/Exercise	german
Linear and Combinatorial Optimization	1,0	Exercise, small group	german

Title	Mathematical Foundations of Information Theory and Coding Theory		
Number	1294600	**Module version**	V3
Shorttext		**Language**	english german
Frequency of offer	every 2 years in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1 Semester	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Studiendekan der Mathematik
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 oral exam (20-30 minutes) according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework or presentation according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Examination language	english german		

Contents

- Kraft Inequality and McMillan's Theorem
- Huffman Codes
- Stochastic Processes
- Entropy and Entropy Rates
- The Shannon-McMillan-Breiman Theorem
- Universal Codes and the Lempel-Ziv Code
- Rate Allocation

Objective qualification

Technical/methodological skills

Students understand the interconnections and complex relationships between their own mathematical knowledge and the content of the course. They understand the theory of the course as a whole and have mastered the associated methods. Students can apply and analyse the methods taught in the course and have mastered the essential fundamentals of the field. They can place individual methods in a larger context.

Social skills

Social skills are strengthened in particular through professional exchange among students, for example when working together to develop solution strategies, discussing mathematical concepts or cooperatively dealing with complex problems.

Personal skills

Students independently acquire new knowledge and perspectives and discuss mathematical content with others; they develop solutions in a focused, precise and goal-oriented manner. Students can train and improve their teamwork skills in homework assignments, compare the requirements of the module with their

own prior knowledge and independently close any gaps in their knowledge, as well as reflect on their learning progress and adjust their learning behaviour if necessary.
Literature
- Cover & Thomas „Elements of Information Theory“ (Wiley)

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Related courses			
Rules for the choice of courses			
The module ‘Mathematical Foundations of Information Theory and Coding Theory’ consists of a lecture and a tutorial.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Mathematical Foundations of Information Theory and Coding Theory	3,0	Lecture/Exercise	english german

Title	Computer Science Seminar		
Number	4299000040	**Module version**	V2
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Studiendekan der Informatik
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Presentation (examination). The grade is determined by the active participation in the seminar and the quality of the presentation and any accompanying paper.		
Course achievement			
Examination language	english german		
Contents			
The course content in the seminar depends on the topics worked on and may vary each semester.			
Objective qualification			
The students are enabled to work independently on a topic, to prepare it and to present it. They also become aware of the effect of their own presentation on other students. In addition, important key competencies are acquired: For example, students train and improve their presentation technique as well as their rhetorical skills.			
Literature			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Seminar	german

	3,0	Seminar	german
Literature			
individuell			

Seminar Application Security (Master)	3,0	Seminar	german
Literature			
Die Literaturquellen variieren - je nach gewähltem Seminarthema.			

Seminar Theoretical Computer Science (Master)	3,0	Seminar	english
Literature			
Literature sources vary - depending on the chosen seminar topic.			

Seminar Connected and Mobile Systems (Master)	3,0	Seminar	english german
Literature			
The course content in the seminar depends on the topics worked on and may vary each semester.			

Seminar Databases and Information systems	3,0	Seminar	english german
Literature			
Literature sources vary - depending on the chosen seminar topic.			

Seminar Robotics and Process Control (Master)	3,0	Seminar	german
Literature			
Die Literaturquellen variieren je nach gewähltem Thema.			

Seminar Computer Graphics (Master)	3,0	Seminar	english german

Seminar Computer Vision (Master)	3,0	Seminar	english
Literature			
Die Literaturquellen variieren, je nach gewähltem Thema.			

Seminar Computer Engineering (Master)	3,0	Seminar	german
Literature			
Will be announced separately for the respective topic.			

Seminar Medical Informatics (Master)	3,0	Seminar	english

Seminar Data Science in Biomedicine (Master)	3,0	Seminar	english

Seminar Reliable System Software (Master)	3,0	Seminar	english

Seminar Algorithmics (Master)	3,0	Seminar	english german
Literature			
Literature sources vary - depending on the chosen seminar topic.			

	3,0	Seminar	english

Seminar Bioinformatik (Master)	3,0	Seminar	german
Literature			
Die Literaturquellen variieren - je nach gewähltem Seminarthema.			

Seminar Software Engineering and Automotive Informatics (Master)	3,0	Seminar	english german
Literature			
Die Literaturquellen variieren - je nach gewähltem Seminarthema.			

Seminar Information Systems (Master)	3,0	Seminar	english
Literature			
Die Literaturquellen variieren, je nach gewähltem Thema.			

Seminar Artificial Intelligence (Master)	3,0	Seminar	english
Literature			
Die Literaturquellen variieren, je nach gewähltem Thema.			

Project Work

Title	Project Work		
Number	4299650	**Module version**	V2
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	1 / 15,0	**Module owner**	Studiendekan der Informatik
Workload (h)	450		
Class attendance (h)	14	**Self studying (h)**	436
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			
Aktuelle Literatur für Ihre Projektarbeit erfragen Sie bitte bei Ihrem Betreuer.			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

Interdisciplinary Qualifications

Title	Elective Courses in Mathematics and Interdisciplinary Qualifications		
Number	4299000050	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	Studiendekan der Informatik
Workload (h)	240		
Class attendance (h)	84	**Self studying (h)**	156
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	english german		
Contents			
Objective qualification			
Literature			
wird von den jeweiligen Lehrenden bekannt gegeben			

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Block course	german

Image Aspects	2,0	Lecture	english german
Literature			
- Donald Hoffman: Visual Intelligence. Norton, 1998. - Simon Ings: A Natural History of Seeing. Norton, 2007. - Patrick Cavanagh: The Artist as Neuroscientist. Nature, vol. 434, March 2005.			

Visualization Techniques	2,0	Lecture	english

	2,0	Lecture	german

IT-Law: Contract Law	2,0	Lecture	german
Literature			
Gesetzessammlung Computerrecht - DTV-Beck weitere Empfehlungen in der Veranstaltung Achtung: Es wird empfohlen, die Literatur erst nach der ersten Veranstaltung anzuschaffen, da sich aktualitätsbedingt Änderungen ergeben könnten.			

	2,0	Lecture	german

Master's Thesis

Title	Master's Thesis		
Number	4299820	**Module version**	
Shorttext		**Language**	german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	0 / 30,0	**Module owner**	Studiendekan der Informatik
Workload (h)	900		
Class attendance (h)	1	**Self studying (h)**	899
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Examination language	german		
Contents			
Objective qualification			
Literature			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**