Modules for Embedded Systems and Microrobotics

Kernmodule

inf900 - Group Project

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<td>Module code</td>
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<td>Credit points</td>
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<td>Workload</td>
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<td></td>
<td>Master Informatik &gt; Kernmodule</td>
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<tr>
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<td>Master Wirtschaftsinformatik &gt; Kernmodule</td>
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<tr>
<td>Contact person</td>
<td>Module responsibility</td>
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<td></td>
<td>Die im Modul Lehrenden</td>
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<tr>
<td>Authorized examiners</td>
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<tr>
<td>Entry requirements</td>
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<tr>
<td>Skills to be acquired in this module</td>
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<tr>
<td>The students get familiar with different software development aspects in a team. Apart from software engineering knowledge and skills they develop key competences like project management, teamwork, problem solving competence and conflict management. Additionally, students develop special knowledge, skills and competences from the project group topic.</td>
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</table>

Professional competence
The students:

- characterise and apply computer science basics (algorithms, data structures, programming, basics of practical, technical and theoretical computer science)
- define and describe essential mathematical, logical and physical basics of computer science
- define and illustrate the core disciplines of computer science (theoretical, practical and technical computer science)

Methodological competence
The students:

- examine problems, use formal methods to phrase and analyze them appropriately
- evaluate problems by the use of technical and scientific literature
- reflect on a scientific topic and write a scientific seminar paper under guidance and present their findings

Social competence
The students:

- integrate criticism into their own actions
- respect team decisions
- communicate with users and experts convincingly

Self-competence
The students:

- take on project management tasks
- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently
- recognise their abilities and extend them purposefully
- reflect their self-perception and actions with regard to professional, methodological and social aspects
- develop and reflect self-developed hypotheses to theories independently
- work in their field independently

Module contents
Cooperative development of a large-scale computer science project. This project general includes the (further) development of a hard or software system.

Reader's advisory
According to the assigned task

Links
<table>
<thead>
<tr>
<th><strong>Languages of instruction</strong></th>
<th>German, English</th>
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<td><strong>Duration (semesters)</strong></td>
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<td><strong>Module capacity</strong></td>
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<td><strong>Module level</strong></td>
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<tr>
<td><strong>Module type</strong></td>
<td>Pflicht o. Wahlpflicht / compulsory or optional</td>
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<tr>
<td><strong>Lern- Lehrform / Type of program</strong></td>
<td>PG</td>
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| **Vorkenntnisse / Previous knowledge** | - Programmierkurs  
- Softwaretechnik  
- Soft Skills |
| **Examination** | **Time of examination** | **Type of examination** |
| Final exam of module |  | Active involvement, presentation, final report, project assessment |
| **Course type** | Project group |
| **SWS** | 8.00 |
| **Frequency** |  |
| **Workload attendance** | 112 h |
**Akzentsetzungsmodulen**

inf100 - Human Computer Interaction

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<td>Master Informatik &gt; Mastermodule</td>
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<td>Contact person</td>
<td>Susanne Boll-Westermann</td>
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<td>Authorized examiners</td>
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<td>Entry requirements</td>
<td>Professional competence</td>
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<td>Skills to be acquired in this module</td>
<td>The students:</td>
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<tr>
<td></td>
<td>Name the human-computer interaction core principles</td>
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<tr>
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<td>Characterise the basic elements of the human-centered design of interactive systems</td>
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<td>Methodological competence</td>
<td>The students:</td>
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<tr>
<td></td>
<td>Comprehend context of use and user requirements of human-machine interfaces</td>
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<tr>
<td></td>
<td>Design, develop and evaluate human-machine interfaces</td>
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<td></td>
<td>Conduct experiments with their prototypes</td>
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<tr>
<td>Social competence</td>
<td>The students:</td>
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<tr>
<td></td>
<td>Implement human-computer interfaces in practical hands-on projects in teams</td>
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<td></td>
<td>Evaluate human-machine interfaces with potential users</td>
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<td></td>
<td>Develop and present solutions for Human-Computer Interaction related problems</td>
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<td></td>
<td>Integrate technical and factual comments into own results</td>
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<tr>
<td>Module contents</td>
<td>The module introduces the field of human-computer interfaces and their historical context. Moreover, it shows motivating examples of human-computer interaction.</td>
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<tr>
<td></td>
<td>The module covers the core principles of human-computer interaction. In detail, the module deals with the design concepts of interactive systems: context of use, requirements and task analysis, human perception capabilities, design process, usability, prototyping and evaluation. During the practical project a concrete human-computer interface will be designed, developed and evaluated according to these concepts.</td>
</tr>
<tr>
<td></td>
<td>Markus Dahm, Grundlagen der Mensch Computer-Interaktion. Pearson, 2006</td>
</tr>
<tr>
<td></td>
<td>Literature in the reserve shelf in the university bibliography. Link list in Stud.IP.</td>
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<tr>
<td>Links</td>
<td>medien.informatik.uni-oldenburg.de/lehre</td>
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<td>Language of instruction</td>
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<td>Duration (semesters)</td>
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Modulart  Pflicht o. Wahlpflicht / compulsory or optional

Lern- / Lehrform / Type of program  V+P

Vorkenntnisse / Previous knowledge  Basic programming skills

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<th>Time of examination</th>
<th>Type of examination</th>
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<td>Final exam of module</td>
<td>The completed practical projects will be presented on a single project day, which will take place at the end of the lecture period. The oral exam takes place within the last two weeks of the lecture period. If necessary, re-examinations will take place at the end of the term. Find out more about the schedule on the websites of the department and in Stud.IP.</td>
<td>Practical group project which progress has to be presented regularly during the tutorials. Oral exam on the topics of the lecture. Practical project and oral exam count 50% each to the final grade. Both practical project and oral exam have to be passed individually.</td>
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<table>
<thead>
<tr>
<th>Course type</th>
<th>Comment</th>
<th>SWS</th>
<th>Frequency</th>
<th>Workload attendance</th>
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<tr>
<td>Lecture</td>
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Total time of attendance for the module  56 h
**inf105 - Fault Tolerance in Distributed Systems**

<table>
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| Used in course of study | Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule  
                         | Master Informatik > Mastermodule        |

**Contact person**

- Module responsibility
  - Oliver Theel
  - Die im Modul Lehrenden
- Authorized examiners
  - Die im Modul Lehrenden
  - Die Modulverantwortlichen
- Module counseling
  - Die im Modul Lehrenden

**Entry requirements**

**Skills to be acquired in this module**

This module provides knowledge of fault-tolerant distributed systems. The terminology, structure, conception, core challenges and related implementation concepts will be covered in detail.

**Professional competence**

The students:

- Assess what a fault-tolerant distributed system is and develop awareness of its capabilities
- Name and discuss common implementations of fault-tolerant distributed systems

**Methodological competence**

The students:

- Reflect the implementation challenges of a distributed system
- Are able to adapt and evolve implementation concepts of fault-tolerant distributed systems in new contexts

**Social competence**

The students:

- Solve problems in small teams
- Present their solutions to the members of the tutorial
- Discuss their different solutions with members of the tutorial

**Self-competence**

The students:

- Accept criticism
- Question their initially applied methods for problem solving
- Question their initial solutions in the light of newly learned methods

**Module contents**

1) Fault, Error, Failure
2) Failure semantics, Fault tolerance
3) Byzantine agreement protocols
4) Stable storage
5) Fail-stop processors
6) Atomic commit protocols
7) Classification of replication control schemes
   - pessimistic vs. optimistic
   - semantic vs. syntactic
   - static vs. dynamic
8) Consistency notions
9) Quality criteria
10) Survey of replication control schemes
11) Design of replication control schemes
12) Unifying frameworks
13) Replication in practice

**Reader's advisory**

**Links**

**Language of instruction**
- German

**Duration (semesters)**
- 1 Semester

**Module frequency**
- jährlich

**Module capacity**
- unlimited

**Reference text**
- connectet with:
  - Betriebssysteme 1 und 2
  - Betriebssysteme-Praktikum
  - Verteilte Betriebssysteme

**Modul level**
- AS (Akzentsetzung / Accentuation)

**Modulart**
- Wahlpflicht / Elective

**Vorkenntnisse / Previous knowledge**
- V+Ü oder V+S

**Vorkenntnisse / Previous knowledge**
- Verteilte Betriebssysteme

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<td>End of lecture period</td>
<td>written exam or oral exam or practical work</td>
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<td>Seminar or exercise</td>
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**Total time of attendance for the module**
- 56 h
inf300 - Hybrid Systems

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<td>Module responsibility</td>
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<td></td>
<td>• Martin Georg Fränzle</td>
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<td>• Die im Modul Lehrenden</td>
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<td>• Martin Georg Fränzle</td>
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<td></td>
<td>• Die im Modul Lehrenden</td>
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Entry requirements

Skills to be acquired in this module

The module gives an introduction to hybrid discrete-continuous systems, as arising by embedding digital hardware into physical environments, and it elaborates on state of the art methods for the mathematical modelling and the analysis of such systems. It thus provides central competences for understanding and designing reliable cyber-physical systems.

Professional competence

The students:

- characterise formal models of cyber-physical systems: hybrid automata, hybrid state transition systems
- name domain-specific system requirements: safety, stability, robustness
- name analysis methods: symbolic state-space exploration, abstraction and abstraction refinement, generalized Lyapunov-Methods
- use state-of-the-art analysis tools
- select and apply adequate modelling and analysis methods for concrete application scenarios
- apply methods to reduce large state spaces and reduce infinite-state systems by abstraction
- know the de-facto industry standards for system modelling and are able to apply the corresponding modelling frameworks and tools

Methodological competence

The students:

- model heterogeneous dynamical systems with adequate modelling and design tools, in particular Simulink/Stateflow
- transfer modelling and analysis methods to other heterogeneous domains, e.g. socio-technical systems

Social competence

The students:

- work in teams
- solve complex modelling, design, and analysis tasks in teams

Self-competence

The students:

- reflect their actions and respect the scope of methods dedicated to hybrid systems

Module contents

Embedded computer systems continuously interact with their environment, which generally comprises state- and time-continuous components. The coupling of the embedded system to its environment thus induces complex interleavings between discrete computational and decision processes and continuous processes. The resulting processes are neither amenable to the analytic techniques of continuous control nor of discrete mathematics. They instead require a broader, integrated theory: hybrid discrete-continuous systems. The lectures provide an in-depth introduction into a variety of analysis and design methods of these computer-based systems and their recent extensions to cyber-physical systems.

The accompanying hands-on-project enhances the lecture by developing and using design and verification tools.

Reader's advisory

- Luca P Carloni, Roberto Passerone, Allesandro Pinto & Alberto L Sangiovanni-Vincentelli: Languages

<table>
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<td>Duration (semesters)</td>
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<td>Module frequency</td>
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<td>Module level</td>
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<td>Modulart</td>
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<td>Lern- Lehrform / Type of program</td>
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| Total time of attendance for the module | 56 h |
inf301 - Machine-oriented Systems Engineering

Module label       Machine-oriented Systems Engineering
Module code        inf301
Credit points      6.0 KP
Workload           180 h

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodul
- Master Engineering of Socio-Technical Systems > Embedded Brain Computer Interaction
- Master Engineering of Socio-Technical Systems > Human-Computer Interaction
- Master Engineering of Socio-Technical Systems > Systems Engineering
- Master Informatik > Mastermodule

Contact person
Module responsibility
- Alfred Mikschl
- Werner Damm
- Die im Modul Lehrenden

Authorized examiners
- Alfred Mikschl
- Die im Modul Lehrenden

Entry requirements
Skills to be acquired in this module
The module provides practical relevance to the design of digital embedded systems.

Professional competence
The students:
- characterise the structure of microprocessor systems
- name control aspects of time sensitive external components
- program efficient embedded systems

Methodological competence
The students:
- use specifications from electrical components data sheets

Social competence
The students:
- work in a team
- discuss solutions

Module contents
Embedded systems support complex feedback problems, control problems and data processing tasks. They have an important value creation potential for telecommunications, production management, transport and electronics. The functionality of embedded systems is realised by the integration of processors, special hardware and software. The embedded systems design is influenced by the heterogeneity of system architectures, the complexity of systems and technical and economic requirements.

This module gives an initial review of computer architectures. After that embedded systems are introduced by a specific microprocessor. Furthermore, external hardware will be connected to the microprocessor. Besides this, the design of circuit boards will be discussed. The students will design, develop and implement a circuit layout with CAD and programme this embedded system with a Flash-eprom.

Reader's advisory
Lecturers notes, hardware manuals and data sheets, and development tool manuals

Links
Languages of instruction       German, English
Duration (semesters)           1 Semester
Module frequency               semi-anual
Module capacity                unlimited
Modulelevel                    AS (Akzentsetzung / Accentuation)
Modulart                      Pflicht o. Wahlpflicht / compulsory or optional
Lern-Lehrform / Type of program V+P
Vorkenntnisse / Previous knowledge „Eingebettete Systeme I and II”and successful completion of the module „Praktikum Technische Informatik“
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<td>Final exam of module</td>
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<td>Portfolio (Design, development and implementation of embedded systems, colloquium)</td>
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<tr>
<td>Practical</td>
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Total time of attendance for the module 56 h
inf303 - Fuzzy Control and Artificial Neural Networks in Robotics and Automation

<table>
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**Used in course of study**
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodulle
- Master Engineering of Socio-Technical Systems > Embedded Brain Computer Interaction
- Master Engineering of Socio-Technical Systems > Human-Computer Interaction
- Master Engineering of Socio-Technical Systems > Systems Engineering
- Master Informatik > Mastermodule

**Contact person**
- Module responsibility
  - Sergej Fatikow
  - Die im Modul Lehrenden

**Authorized examiners**
- Sergej Fatikow
- Die im Modul Lehrenden

**Entry requirements**

**Skills to be acquired in this module**
Experts in different branches try to approach their application-specific control and information processing problems by using fuzzy logic and artificial neural networks (ANN). The experiences gathered up to now prove robotics and automation technology to be predestined fields of application of both these approaches. The major topics of the course are control problems in robotics and automation technology, principles of fuzzy logic and ANN and their practical applications, comparison of conventional and advanced control methods, combination of fuzzy logic and ANN in control systems. The course gives a comprehensive treatment of these advanced approaches for interested students.

**Professional competence**
The students:
- recognise control problems in robotics and automation technology,
- name principles of fuzzy logic and ANN and their practical applications,
- compare conventional and advanced control methods,
- characterise the combination of fuzzy logic and ANN in control systems

**Methodological competence**
The students:
- will acquire knowledge of the tools, methods and applications in fuzzy logic and ANN
- deepen their knowledge for the practical use of the given methods
- can use common software tools for design and application of fuzzy logic and ANN

**Social competence**
The students:
- gain experience in interdisciplinary work
- are integrated into the recent research work

**Objective of the module / skills:**

**Self-competence**
The students:
- are able to transfer the gained knowledge for later use in their theses or studies for AMIR
- can Design (complex) fuzzy logic controller and ANN systems
- reflect their (control) solutions by using methods learned in this course

**Module contents**
- Control problems in robotics and automation technology
- Basic ideas of fuzzy logic and ANN
- Principles of fuzzy logic
- Fuzzy logic of rule-based systems
- ANN models
- ANN learning rules
- Multilayer perceptron networks and backpropagation
- Associative networks
- Self-organizing feature maps
- PID design principles
- Design of fuzzy control systems
- Fuzzy logic application examples
- Design of ANN control systems
- ANN application examples
- Fuzzy + Neuro: principles and applications

Reader’s advisory

Essential:

- Lecture notes (available at the secretariat, A1-3-303) in book form

Recommended:


Secondary Literature:

- Altrock, M. O. R.: Fuzzy Logic, R. Oldenbourg Verlag, 1993
- Kahlerl, J. und Hubert, F.: Fuzzy-Logik und Fuzzy-Control, Vieweg, 1993
- Kratzer, K.P.: Neuronale Netze, Carl Hanser, 1993
- Lawrence, J.: Neuronale Netze, Synthese Verlag, München, 1992
- Patterson, D.W.: Künstliche neuronale Netze, Prentice Hall, 1996
- Pham, D.T. a200
- Schulte, U.: Einführung in Fuzzy-Logik, Franzis-Verlag, München, 1993
- Zakharian, S. Ladewig-Riebler, P. und Thoer, St.: Neuronale Netze für Ingenieure, Vieweg, Wiesbaden, 1998
- Zimmermann H.-J. (Hrsg.): Datenanalyse, VDI-Verlag, 1995

Links

Languages of instruction
German, English

Duration (semesters)
1 Semester

Module frequency
once a year

Module capacity
unlimited

Module level
AS (Akzentsetzung / Accentuation)

Modulart
Pflicht o. Wahlpflicht / compulsory or optional

Lern- Lehrform / Type of program
V+Ü

Vorkenntnisse / Previous knowledge
Control engineering

Examination

<table>
<thead>
<tr>
<th>Time of examination</th>
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Final exam of module

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inf305 - Medical Technology

Module code inf305
Credit points 6.0 KP
Workload 180 h

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodul
- Master Engineering of Socio-Technical Systems > Embedded Brain Computer Interaction
- Master Engineering of Socio-Technical Systems > Human-Computer Interaction
- Master Engineering of Socio-Technical Systems > Systems Engineering
- Master Informatik > Mastermodule

Contact person
- Module responsibility
  - Andreas Hein
  - Die im Modul Lehrenden
- Authorized examiners
  - Die im Modul Lehrenden
  - Andreas Hein

Entry requirements

Skills to be acquired in this module

Professional competence
The students:

- Describe medical diagnosis and therapy methods
- Understand the core concepts of computer-assisted medical interventions
- Are aware of the basic concepts and legal conditions of the development of medical devices
- Define the character of medical devices' software parts and implement them
- Assess the complex interaction of medical products and patients
- Get familiar with the development of medical products within a short period of time

Methodological competence
The students:

- Recognise the interdisciplinary challenges and accordingly exchange information with other disciplines

Social competence
The students:

- Present solutions for specific questions

Self-competence
The students:

- reflect their solutions by using methods learned in this course

Module contents

- Medical areas and areas of application
- Basic requirements for medical systems (hygiene, MPG, technical security, materials)
- Medical systems:
  - Functional diagnostics (ECG, EMG, EEG)
  - Imaging systems (CT, MRI, ultrasound, PET, SPECT)
  - Therapy equipment (Laser, RF, Microtherapy)
  - Signal processing / monitoring (cardiovascular, hemodynamic, respiratory, metabolic, cerebral)
- Medical Informatics (HIS, DICOM, Telemedicine, VR, image processing).

Reader's advisory

essential:

- Lecture slides

recommended:

**secondary literature:**

### Links

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### Examination

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### Total time of attendance for the module

56 h
inf307 - Robotics

Module label: Robotics
Module code: inf307
Credit points: 6.0 KP
Workload: 180 h

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodul
- Master Engineering of Socio-Technical Systems > Embedded Brain Computer Interaction
- Master Engineering of Socio-Technical Systems > Human-Computer Interaction
- Master Engineering of Socio-Technical Systems > Systems Engineering
- Master Informatik > Mastermodule

Contact person:
Module responsibility:
- Andreas Hein
- Die im Modul Lehrenden

Authorized examiners:
- Die im Modul Lehrenden
- Andreas Hein

Entry requirements:

Skills to be acquired in this module:

Professional competence:
The students:
- Name and know the functions and applications of robot systems
- Characterise the basic concepts to program robot systems
- Differentiate between the interaction of mechanical, electrical and software components

Methodological competence:
The students:
- Define characteristics and components of robot systems for a specific application
- Design and implement robot system sub-components
- Design and parameterise simple control structures
- Plan the application of robot systems and derive the requirements
- Model electrical and mechanical systems
- Develop and realise simple robot systems

Social competence:
The students:
- Solve robot systems problems in team work

Self-competence:
The students:
- Reflect their solutions in reference to robot system methods

Module contents:
- Integration in production plants / aims / subsystems
- Architectures / classifications (classification of robots)
- Robot components + Computer systems for programming
  - PA-10
  - Lego Mindstorms
- Basics of kinematics
  - Coordinate transformation, homogeneous coordinates, Coordinate transitions
  - Kinematic equation systems, transformation of vectors
- Kinematic:
  - Joint types (manipulators) / Wheels, TCP
  - Denavit-Hartenberg-Transformation
  - Forward calculation
  - Backward calculation
- Sensors
  - General properties of sensors, parameter
  - Simple optical position sensors
  - Inductive-, capacitive- und ultrasonic-sensors
- Distance sensors (laser scanner, triangulation sensors)
- Force sensors
- Sensor data preparation
- Planing / Regulation
  - Overall regulation approach, terms, process- and control functions, PID-controller
  - Planning concepts and approaches (On-Line, Off-Line), planning processes, construction and path planning
- Actuators

Reader's advisory

**essential:**
lecture notes

**recommended:**

**secondary literature:**

Links

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Total time of attendance for the module: 56 h
inf308 - Microrobotics II

Module label: Microrobotics II
Module code: inf308
Credit points: 6.0 KP
Workload: 180 h

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Engineering of Socio-Technical Systems > Embedded Brain Computer Interaction
- Master Engineering of Socio-Technical Systems > Human-Computer Interaction
- Master Engineering of Socio-Technical Systems > Systems Engineering
- Master Informatik > Mastermodule

Contact person:
- Module responsibility:
  - Sergej Fatikow
  - Die im Modul Lehrenden
- Authorized examiners:
  - Sergej Fatikow
  - Die im Modul Lehrenden

Entry requirements:

Skills to be acquired in this module:
After having given an established introduction in the module “Microrobotics and Microsystem Technology” this lecture offers a further specialisation in microrobotics. Within the course, all relevant areas (among others the research topics of the division “Microrobotics and Control Engineering (AMiR)”) will be presented and analysed. The student will be provided with an insight into current research projects of AMiR and of other research institutes of microrobotics worldwide; here mainly the requirements of industry to microrobots will be discussed. The lecture will be enhanced by practical courses in the research laboratories of AMiR.

Professional competence:
The students:
- name and recognise the basic concepts of nanotechnology, in particular, micro- and nanorobotics approaches
- differentiate the development, control and application of micro- and nanorobotics systems
- implement and design application-specific micro- and nanorobotics systems

Methodological competence:
The students:
- transfer their control engineering and image processing abilities on interdisciplinary problems
- transfer their hands-on experience to develop controls and applications of microrobotic systems on new tasks

Social competence:
The students:
- work in a team

Self-competence:
The students:
- reflect their problem-solving behaviour and use hands-on experience to develop, control and application of microrobotics

Module contents:
Smart and versatile microrobots; micro actuators (piezo-, ferrofluid- and SMA-actuators) for microrobots; real-time image processing in the micro world (SEM, optical microscopy); micro force sensors and tactile sensors for microrobots; microrobot control systems, e.g. neural networks and fuzzy logic; haptic interface for the control of microrobots; neural speech interface for the control of microrobots; robot-based micro- and nanohandling (SEM, optical microscopy); applications: microassembly, nano-testing, cell handling; Micro Air Vehicles (MAVs); multi-robot systems: team behavior, communication, control issues

Reader’s advisory:
- Lecture notes (can be obtained in secretariate, A1-3-303)
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**Examination**

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**Course type**

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**Total time of attendance for the module**

56 h
inf311 - Low Energy System Design

Module label: Low Energy System Design
Module code: inf311
Credit points: 6.0 KP
Workload: 180 h

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Engineering of Socio-Technical Systems > Embedded Brain Computer Interaction
- Master Engineering of Socio-Technical Systems > Systems Engineering
- Master Informatik > Mastermodule

Contact person:
Module responsibility:
- Wolfgang Nebel
- Die im Modul Lehrenden

Authorized examiners:
- Die im Modul Lehrenden
- Wolfgang Nebel

Entry requirements:
This module introduces the estimation of power dissipation and optimisation.

Professional competence:
The students:
- Discuss the fundamental problems of power dissipation
- Characterise the requirements-driven design process of embedded systems
- Name power loss analysis and optimization methods
- Design embedded systems with common design and analysis tools
- Design power-optimized embedded systems

Methodological competence:
The students:
- Model systems with a hardware description language
- Analyze and model hardware components
- Perform multi-dimensional optimization of systems

Social competence:
The students:
- Implement solutions of given problems in teams
- Discuss their outcomes appropriately

Self-competence:
The students:
- Acknowledge the limits of their ability to cope with pressure during the modeling process of systems

Module contents:
According to Moore's Law the number of integratable transistors on a computer chip doubles every two years. In addition, new circuits are getting faster and faster. This leads not only to an increased functionality of a system, but it also increases the electrical power consumption.

This electrical power consumption is problematic from two different points of view: Firstly, the electrical power must be supplied. Secondly, the resulting heat has to dissipate from the system. An increased power consumption always causes lower battery life and higher energy costs. The heat generation reduces the reliability and life of integrated circuits. The cooling (ceramic housings, cooling elements, fans, etc.) increases the system's costs.

Today the development of heat, caused by power dissipation, needs to be considered during the embedded system design process. This knowledge takes the system's reliability and operation costs into account.

This module introduces the estimation of power dissipation and optimisation.

Reader's advisory:
- Designing CMOS Circuits for Low Power – Dimitros Soudris, Christian Piguet, Costas Goutis
- Low-Power CMOS VLSI Circuit Design – Kaushik Roy, Sharat C. Prasad
- Low-Power Electronics Design – Christian Piguet et al.
- Leakage in Nanometer CMOS Technologies – Siva G. Narendra, Anantha Chandrakasan
- Entwurf von digitalen Schaltungen und Systemen mit HDLs und FPGAs – F. Kesel, R. Bartholomä
- Slides of the module „Eingebettete Systeme I+II“ von Professor Dr.-Ing. Wolfgang Nebel
- Slides and technical readouts of the used hardware and development tools

**Links**

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**Vorkenntnisse / Previous knowledge**

- inf200 Grundlagen der Technische Informatik,
- inf201 Technische Informatik,
- inf203 Eingebettete Systeme I,
- inf204 Eingebettete Systeme II

**Examination**

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**Total time of attendance for the module**

| 56 h |
inf350 - Special Topics in 'Safety-Critical Systems' I

Module label
Special Topics in 'Safety-Critical Systems' I

Module code
inf350

Credit points
6.0 KP

Workload
180 h

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodelle
- Master Informatik > Mastermodule

Contact person
Module responsibility
- Andreas Hein
- Werner Damm

Authorized examiners
- Andreas Hein
- Werner Damm

Entry requirements

Skills to be acquired in this module
This module integrates current developments in the field in adequate study courses.

Professional competences
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:
- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

Social competences
The students:
- support team process by their abilities

Self-competences
The students:
- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

Module contents
See assigned course description, e.g. „Sicherheitsanalysetechniken“, „Zielarchitekturen Eingebetteter Systeme für Automotive-Anwendungen“, „Modellbasierter Systementwurf“, ...

Reader's advisory
As announced in course

Links

Language of instruction
German

Duration (semesters)
1 Semester

Module frequency
unregelmäßig

Module capacity
unlimited

Module level
AS (Akzentsetzung / Accentuation)

Modulart
je nach Studiengang Pflicht oder Wahlpflicht

Lern-Lehrform / Type of program
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inf351 - Special Topics in 'Safety-Critical Systems' II

Module label: Special Topics in 'Safety-Critical Systems' II
Module code: inf351
Credit points: 6.0 KP
Workload: 180 h

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodul
- Master Informatik > Mastermodule

Contact person:
Module responsibility:
- Andreas Hein
- Werner Damm
- Die im Modul Lehrenden

Authorized examiners:
- Andreas Hein
- Werner Damm
- Die im Modul Lehrenden

Entry requirements:

Skills to be acquired in this module:
This module integrates current developments in the field in adequate study courses.

Professional competences:
The students:

- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences:
The students:

- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

Social competences:
The students:

- support team process by their abilities

Self-competences:
The students:

- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

Module contents:
See assigned course description, e.g. „Sicherheitsanalysetechniken“, „Modellbasierter Systementwurf“, ...

Reader's advisory:
As announced in course

Links:
Language of instruction: German
Duration (semesters): 1 Semester
Module frequency: halbjährlich
Module capacity: unlimited
Modullevel: AS (Akzentsetzung / Accentuation)
Modulart: je nach Studiengang Pflicht oder Wahlpflicht
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inf352 - Current Topics in 'Safety-Critical Systems' I

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                                         • Master Informatik > Mastermodule |
| Contact person                     | Module responsibility                         |
|                                    | • Andreas Hein                               |
|                                    | • Werner Damm                                |
|                                    | • Die im Modul Lehrenden                      |
| Authorized examiners               | • Andreas Hein                               |
|                                    | • Werner Damm                                |
|                                    | • Die im Modul Lehrenden                      |

| Entry requirements                 | This module integrates current developments in the field in adequate study courses. |

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<td>• apply state of the art and innovative methods to solve problems, if necessary from other disciplines</td>
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<td>• are aware of the current limits and contribute to the development of computer science research and technology</td>
</tr>
<tr>
<td></td>
<td>• discuss and evaluate recent computer science developments</td>
</tr>
</tbody>
</table>

|                                      | Methodological competences                                                               |
|                                      | The students:                                                                             |
|                                      | • examine tasks with technical and research literature, write an academic article and present their solutions academically |
|                                      | • evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research |
|                                      | • schedule time processes and resources                                                    |

|                                      | Social competences                                                                       |
|                                      | The students:                                                                             |
|                                      | • communicate with users and experts convincingly                                          |

|                                      | Self-competences                                                                         |
|                                      | The students:                                                                             |
|                                      | • pursue the overall and special computer science development critically                  |
|                                      | • develop and reflect self-developed hypotheses to theories independently                  |

<p>| Module contents                     | See assigned course description                                                          |
| Reader's advisory                   | As announced in course                                                                  |
| Links                                |                                                                                       |
| Language of instruction              | German                                                                                   |
| Duration (semesters)                 | 1 Semester                                                                              |
| Module frequency                     | unregelmäßig                                                                            |
| Module capacity                      | unlimited                                                                               |
| Module level                        | AS (Akzentsetzung / Accentuation)                                                       |
| Modularart                           | je nach Studiengang Pflicht oder Wahlpflicht                                             |</p>
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<th>Lern-/Lehrform / Type of program</th>
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<td>Examination</td>
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<td>Final exam of module</td>
<td>At the end of the lecture period</td>
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<tr>
<td>Course type</td>
<td>Course or seminar</td>
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<td>Frequency</td>
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<tr>
<td>Workload attendance</td>
<td>28 h</td>
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</table>
inf353 - CurrentTopics in 'Safety-Critical Systems' II

Module label
CurrentTopics in 'Safety-Critical Systems' II

Module code
inf353

Credit points
3.0 KP

Workload
90 h

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Mastermodule

Contact person
Module responsibility
- Andreas Hein
- Werner Damm
- Die im Modul Lehrenden

Authorized examiners
- Andreas Hein
- Werner Damm
- Die im Modul Lehrenden

Entry requirements
This module integrates current developments in the field in adequate study courses.

Professional competences
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:
- examine tasks with technical and research literature, write an academic article and present their solutions academically
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research
- schedule time processes and resources

Social competences
The students:
- communicate with users and experts convincingly

self-competences
The students:
- pursue the overall and special computer science development critically
- develop and reflect self-developed hypotheses to theories independently

Module contents
See assigned course description

Reader’s advisory
As announced in course

Links
Language of instruction
German

Duration (semesters)
1 Semester

Module frequency
unregelmäßig

Module capacity
unlimited

Modullevel
AS (Akzentsetzung / Accentuation)

Modulart
je nach Studiengang Pflicht oder Wahlpflicht
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<td>Frequency</td>
<td>WiSe</td>
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<tr>
<td>Workload attendance</td>
<td>28 h</td>
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</table>
inf354 - Special Topics in 'Hybrid Systems' I

Module label: Special Topics in 'Hybrid Systems' I
Module code: inf354
Credit points: 6.0 KP
Workload: 180 h

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodul
- Master Informatik > Mastermodule

Contact person
Module responsibility:
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

Authorized examiners:
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

Entry requirements

Skills to be acquired in this module
This module integrates current developments in the field in adequate study courses.

Professional competences
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:
- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

Social competences
The students:
- support team process by their abilities

self-competences
The students:
- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

Module contents
See assigned course description, e.g. „Modellbasierter Systementwurf“, „Konstruktionsprinzipien ausgewählter Klassen von Fahrzeugfunktionen“

Reader's advisory
As announced in course

Links

Language of instruction: German
Duration (semesters): 1 Semester
Module frequency: halbjährlich
Module capacity: unlimited
Modullevel: AS (Akzentsetzung / Accentuation)
Modulart: je nach Studiengang Pflicht oder Wahlpflicht
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<th>Lern-/Lehrform / Type of program</th>
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<td>Course type</td>
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<tr>
<td>Workload attendance</td>
<td>28 h</td>
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</tbody>
</table>
inf355 - Special Topics in 'Hybrid Systems' II

Module label: Special Topics in 'Hybrid Systems' II

Module code: inf355

Credit points: 6.0 KP

Workload: 180 h

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Mastermodule

Contact person

Module responsibility:
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

Authorized examiners:
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

Entry requirements

Skills to be acquired in this module
This module integrates current developments in the field in adequate study courses.

Professional competences
The students:

- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:

- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

Social competences
The students:

- support team process by their abilities

Self-competences
The students:

- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

Module contents
See assigned course description

Reader's advisory
As announced in course

Links

Language of instruction
German

Duration (semesters)
1 Semester

Module frequency
unregelmäßig

Module capacity
unlimited

Modullevel
AS (Akzentsetzung / Accentuation)

Modulart
je nach Studiengang Pflicht oder Wahlpflicht
<table>
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<td>Workload attendance</td>
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</table>
inf356 - CurrentTopics in 'Hybrid Systems' I

Module label: CurrentTopics in 'Hybrid Systems' I
Module code: inf356
Credit points: 3.0 KP
Workload: 90 h

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodul
- Master Informatik > Mastermodule

Contact person:
Module responsibility:
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

Authorized examiners:
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

Entry requirements:

Skills to be acquired in this module:
This module integrates current developments in the field in adequate study courses.

Professional competences
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:
- examine tasks with technical and research literature, write an academic article and present their solutions academically
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research
- schedule time processes and resources

Social competences
The students:
- communicate with users and experts convincingly

Self-competences
The students:
- pursue the overall and special computer science development critically
- develop and reflect self-developed hypotheses to theories independently

Module contents: See assigned course description
Reader's advisory: As announced in course
Links
Languages of instruction: German, English
Duration (semesters): 1 Semester
Module frequency: unregelmäßig
Module capacity: unlimited
Modul level: AS (Akzentsetzung / Accentuation)
Modulart: je nach Studiengang Pflicht oder Wahlpflicht
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<td><strong>Workload attendance</strong></td>
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inf357 - Aktuelle Themen aus dem Gebiet "Hybride Systeme" II

Module label  Aktuelle Themen aus dem Gebiet "Hybride Systeme" II
Module code  inf357
Credit points  3.0 KP
Workload  90 h

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Mastermodule

Contact person
Module responsibility
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

Authorized examiners
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

Entry requirements
Skills to be acquired in this module
This module integrates current developments in the field in adequate study courses.

Professional competences
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:
- examine tasks with technical and research literature, write an academic article and present their solutions academically
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research
- schedule time processes and resources

Social competences
The students:
- communicate with users and experts convincingly

Self-competences
The students:
- pursue the overall and special computer science development critically
- develop and reflect self-developed hypotheses to theories independently

Module contents
See assigned course description

Reader's advisory
As announced in course

Links

Language of instruction  German
Duration (semesters)  1 Semester
Module frequency  unregelmäßig
Module capacity  unlimited
Modullevel  AS (Akzentsetzung / Accentuation)
Modulart  je nach Studiengang Pflicht oder Wahlpflicht
<table>
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<th>Lern-Lehrform / Type of program</th>
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inf358 - Special Topics in 'Hardware/Software Systems' I

<table>
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<td>Module code</td>
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<tr>
<td>Credit points</td>
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<tr>
<td>Contact person</td>
<td>Module responsibility</td>
</tr>
<tr>
<td></td>
<td>• Andreas Hein</td>
</tr>
<tr>
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<td>• Wolfgang Nebel</td>
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<td>• Die im Modul Lehrenden</td>
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<td>• Andreas Hein</td>
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<td>• Wolfgang Nebel</td>
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<tr>
<td></td>
<td>• Die im Modul Lehrenden</td>
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</table>

**Entry requirements**

**Skills to be acquired in this module**

This module integrates current developments in the field in adequate study courses.

**Professional competences**

The students:

- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

**Methodological competences**

The students:

- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

**Social competences**

The students:

- support team process by their abilities

**Self-competences**

The students:

- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

**Module contents**

See assigned course description, e.g. „Spezifikation und Modellierung Eingebetteter Systeme“

**Reader's advisory**

As announced in course

**Links**

**Language of instruction**

German

**Duration (semesters)**

1 Semester

**Module frequency**

halbjährlich

**Module capacity**

unlimited

**Modullevel**

AS (Akzentsetzung / Accentuation)

**Modulart**

je nach Studiengang Pflicht oder Wahlpflicht
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<th>Lern-Lehrform / Type of program</th>
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<td>Final exam of module</td>
<td>The exam period will be announced during the course</td>
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inf359 - Spezielle Themen aus dem Gebiet "Hardware-/Software-Systeme" II

Module label
Spezielle Themen aus dem Gebiet "Hardware-/Software-Systeme" II

Module code
inf359

Credit points
6.0 KP

Workload
180 h

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Mastermodule

Contact person
Module responsibility
- Andreas Hein
- Wolfgang Nebel
- Die im Modul Lehrenden

Authorized examiners
- Andreas Hein
- Wolfgang Nebel
- Die im Modul Lehrenden

Entry requirements

Skills to be acquired in this module
This module integrates current developments in the field in adequate study courses.

Professional competences
The students:

- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:

- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

Social competences
The students:

- support team process by their abilities

Self-competences
The students:

- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

Module contents
See assigned course description, e.g. „Spezifikation und Modellierung Eingebetteter Systeme“

Reader's advisory
As announced in course

Links

Language of instruction
German

Duration (semesters)
1 Semester

Module frequency
unregelmäßig

Module capacity
unlimited

Modullevel
AS (Akzentsetzung / Accentuation)

Modulart
je nach Studiengang Pflicht oder Wahlpflicht
<table>
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<tr>
<th>Lern-Lehrform / Type of program</th>
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<tr>
<td>Final exam of module</td>
<td>The exam period will be announced during the course</td>
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<tr>
<td>Course type</td>
<td>Course selection</td>
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<td>SWS</td>
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<td>Frequency</td>
<td>WiSe</td>
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<td>Workload attendance</td>
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## inf360 - CurrentTopics in 'Hardware/Software Systems' I

<table>
<thead>
<tr>
<th>Module label</th>
<th>CurrentTopics in 'Hardware/Software Systems' I</th>
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<tbody>
<tr>
<td>Module code</td>
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</tr>
<tr>
<td>Credit points</td>
<td>3.0 KP</td>
</tr>
<tr>
<td>Workload</td>
<td>90 h</td>
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</table>
| Used in course of study             | - Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule  
                                         - Master Informatik > Mastermodule |
| Contact person                      | Module responsibility  
                                         - Andreas Hein  
                                         - Wolfgang Nebel  
                                         - Die im Modul Lehrenden  
                                         Authorized examiners  
                                         - Andreas Hein  
                                         - Wolfgang Nebel  
                                         - Die im Modul Lehrenden |
| Entry requirements                  | This module integrates current developments in the field in adequate study courses.  
                                         Professional competences  
                                         The students:  
                                         - Define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general  
                                         - Recognise and evaluate applied techniques and methods of their subject and are aware of their limits  
                                         - Identify, structure and solve problems/tasks, also in new or developing subject areas  
                                         - Apply state of the art and innovative methods to solve problems, if necessary from other disciplines  
                                         - Are aware of the current limits and contribute to the development of computer science research and technology  
                                         - Discuss and evaluate recent computer science developments  
                                         Methodological competences  
                                         The students:  
                                         - Examine tasks with technical and research literature, write an academic article and present their solutions academically  
                                         - Evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research  
                                         - Schedule time processes and resources  
                                         Social competences  
                                         The students:  
                                         - Communicate with users and experts convincingly  
                                         Self-competences  
                                         The students:  
                                         - Pursue the overall and special computer science development critically  
                                         - Develop and reflect self-developed hypotheses to theories independently |
<p>| Module contents                     | See assigned course description, e.g. „Energieeffizienz in der IKT“&quot;, „Smart Resource Integration&quot;, ... |
| Reader's advisory                   | As announced in course                        |
| Links                               |                                               |
| Language of instruction             | German                                        |
| Duration (semesters)                | 1 Semester                                    |
| Module frequency                    | unregelmäßig                                  |
| Module capacity                     | unlimited                                     |
| Modullevel                          | AS (Akzentsetzung)                            |
| Modulart                            | Wahlpflicht                                   |</p>
<table>
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<td>Final exam of module</td>
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<tr>
<td>Course type</td>
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<tr>
<td>SWS</td>
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<td>WiSe</td>
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<tr>
<td>Workload attendance</td>
<td>28 h</td>
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</table>
inf361 - Current Topics in 'Hardware/Software Systems' II

Module label
Current Topics in 'Hardware/Software Systems' II

Module code
inf361

Credit points
3.0 KP

Workload
90 h

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Mastermodule

Contact person
Module responsibility
- Andreas Hein
- Wolfgang Nebel
- Die im Modul Lehrenden

Authorized examiners
- Andreas Hein
- Wolfgang Nebel
- Die im Modul Lehrenden

Entry requirements
This module integrates current developments in the field in adequate study courses.

Professional competences
The students:

- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:

- examine tasks with technical and research literature, write an academic article and present their solutions academically
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research
- schedule time processes and resources

Social competences
The students:

- communicate with users and experts convincingly

Self-competences
The students:

- pursue the overall and special computer science development critically
- develop and reflect self-developed hypotheses to theories independently

Module contents
See assigned course description, e.g. „Energieeffizienz in der IKT“; „Smart Resource Integration“; ...

Reader's advisory
As announced in course

Links

Language of instruction
German

Duration (semesters)
1 Semester

Module frequency
unregelmäßig

Module capacity
unlimited

Modul level
AS (Akzentsetzung / Accentuation)

Modulart
je nach Studiengang Pflicht oder Wahlpflicht
<table>
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<tr>
<th>Lern-/Lehrform / Type of program</th>
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<td>At the end of the lecture period</td>
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<tr>
<td>Workload attendance</td>
<td>28 h</td>
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</table>
inf366 - Special Topics in 'Microrobotics and Control Engineering' I

Module label: Special Topics in 'Microrobotics and Control Engineering' I
Module code: inf366
Credit points: 6.0 KP
Workload: 180 h

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodul
- Master Informatik > Mastermodule

Contact person:
Module responsibility:
- Andreas Hein
- Sergej Fatikow
- Die im Modul Lehrenden

Authorized examiners:
- Andreas Hein
- Sergej Fatikow
- Die im Modul Lehrenden

Entry requirements:

Skills to be acquired in this module:
This module integrates current developments in the field in adequate study courses.

Professional competences
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:
- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

Social competences
The students:
- support team process by their abilities

Self-competences**
The students:
- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

Module contents:
See assigned course description, e.g. „Nanomontage und Nanohandhabung“

Reader's advisory:
As announced in course

Links

Language of instruction: German
Duration (semesters): 1 Semester
Module frequency: jährlich
Module capacity: unlimited
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<th>Type of examination</th>
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<td>Portfolio or presentation or oral exam</td>
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### Module label
Spezielle Themen aus dem Gebiet "Mikrorobotik und Regelungstechnik" II

### Module code
inf367

### Credit points
6.0 KP

### Workload
180 h

### Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Mastermodule

### Contact person

<table>
<thead>
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<th>Module responsibility</th>
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<tbody>
<tr>
<td>Andreas Hein</td>
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<tr>
<td>Sergej Fatikow</td>
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<tr>
<td>Die im Modul Lehrenden</td>
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<th>Authorized examiners</th>
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<tr>
<td>Andreas Hein</td>
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<tr>
<td>Sergej Fatikow</td>
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<tr>
<td>Die im Modul Lehrenden</td>
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</table>

### Entry requirements

This module integrates current developments in the field in adequate study courses.

### Professional competences

The students:

- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

### Methodological competences

The students:

- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

### Social competences

The students:

- support team process by their abilities

### Self-competences

The students:

- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

### Module contents
See assigned course description

### Reader's advisory
As announced in course

### Links

### Language of instruction
German

### Duration (semesters)
1 Semester

### Module frequency
unregelmäßig

### Module capacity
unlimited

### Modullevel
AS (Akzentsetzung / Accentuation)

### Modulart
je nach Studiengang Pflicht oder Wahlpflicht
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<td>Wi/Se</td>
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inf368 - Aktuelle Themen aus dem Gebiet "Mikrorobotik und Regelungstechnik" I

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<td>Master Informatik &gt; Mastermodule</td>
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<td>Contact person</td>
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<td>Module responsibility</td>
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<tr>
<td>• Andreas Hein</td>
<td></td>
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<tr>
<td>• Sergej Fatikow</td>
<td></td>
</tr>
<tr>
<td>• Die im Modul Lehrenden</td>
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<td>Authorized examiners</td>
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<tr>
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<td>• Sergej Fatikow</td>
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<td>• Die im Modul Lehrenden</td>
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<tr>
<td>Entry requirements</td>
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<tr>
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<tr>
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<tr>
<td>• define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general</td>
<td></td>
</tr>
<tr>
<td>• recognise and evaluate applied techniques and methods of their subject and are aware of their limits</td>
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<tr>
<td>• identify, structure and solve problems/tasks, also in new or developing subject areas</td>
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<tr>
<td>• apply state of the art and innovative methods to solve problems, if necessary from other disciplines</td>
<td></td>
</tr>
<tr>
<td>• are aware of the current limits and contribute to the development of computer science research and technology</td>
<td></td>
</tr>
<tr>
<td>• discuss and evaluate recent computer science developments</td>
<td></td>
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<tr>
<td>Methodological competences</td>
<td></td>
</tr>
<tr>
<td>The students:</td>
<td></td>
</tr>
<tr>
<td>• examine tasks with technical and research literature, write an academic article and present their solutions academically</td>
<td></td>
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<tr>
<td>• evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research</td>
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</tr>
<tr>
<td>• schedule time processes and resources</td>
<td></td>
</tr>
<tr>
<td>Social competences</td>
<td></td>
</tr>
<tr>
<td>The students:</td>
<td></td>
</tr>
<tr>
<td>• communicate with users and experts convincingly</td>
<td></td>
</tr>
<tr>
<td>Self-competences</td>
<td></td>
</tr>
<tr>
<td>The students:</td>
<td></td>
</tr>
<tr>
<td>• pursue the overall and special computer science development critically</td>
<td></td>
</tr>
<tr>
<td>• develop and reflect self-developed hypotheses to theories independently</td>
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</tr>
<tr>
<td>Module contents</td>
<td>See assigned course description</td>
</tr>
<tr>
<td>Reader's advisory</td>
<td>As announced in course</td>
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<td>Links</td>
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<td>Duration (semesters)</td>
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<td>Module frequency</td>
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<td>S or V</td>
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<td>Vorkenntnisse / Previous knowledge</td>
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<td>Examination</td>
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<td>Final exam of module</td>
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<td>Course type</td>
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<td>SWS</td>
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<td>Frequency</td>
<td>WiSe</td>
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<tr>
<td>Workload attendance</td>
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</table>
inf369 - Current Topics in 'Microrobotics and Control Engineering' II

<table>
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<tr>
<th>Module label</th>
<th>Current Topics in 'Microrobotics and Control Engineering' II</th>
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<tbody>
<tr>
<td>Module code</td>
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</tr>
<tr>
<td>Credit points</td>
<td>3.0 KP</td>
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<tr>
<td>Workload</td>
<td>90 h</td>
</tr>
</tbody>
</table>
| Used in course of study       | • Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule  
                              | • Master Informatik > Mastermodule                          |
| Contact person                | Module responsibility                                       |
|                               | • Andreas Hein                                              |
|                               | • Die im Modul Lehrenden                                    |
| Authorized examiners          | • Andreas Hein                                              |
|                               | • Die im Modul Lehrenden                                    |

Entry requirements

Skills to be acquired in this module

This module integrates current developments in the field in adequate study courses.

Professional competences

The students:

- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences

The students:

- examine tasks with technical and research literature, write an academic article and present their solutions academically
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research
- schedule time processes and resources

Social competences

The students:

- communicate with users and experts convincingly

Self-competences

The students:

- pursue the overall and special computer science development critically
- develop and reflect self-developed hypotheses to theories independently

Module contents

See assigned course description

Reader's advisory

As announced in course

Links

Language of instruction  German
Duration (semesters)   1 Semester
Module frequency      unregelmäßig
Module capacity        unlimited
Module level           AS (Akzentsetzung / Accentuation)
Modulart              je nach Studiengang Pflicht oder Wahlpflicht
Lern-Lehrform / Type of program  S or V
### Previous Knowledge

<table>
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<tbody>
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<td>Workload attendance</td>
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### inf374 - Special Topics in 'Automotive' I

<table>
<thead>
<tr>
<th>Module label</th>
<th>Special Topics in 'Automotive' I</th>
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<tr>
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<td>6.0 KP</td>
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<tr>
<td>Workload</td>
<td>180 h</td>
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</table>
| Used in course of study | • Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule  
                      | • Master Informatik > Mastermodule                                |
| Contact person     | Module responsibility  
                      | • Andreas Hein  
                      | • Martin Georg Fränzle  
                      | • Die im Modul Lehrenden  
                      | Authorized examiners  
                      | • Andreas Hein  
                      | • Martin Georg Fränzle  
                      | • Die im Modul Lehrenden |
| Entry requirements |  
                      | Skills to be acquired in this module  
                      | This module integrates current developments in the field in adequate study courses.  
                      | **Professional competences**  
                      | The students:  
                      | • define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general  
                      | • recognise and evaluate applied techniques and methods of their subject and are aware of their limits  
                      | • identify, structure and solve problems/tasks, also in new or developing subject areas  
                      | • apply state of the art and innovative methods to solve problems, if necessary from other disciplines  
                      | • are aware of the current limits and contribute to the development of computer science research and technology  
                      | • discuss and evaluate recent computer science developments  
                      | **Methodological competences**  
                      | The students:  
                      | • evaluate and apply tools, technology and methods sophisticatedly  
                      | • combine new and original approaches and methods creatively  
                      | • evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research  
                      | **Social competences**  
                      | The students:  
                      | • support team process by their abilities  
                      | **Self-competences**  
                      | The students:  
                      | • pursue the overall and special computer science development critically  
<pre><code>                  | • implement innovative professional activities effectively and independently |
</code></pre>
<p>| Module contents    | See assigned course description, e.g. „Zielarchitekturen Eingebetteter Systeme für Automotive-Anwendungen“ |
| Reader's advisory  | As announced in course                                           |
| Links              |<br />
| <strong>Language of instruction</strong> German                                  |
|                    | <strong>Duration (semesters)</strong> 1 Semester                                 |
|                    | <strong>Module frequency</strong> halbjährlich                                   |
|                    | <strong>Module capacity</strong> unlimited                                       |
|                    | <strong>Modulelevel</strong> AS (Akzentsetzung / Accentuation)                   |
|                    | <strong>Modulart</strong> je nach Studiengang Pflicht oder Wahlpflicht           |</p>
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<thead>
<tr>
<th>Lern-Lehrform / Type of program</th>
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<td>Vorkenntnisse / Previous knowledge</td>
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<td>Examination</td>
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**inf375 - Special Topics in 'Automotive' II**

<table>
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<tr>
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<td>Master Informatik &gt; Mastermodule</td>
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<tr>
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<tr>
<td></td>
<td>Andreas Hein</td>
</tr>
<tr>
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<td>Die im Modul Lehrenden</td>
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<tr>
<td>Authorized examiners</td>
<td>Andreas Hein</td>
</tr>
<tr>
<td></td>
<td>Die im Modul Lehrenden</td>
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</table>

**Entry requirements**

**Skills to be acquired in this module**

This module integrates current developments in the field in adequate study courses.

**Professional competences**

The students:

- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

**Methodological competences**

The students:

- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

**Social competences**

The students:

- Support team process by their abilities

**Self-competences**

The students:

- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

**Module contents**

See assigned course description

**Reader's advisory**

As announced in course

**Links**

- **Language of instruction**: German
- **Duration (semesters)**: 1 Semester
- **Module frequency**: unregelmäßig
- **Module capacity**: unlimited
- **Module level**: AS (Akzentsetzung / Accentuation)
- **Modulart**: je nach Studiengang Pflicht oder Wahlpflicht
- **Lern-Lehrform / Type of program**: 2 courses out of V, S, Ü, P, PR

**Vorkenntnisse / Previous knowledge**
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<th>Type of examination</th>
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<td>Final exam of module</td>
<td>The exam period will be announced during the course</td>
<td>Portfolio or presentation or oral exam</td>
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<td>Frequency</td>
<td>WiSe</td>
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<tr>
<td>Workload attendance</td>
<td>28 h</td>
</tr>
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</table>
inf376 - Current Topics in 'Automotive' I

<table>
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<th>Module label</th>
<th>Current Topics in 'Automotive' I</th>
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                          | Master Informatik > Mastermodule  |
| Contact person         | Module responsibility              |
|                        | Andreas Hein                       |
|                        | Die im Modul Lehrenden             |
| Authorized examiners   | Andreas Hein                       |
|                        | Die im Modul Lehrenden             |

**Entry requirements**

**Skills to be acquired in this module**

- This module integrates current developments in the field in adequate study courses.

**Professional competences**

- The students:
  - Define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
  - Recognise and evaluate applied techniques and methods of their subject and are aware of their limits
  - Identify, structure and solve problems/tasks, also in new or developing subject areas
  - Apply state of the art and innovative methods to solve problems, if necessary from other disciplines
  - Are aware of the current limits and contribute to the development of computer science research and technology
  - Discuss and evaluate recent computer science developments

**Methodological competences**

- The students:
  - Examine tasks with technical and research literature, write an academic article and present their solutions academically
  - Evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research
  - Schedule time processes and resources

**Social competences**

- The students:
  - Communicate with users and experts convincingly

**Self-competences**

- The students:
  - Pursue the overall and special computer science development critically
  - Develop and reflect self-developed hypotheses to theories independently

**Module contents**

See assigned course description

**Reader's advisory**

As announced in course

**Links**

- Language of instruction: German
- Duration (semesters): 1 Semester
- Module frequency: unregelmäßig
- Module capacity: unlimited
- Module level: AS (Akzentsetzung / Accentuation)
- Modulart: je nach Studiengang Pflicht oder Wahlpflicht
- Lern-/Lehrform / Type of program: S or V
**Vorkenntnisse / Previous knowledge**

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Course or seminar

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inf377 - Current Topics in 'Automotive' II

Module label
Current Topics in 'Automotive' II

Module code
inf377

Credit points
3.0 KP

Workload
90 h

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Mastermodule

Contact person
Module responsibility
- Andreas Hein
- Die im Modul Lehrenden

Authorized examiners
- Andreas Hein
- Die im Modul Lehrenden

Entry requirements

Skills to be acquired in this module
This module integrates current developments in the field in adequate study courses.

Professional competences
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:
- examine tasks with technical and research literature, write an academic article and present their solutions academically
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research
- schedule time processes and resources

Social competences
The students:
- communicate with users and experts convincingly

Self-competences
The students:
- pursue the overall and special computer science development critically
- develop and reflect self-developed hypotheses to theories independently

Module contents
See assigned course description

Reader's advisory
As announced in course

Links
Language of instruction
German

Duration (semesters)
1 Semester

Module frequency
unregelmäßig

Module capacity
unlimited

Module level
AS (Akzentsetzung / Accentuation)

Modulart
je nach Studiengang Pflicht oder Wahlpflicht

Lern-/Lehrform / Type of program
S or V
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## inf450 - Correctness of Graph Programs

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### Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodul
- Master Informatik > Mastermodule

### Contact person
- **Module responsibility**
  - Annegret Habel
  - Die im Modul Lehrenden
- **Authorized examiners**
  - Andreas Hein
  - Die im Modul Lehrenden

### Entry requirements

#### Skills to be acquired in this module
- **The objectives of this module are modelling of systems, system changes and system properties. Introduction to graph programs. Introduction into system correctness. Methods for proving system correctness.**

#### Professional competence
- The students:
  - Describe the basics of graph programs and graph properties
  - Describe verification procedures of system correctness

#### Methodological competence
- The students:
  - Model systems, system changes and system properties
  - Apply the formalism of graph programs

#### Social competence
- The students:
  - Solve problems in a team
  - Present and discuss their proposed solutions

#### Self-competence
- The students:
  - Reflect upon their actions with regard to term rewriting systems and the methods of those

### Module contents
- The module is an introduction to the modelling of systems, system changes and system properties by means of graphs, graph programs and graph conditions and presents a method for proving correctness of systems with respect to a pre- and a postcondition.

The basic structures used in this lecture are graphs; they are used in practically all domains of computing science for the representation of complex structures. Graph programs are constructed from the core constructs of nondeterministic rule application, sequential composition and iteration and they can effect programmatic changes of a graph structure. One well-known method for determining the correctness of programs with respect to a pre- and a postcondition is based on the construction of a weakest precondition of the postcondition with respect to the program and the attempt to decide whether the given precondition implies the computed weakest precondition.

### Reader's advisory

### Links
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| Vorkenntnisse / Previous knowledge | - inf400 Theoretische Informatik I  
- inf401 Theoretische Informatik II |
| Examination             | Time of examination | Type of examination |
| Final exam of module    | Will be announced during the course | presentation or oral exam |
| Course type             | Comment | SWS | Frequency | Workload attendance |
| Lecture                 | 3.00 | | | 42 h |
| Exercises               | 1.00 | | | 14 h |
| Total time of attendance for the module | | | | 56 h |
Inf453 - Combination of Specification Techniques

Module label
Combination of Specification Techniques

Module code
Inf453

Credit points
6.0 KP

Workload
180 h

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodul
- Master Informatik > Mastermodule

Contact person
Module responsibility
- Andreas Hein
- Ernst-Rüdiger Olderog
- Die im Modul Lehrenden

Authorized examiners
- Andreas Hein
- Ernst-Rüdiger Olderog
- Die im Modul Lehrenden

Entry requirements
Inf400/Inf401 Theoretische Informatik I and II

Skills to be acquired in this module
Introduction to the specification languages Z for data, CSP for processes, and their combination CSP-OZ for reactive systems with data and process parts.

Professional competence
The students:
- specify data and processes with Z, CSP and CSP-OZ formally
- check data refinement relations formally
- verify CSP-OZ specifications with FDR model checker

Methodological competence
The students:
- are able to integrate complementary specification methods

Social competence
The students:
- work together in small groups to solve problems
- present solutions to problems to groups of other students

Self-competence
The students:
- learn persistence in pursuing difficult tasks
- learn precision in specifying problems

Module contents
The course addresses a research trend in formal methods, the combination and integration of different specification methods. It focuses on a concrete combination CSP-OZ of the specification techniques CSP (Communicating Sequential Processes) for processes and Z and Object-Z for data, respectively. Reactive systems are described by CSP-OZ.

As a preparation, the specification languages Z and CSP are described, followed by the combination CSP-OZ with its process-oriented semantics. The concepts of refinement and inheritance and the possibility of automatic verification of a sublanguage of CSP-OZ with the FDR model checker for CSP will be discussed. Finally, the course explains possibilities of extending CSP-OZ for the specification of time-critical systems.

Topics:
- specification of complex data and operations in Z, type definition and pattern calculations of Z, data refinement
- specifications of communicating processes in CSP, operational semantics of CSP, three abstract semantic models

for CSP: Trace semantics, failures semantics, failures-divergences semantics, process refinement in the above semantics, FDR model checker for CSP
• combined specification method CSP-OZ, transformational semantics as CSP-process, theorems of refinements,

object-oriented concepts of class and inheritance in CSP-OZ

Reader's advisory

Essential:


Recommended:


Links

Language of instruction German
Duration (semesters) 1 Semester
Module frequency unregelmäßig
Module capacity unlimited
Modullevel ---
Modulart je nach Studiengang Pflicht oder Wahlpflicht

Lern-Lehrform / Type of program

Vorkenntnisse / Previous knowledge
- inf400 Theoretische Informatik I
- inf401 Theoretische Informatik II

Examination Time of examination Type of examination
Final exam of module At the end of the lecture period exercises and oral exam

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Total time of attendance for the module 56 h
### Module Information

**inf454 - Communicating and Mobile Systems**

**Module label**: Communicating and Mobile Systems

**Module code**: inf454

**Credit points**: 6.0 KP

**Workload**: 180 h

**Used in course of study**
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodul
- Master Engineering of Socio-Technical Systems > Systems Engineering
- Master Informatik > Mastermodule

**Contact person**

- Ernst-Rüdiger Olderog

**Entry requirements**

**Skills to be acquired in this module**

**Professional competence**

The students:

- Know the theory of the operational semantics of CCS and the ?-calculus
- Perform equivalence proofs using simulations and bisimulations
- Specify communicating and mobile systems with CCS and the ?-calculus

**Methodological competence**

The students:

- Learn about different views on mobility
- Recognize equivalences as formal means for system correctness

**Social competence**

The students:

- Work together in small groups to solve problems
- Present their solutions to groups of other students

**Self-competence**

The students:

- Learn persistence in pursuing difficult tasks
- Learn precision in specifying problems

**Module contents**

Communication is one of the basic concepts of computer science. It occurs between computers in a network as well as between components of a computer. The focus of the course is on Robin Milner’s ?-calculus. It enables a new modelling of communication, taking the location of the communication into account.

The ?-calculus can describe the change of data in a computer as well as the sending of messages or even programs along networks like the internet. It is also possible to describe reconfigurable networks. This will be shown using the examples of mobile phones, schedulers, automatic vending machines, data structures, communication protocols, and objects in object-oriented programming. All these applications are backed by the theory of the ?-calculus, which is based on operational semantics and a concept of behavioural equivalence. The theory will be explained in a step-by-step manner.

**Topics:**

- different views on mobility
- transition systems with simulations and bisimulations
- Milner’s Calculus of Communicating Systems (CCS) and Milner’s ?-calculus for mobile systems, both with operational semantics, structural congruence, strong equivalence and observational equivalence, relationship between reactions and transitions, solvability of recursive equations
- formal specification of examples of communicating and mobile systems using CCS and the ?-calculus
- proof of strong equivalence and observational equivalence of given processes
• specification of dynamic data structures in the ?-calculus

Reader's advisory


Links

Languages of instruction German, English
Duration (semesters) 1 Semester
Module frequency irregular
Module capacity unlimited
Module level AS (Akzentsetzung / Accentuation)
Modulart Pflicht o. Wahlpflicht / compulsory or optional
Lern-Lehrform / Type of program V+Ü
Vorkenntnisse / Previous knowledge Theoretical Computer Science II

Examination

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Course type

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Total time of attendance for the module 56 h
inf456 - Real-Time Systems

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**Used in course of study**
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Engineering of Socio-Technical Systems > Embedded Brain Computer Interaction
- Master Engineering of Socio-Technical Systems > Systems Engineering
- Master Informatik > Mastermodule

**Contact person**

- Module responsibility
  - Ernst-Rüdiger Olderog
  - Die im Modul Lehrenden

- Authorized examiners
  - Die im Modul Lehrenden
  - Ernst-Rüdiger Olderog

**Entry requirements**

**Skills to be acquired in this module**

**Introduction to formal methods of the specification and verification of time sensitive systems and their combinations.**

**Professional competence**
The students:

- Learn about different models of time and real-time properties
- Specify and verify real-time systems
- Model real-time systems using Timed Automata and PLC-Automata
- Apply the model checker UPPAAL for the verification of real-time properties
- Specify real-time systems using the Duration Calculus
- Learn about decidability and undecidability results for real-time systems

**Methodological competence**
The students:

- Recognize logic and automata as adequate forms for describing real-time systems

**Social competence**
The students:

- Work together in small groups to solve problems
- Present their solutions to groups of other students

**Self-competence**
The students:

- Learn persistence in pursuing difficult tasks
- Learn precision in specifying problems

**Module contents**

Examples of time-critical systems are railway control systems, robots, or even gas burners. It is essential for these systems to comply with certain timing conditions. For example, the control of a railway crossing must close the gates not later than 4 seconds after the sensors have reported an approaching train. If the gates are open, they should stay that way for at least 15 seconds to allow for a safe crossing of vehicles. Different specification methods have been developed to describe such timing conditions.

The Duration Calculus developed by Zhou Chaochen in 1991 is one attractive method. It is a logic combined with a calculus, in which the duration of states can be described. The course will introduce the Duration Calculus and will explain its application by means of examples. As further specification method Timed Automata introduced by Alur & Dill in 1994 will be presented. After the specification of real-time system requirements the verification of programs implementing these requirements will follow. The specification methods of the Duration Calculus and Timed Automata are used to describe the real-time behaviour of these programs. The correctness is then proven on the basis of these behavioral descriptions.

**Topics:**
• discrete and continuous model of time
• logics and automata models for the specification of real-time systems (predicate logic, Duration Calculus, Timed CTL, Timed Automata, PLC-Automata)
• decidability and undecidability results for real-time systems
• model checker UPPAAL for Timed Automata
• formal specification of real-time systems using Duration Calculus as well as Timed Automata and PLC-Automata
• verification of concrete Timed Automata using the model checker UPPAAL,
• transformation of Duration Calculus for discrete time into regular languages
• implementability of real-time systems on PLC-like hardware

Reader's advisory

essential:


recommended:


Links

Languages of instruction  German, English
Duration (semesters)  1 Semester
Module frequency  irregular
Module capacity  unlimited
Module level  AS (Akzentsetzung / Accentuation)
Modulart  Pflicht o. Wahlpflicht / compulsory or optional
Lern-Lehrform / Type of program  V+Ü
Vorkenntnisse / Previous knowledge  Theoretical Computer Science I and II

Examination Time of examination Type of examination
Final exam of module  At the end of the lecture period  Exercises and written or oral exam

Course type  Comment  SWS  Frequency  Workload attendance
Lecture  3.00  WiSe  42 h
Exercises  1.00  WiSe  14 h

Total time of attendance for the module  56 h
### inf458 - Term Rewriting Systems

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### Entry requirements

**Skills to be acquired in this module**
The objectives of this module are an introduction to (term) rewriting systems, termination and confluence, the undecidable sets of termination and confluence problems, verification procedures of termination and confluence.

**Professional competence**
The students:

- describe the basics of term rewriting systems
- characterise the undecidability of termination and confluence problems
- describe verification procedures of termination and confluence

**Methodological competence**
The students:

- apply verification procedures of termination and confluence
- apply Huet's completion procedure

**Social competence**
The students:

- solve problems in a team
- present and discuss their results

**Self-competence**
The students:

- reflect their actions with regard to term rewriting systems and the methods of those

### Module contents
The module is an introduction to term rewriting systems and provides verification procedures for termination and confluence. Term rewriting systems, termination and confluence are introduced, the undecidability of termination and confluence problems and the decidability for a set of special term rewriting systems are shown. For this purpose reduction and simplification orders, critical pairs, orthogonality and Huet's completion procedure are introduced, examined and combined.

### Reader's advisory


### Links

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Modullevel  ---
Modulart  je nach Studiengang Pflicht oder Wahlpflicht

Lern-/Lehrform / Type of program

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Course type  Comment  SWS  Frequency  Workload attendance
Lecture  3.00  42 h
Exercises  1.00  14 h

Total time of attendance for the module  56 h
Energy Informatics Practical

Module label
Energy Informatics Practical

Module code
inf513

Credit points
6.0 KP

Workload
180 h

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Mastermodule
- Master Wirtschaftsinformatik > Bereichswahlmodule

Contact person
Module responsibility
- Andreas Hein
- Jorge Marx Gomez
- Sebastian Lehnhoff
- Die im Modul Lehrenden

Authorized examiners
- Andreas Hein
- Jorge Marx Gomez
- Sebastian Lehnhoff
- Die im Modul Lehrenden

Entry requirements
Programming with JAVA

Skills to be acquired in this module
Successfully completing this lecture will enable the students to mathematically model simple controllable electrical generators and consumers and to simulate them together with appropriate control algorithms within smart grid scenarios. To achieve this goal, students will start with deriving computational models from physical models and evaluate them. In order to manage the integration of control algorithms, students are taught the principles of cosimulation using the "mosaik" smart grid co-simulation framework as an example.

Students will be able to understand and apply distributed, agent-based control schemes to decentralized energy generators and/or consumers. As a result, students are able to analyze the requirements for successful application to real power balancing regarding capacity utilization, robustness, and flexibility. In addition, students learn the foundations of planning and conducting simulation based experiments as well as the interpretation of the results. Special attention will be paid on establishing a balance between the results' precision and robustness and the necessary effort (design of experiments) in order to gain as much insight into interdependencies with as few experiments as possible.

Professional competence
The students:
- derive and evaluate computational models from physical models
- use the "mosaik" smart grid co-simulation framework
- analyze the requirements for successful applications to real power balancing regarding capacity utilization, robustness, and flexibility
- name the foundations of planning and conducting simulation based experiments as well as the interpretation of the results
- are aware of the balance between the results' precision and robustness and the necessary effort (design of experiments) in order to gain as much insight into interdependencies with as few experiments.

Methodological competence
The students:
- model simple controllable electrical generators and consumers
- simulate simple controllable electrical generators and consumers with appropriate control algorithms within smart grid scenarios
- apply distributed agent-based control schemes to decentralized energy generators and/or consumers
- evaluate simulation results
- search information and look into methods to implement models
- propose hypothesis and check their validity with design of experiments methods

Social competence
The students:
- apply the pair programming development technique
- discuss design decisions
- identify work packages and are responsible for it

Self-competence
The students:
• reflect on their own use of power as a limited resource
• accept and use criticism to develop their own behaviour

Module contents

In this practical course students:

• model controllable, modulating electrical energy generators and consumers,
• put their hands on mosaik (installation, description and configuration of scenarios, conduction of simulations),
• learn the principles of agent-based heuristics for optimization problems in future smart grid scenarios,
• learn about the challenges of implementing agent-based mechanisms (multi-criticality, convergency, quality) on the training,
• learn the foundations for choice and design of simulation based experiments.

Reader's advisory

Suggested reading:

Smart Grids:


Multiagentensysteme:

• Ferber J.; Kirn, S.: "Multiagentensysteme: eine Einführung in die Verteilte Künstliche Intelligenz", Addison-Wesley, 2001

Co-Simulation


Versuchsplanung:

• Kleppmann, W.: "Versuchsplanung", Hanser, 2013
• Klein, B.: "Versuchsplanung - DoE", Oldenburg, 2011

Links

http://mosaik.offis.de

Language of instruction

German

Duration (semesters)

1 Semester

Module frequency

jährlich

Module capacity

unlimited

Reference text

Elective module in the master specialization area (energy computer science).

Associated with the modules:

• Energieinformationssysteme
• Smart Grid Management

Modullevel

AS (Akzentsetzung / Accentuation)

Modulart

je nach Studiengang Pflicht oder Wahlpflicht

Lern-Lehreform / Type of program

Vorkenntnisse / Previous knowledge

- Programmierung mit Java
- Programmierung mit Python

Examination

Time of examination

Type of examination

Final exam of module

At the end of the semester

Oral exam

Course type

Practical
<p>| | |</p>
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<tr>
<td>Workload attendance</td>
<td>56 h</td>
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inf533 - Probabilistic Modelling I

Module label: Probabilistic Modelling I
Module code: inf533
Credit points: 3.0 KP
Workload: 90 h

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Engineering of Socio-Technical Systems > Systems Engineering
- Master Informatik > Mastermodule
- Master Wirtschaftsinformatik > Bereichswahlmodule

Contact person:
Module responsibility:
- Claus Möbus
- Die im Modul Lehrenden

Authorized examiners:
- Claus Möbus
- Die im Modul Lehrenden

Entry requirements:
Skills to be acquired in this module:
Probabilistic Bayesian models are generated with special tools (e.g. BUGS, JAGS, STAN) or programming languages (CHURCH, FIGARO, etc.). If they mimic cognitive processes of humans (e.g. pilots, drivers) or animals they could be used as assistance systems in technical systems like cars or robots.

Professional competence
The students:
- learn to map problem to model classes to come up with practical solutions

Methodological competence
The students:
- acquire basic skills in the design, implementation, and identification of probabilistic models with Bayesian methods
- acquire knowledge about alternative non-Bayesian machine learning methods

Social competence
The students:
- learn to present and discuss probabilistic theories, methods, and models.

Self-competence
The students:
- reflect and evaluate chances and limitations of probabilistic approaches
- learn to deliberate on machine-learning alternatives

Module contents:
Theories, methods, and examples of Bayesian models with practical applications

Reader's advisory:
Recent eBooks, eTutorials

Links:
http://www.uni-oldenburg.de/en/computingscience/lcs/probabilistic-programming/

Languages of instruction:
German, English

Duration (semesters):
1 Semester

Module frequency:
jährlich

Module capacity:
unlimited

Reference text:
Associated with the module:
- inf534 Probabilistic Modelling II

Modullevel:
AS (Akzentsetzung / Accentuation)

Modulart:
Pflicht o. Wahlpflicht / compulsory or optional
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<th>Lern-Lehrform / Type of program</th>
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<tr>
<td>Vorkenntnisse / Previous knowledge</td>
<td>Basic programming skills</td>
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<td>Time of examination</td>
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<td>Will be announced in the lecture</td>
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### inf534 - Probabilistic Modelling II

<table>
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<tr>
<td>Module code</td>
<td>inf534</td>
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<tr>
<td>Credit points</td>
<td>6.0 KP</td>
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<tr>
<td>Workload</td>
<td>180 h</td>
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<td></td>
<td>Master Informatik &gt; Mastermodule</td>
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<tr>
<td></td>
<td>Master Wirtschaftsinformatik &gt; Bereichswahlmodule</td>
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<tr>
<td>Contact person</td>
<td>Module responsibility</td>
</tr>
<tr>
<td></td>
<td>• Andreas Hein</td>
</tr>
<tr>
<td></td>
<td>• Claus Möbus</td>
</tr>
<tr>
<td>Authorized examiners</td>
<td>• Die im Modul Lehrenden</td>
</tr>
<tr>
<td>Entry requirements</td>
<td>Skills to be acquired in this module</td>
</tr>
<tr>
<td></td>
<td>Probabilistic models are generated with special tools (e.g. BUGS, JAGS, STAN) or programming languages (CHURCH, FIGARO, etc.). If they mimic cognitive processes of humans (e.g. pilots, drivers) or animals they could be used as assistance systems in technical systems like cars or robots. In this part of the seminar we read, present, and discuss recent research papers.</td>
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<td></td>
<td><strong>Professional competence:</strong></td>
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<td></td>
<td>The students:</td>
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<tr>
<td></td>
<td>• learn to connect problem- with model classes to come up with practical solutions</td>
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<td><strong>Methodological competence</strong></td>
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<tr>
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<td>The students:</td>
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<tr>
<td></td>
<td>• acquire advanced skills in the design, implementation, and identification of probabilistic models with Bayesian methods</td>
</tr>
<tr>
<td></td>
<td>• acquire knowledge about alternative machine learning methods</td>
</tr>
<tr>
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<td><strong>Social competence</strong></td>
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<tr>
<td></td>
<td>The students:</td>
</tr>
<tr>
<td></td>
<td>• learn to present and discuss probabilistic theories, methods, and models</td>
</tr>
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<td></td>
<td><strong>Self-competence</strong></td>
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<tr>
<td></td>
<td>The students:</td>
</tr>
<tr>
<td></td>
<td>• reflect and evaluate chances and limitations of probabilistic approaches</td>
</tr>
<tr>
<td></td>
<td>• learn to deliberate on machine-learning alternatives</td>
</tr>
<tr>
<td>Module contents</td>
<td>Theories, methods, and examples of Bayesian models with practical applications</td>
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<td>Reader's advisory</td>
<td>Recent publications</td>
</tr>
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<td>Language of instruction</td>
<td>German</td>
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<td>Duration (semesters)</td>
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<td>• inf533 Probabilistische Modellierung I</td>
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<td>AS (Akzentsetzung / Accentuation)</td>
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<td>Modulart</td>
<td>je nach Studiengang Pflicht oder Wahlpflicht</td>
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<tr>
<td>Lern-Lehrform / Type of program</td>
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<td>Vorkenntnisse / Previous knowledge</td>
<td>- Grundkenntnisse Progammierung</td>
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<td>Time of examination</td>
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<td>Final exam of module</td>
<td>seminar talk, reflective written summary</td>
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**inf950 - Interdisziplinäres Modul I**

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| Used in course of study | Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodul  
                         | Master Informatik > Mastermodule |
| Contact person       | Module responsibility      |
|                      | - Die im Modul Lehrenden   |
|                      | Authorized examiners       |
|                      | - Die im Modul Lehrenden   |

**Entry requirements**

**Skills to be acquired in this module**

**Ziele des Moduls/Kompetenzen:**
Die Absolventinnen und Absolventen kennen die Grundlagen und anwendungsrelevanten Hintergründe der ausgewählten Disziplin.

**Fachkompetenzen**
Die Studierenden:

- benennen die Grundlagen und Methoden des gewählten Gebietes
- wenden die Fachsprache des Anwendungsgebietes kompetent an

**Methodenkompetenzen**
Die Studierenden:

- charakterisieren Nutzungskontext und Anforderungen von IT im gewählten Gebiet
- wenden die disziplinären Methoden und Techniken des Anwendungsgebietes an und kontrastieren diese mit den aus der Informatik bekannten Methoden und Techniken
- untersuchen Probleme eines Anwendungsgebietes mit den disziplin-typischen Methoden

**Sozialkompetenzen**
Die Studierenden:

- können die Verschiedenheit von Fachkulturen einschätzen und respektieren andere Fachgebiete und deren Arbeitsweise
- bereiten sich auf Anwendungsszenarien für IT-Systeme vor

**Selbstkompetenzen**
Die Studierenden:

- reflektieren ihr Selbstbild und Handeln vor dem Hintergrund einer anderen Fachdisziplin

**Module contents**
Das Modul wird mit Fachmodulen aus anderen Disziplinen oder Modulen des Departments für Informatik instanziert, die als Nicht Informatik-Modul gekennzeichnet sind. Die Veranstaltungsformen und Prüfungsmodalitäten orientieren sich an dem jeweils gewählten Modul.

**Reader's advisory**

**Languages of instruction**

**Duration (semesters)** 1 Semester

**Module frequency**

**Module capacity** unlimited

**Modulelevel** AS (Akzentsetzung / Accentuation)

**Modulart** je nach Studiengang Pflicht oder Wahlpflicht

**Lern-Lehrform / Type of program**

**Vorkenntnisse / Previous knowledge**

**Examination**

**Time of examination**

**Type of examination**

**Final exam of module** Portfolio oder Referat oder mündliche Prüfung oder
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### inf951 - Interdisziplinäres Modul II

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<td>Master Informatik &gt; Mastermodule</td>
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### Contact person

### Entry requirements

### Skills to be acquired in this module

### Module contents

### Reader's advisory

### Links

### Languages of instruction

### Duration (semesters)

### 1 Semester

### Module frequency

### Module capacity

### unlimited

### Modulelevel

### BC (Basiscurriculum / Base curriculum)

### Modulart

### je nach Studiengang Pflicht oder Wahlpflicht

### Lern-/Lehrform / Type of program

### Vorkenntnisse / Previous knowledge

### Examination

### Time of examination

### Type of examination

**Final exam of module**

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<th>Type of examination</th>
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### Course type

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### SWS

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### Workload attendance

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Abschlussmodul
mam - Master´s Thesis Module

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<tr>
<td></td>
<td>Michael Sonnenschein</td>
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<td>Lehrende der Informatik</td>
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<td></td>
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<tr>
<td></td>
<td>Lehrende der Informatik</td>
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</tbody>
</table>

Entry requirements

Skills to be acquired in this module
The students prove that they are able to process and solve complex computer science tasks based on gained scientific knowledge and applied research methods. The students successfully implement a task especially by using their acquired professional and methodological knowledge and their professional and social competences. The accompanying seminar is used to discuss the master’s thesis methodically and content-related. During the seminar the exchange of research and practical experience fosters the students’ ability to discuss and evaluate their thesis with other students and experts. The master’s thesis is finished by a colloquium.

Professional competence
The students:
- Recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- Design solutions for complex, possibly vaguely defined or unusual computer science tasks/problems and evaluate these with reference to state of the art computer science and technology
- Identify, structure and solve problems/tasks, also in new or developing subject areas
- Apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- Relate knowledge from different disciplines and apply this new knowledge in complex situations
- Develop complex computer systems, processes and datamodels
- Are aware of the current limits and contribute to the development of computer science research and technology
- Discuss and evaluate recent computer science developments

Methodological competence
The students:
- Identify and develop one or more solutions
- Evaluate and apply tools, technology and methods sophisticatedly
- Examine tasks with technical and research literature, write an academic article and present their solutions academically
- Schedule processes and resources
- Apply project management techniques
- Combine new and original approaches and methods creatively
- Evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

Social competence
The students:
- Communicate with users and experts convincingly
- Take reasonable decisions

Self-competence
The students:
- Pursue the overall and special computer science development critically
- Implement innovative professional activities effectively and independently
- Recognise their abilities and extend them purposefully
- Reflect their self-perception and actions with regard to professional, methodological and social aspects
- Develop and reflect self-developed hypotheses to theories independently
- Work in their field independently

<table>
<thead>
<tr>
<th>Module contents</th>
<th>The content of this module is an independent topic research. The research findings will be presented and discussed in a master’s thesis colloquium.</th>
</tr>
</thead>
</table>

**Reader’s advisory**

**Links**

- **Languages of instruction**: German, English
- **Duration (semesters)**: 1 Semester
- **Module frequency**: halbjährlich
- **Module capacity**: unlimited
- **Modullevel**: Abschlussmodul (Abschlussmodul)
- **Modulart**: Pflicht
- **Lern-Lehrform / Type of program**: Master’s thesis

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<th>Time of examination</th>
<th>Type of examination</th>
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<tbody>
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<td>Final exam of module</td>
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<td>Master’s thesis, presentation and discussion.</td>
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<table>
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<th>Seminar</th>
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