# Module Catalog 2024/2025
# Master of Science Computer Science

| **HPI-CS-AAC: Applied Algorithms - Core** | Number of credit points (CP): 6 |
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| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>The subject of this module is the concrete and efficient implementation of algorithms. In particular, it is about the creative solution to problems in the area of algorithms and then the subsequent implementation as a computer program. Various topics from the areas of graph algorithms, string algorithms, algorithmic number theory or related areas are covered.<br>Qualification goals:<br>Students acquire detailed knowledge of the specialized topic covered in the module.<br>Students<br>- become familiar with techniques and libraries for the efficient implementation of algorithms as computer programs,<br>- can analyze a complex, linguistic problem and convert it into a formal problem,<br>- are able to span the entire spectrum from problem description to executable code,<br>- can solve algorithmic problems creatively,<br>- are able to translate algorithms into efficient code in a short time. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | none |
| Department: | Digital Engineering |

| **HPI-CS-AAD: Applied Algorithms - Deep Dive** | Number of credit points (CP): 6 |
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| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>The subject of this in-depth module is the concrete and efficient implementation of algorithms. In particular, it is about the creative solution of advanced problems in the field of algorithms and subsequent implementation as a computer program. Various advanced topics from the areas of graph algorithms, string algorithms, algorithmic number theory or related areas are covered.<br>Qualification goals:<br>Students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- become familiar with advanced techniques and libraries for the efficient implementation of algorithms as computer programs,<br>- can analyze a complex, linguistic problem and convert it into a formal problem,<br>- are able to span the entire spectrum from complex problem descriptions to executable code;<br>- can creatively solve advanced algorithmic problems,<br>- are able to translate complex algorithms into efficient code in a short time. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-AAC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-AAS: Applied Algorithms - Specialization** | Number of credit points (CP): 6 |
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| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>The subject of this in-depth module is the concrete and efficient implementation of algorithms. In particular, it is about the creative solution of advanced problems in the field of algorithms and subsequent implementation as a computer program. Various advanced topics from the areas of graph algorithms, string algorithms, algorithmic number theory or related areas are covered.<br>Qualification goals:<br>Students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- become familiar with advanced techniques and libraries for the efficient implementation of algorithms as computer programs,<br>- can analyze a complex, linguistic problem and convert it into a formal problem,<br>- are able to span the entire spectrum from complex problem descriptions to executable code,<br>- can creatively solve advanced algorithmic problems,<br>- are able to translate complex algorithms into efficient code in a short time. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-AAC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-ADC: Advanced Data Systems - Core** | Number of credit points (CP): 6 |
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| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>Data processing systems are an essential component in all economic sectors (e.g., production, industry, service), in many applications, for example in medicine, trade, infrastructure, communication, and in many scientific disciplines. The underlying information systems require efficient concepts and methods for storing and retrieving data. This module teaches basic data structures and access methods with their advantages, disadvantages, and limitations. Building on this, concepts of scalable information systems are discussed. This module also deals with the efficient processing of queries using intelligent algorithms on the data. The requests are characterized into different types, and efficient algorithms are discussed for processing them. Access and query methods can be further improved, for example, through hardware-related optimization.<br>Qualification goals:<br>Students<br>- learn scalable data structures and access methods,<br>- gain knowledge of intelligent query processing,<br>- learn implementation concepts and algorithms,<br>- expand their professional judgment skills,<br>-gain the ability to independently access and use suitable sources of information to solve problems,<br>- learn how to independently work on a topic based on primary and secondary literature,<br>- gain experience in the formalization and abstraction of problems. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-ADD: Advanced Data Systems - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>The module provides in-depth practical knowledge of scalable data systems using common software tools. Classic access methods and query algorithms are compared with the current state of the art. The limits of classic techniques are thus shown and the limitations of the current state of the art also examined. Students are made aware of open problems and are instructed in developing their own solutions to these open research questions.<br>Qualification goals:<br>Students<br>- learn the practical mastery of data systems,<br>- can assess the differences between classic access methods and query algorithms and the current state of the art,<br>- acquire the ability to independently access and use suitable sources of information to solve problems,<br>- learn how to independently carry out the in-depth investigation of a topic based on primary and secondary literature,<br>- are able to follow current research trends and incorporate them into their work,<br>- can select and apply suitable solution concepts and strategies to a given problem. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-ADC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-ADS: Advanced Data Systems - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module addresses current, in-depth research questions and results in the context of scalable data systems. It particularly deals with the identification of weaknesses in the current state of the art and the scientific development of related, specialized techniques for efficient access and query methods. This is primarily done using one or more specific, advanced application scenarios.<br>Qualification goals:<br>Students<br>- work on developing limitations and extensions of existing scalable complex data systems,<br>- deal with new advanced data processing methods, such as in-memory technologies,<br>- learn how to scientifically process current, in-depth research questions in the area of scalable data systems,<br>- gain subject-specific theoretical, methodological and practical knowledge,<br>- can select and apply suitable solution concepts and strategies to a given, specialized problem,<br>- learn to follow current, advanced research trends and incorporate them into their work,<br>- are able to independently access and evaluate scientific literature on individual topics,<br>- gain experience in the formalization and abstraction of in-depth problems,<br>- get to know criteria and principles of scientific writing,<br>- learn methods for presenting and defending completed tasks. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-ADC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-AIC: AI Applications - Core** | Number of credit points (CP): 6 |
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| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>Artificial intelligence (AI) has opened up a wide range of new applications and is increasingly shaping everyday life. This module covers AI techniques and concepts in applications, such as computer vision, natural language processing (NLP) or digital health. Students acquire both theoretical and practical knowledge in the development of AI systems; for example, through various forms of machine learning or suitable optimization algorithms. Students gain experience in designing application-specific models and systems as well as in modeling domain-specific data. This module provides an in-depth understanding of various AI paradigms with regard to their strengths and weaknesses—as well as potential ethical or social opportunities and risks in the context of specific AI applications. The practical understanding of methods is deepened in the lecture by practical exercises.<br>Qualification goals:<br>Students<br>- learn the practical mastery of artificial intelligence methods,<br>- acquire the ability to assess the differences between various model architectures and algorithms,<br>- acquire the ability to independently access and use suitable sources of information to solve problems,<br>- learn how to independently carry out the in-depth investigation of a topic based on primary and secondary literature,<br>- learn to follow current research trends and incorporate them into their work,<br>- are able to select and apply suitable solution concepts and strategies to a given problem. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-AID: AI Applications - Deep Dive** | Number of credit points (CP): 6 |
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| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>Artificial intelligence (AI) has opened up a wide range of new applications and is increasingly shaping everyday life. This module covers AI techniques and concepts in applications, such as computer vision, natural language processing (NLP) or digital health. Students acquire both theoretical and practical knowledge in the development of AI systems; for example, through various forms of machine learning or suitable optimization algorithms. Students gain experience in designing application-specific models and systems as well as in modeling domain-specific data. This module provides an in-depth understanding of various AI paradigms with regard to their strengths and weaknesses—as well as potential ethical or social opportunities and risks in the context of specific AI applications. The practical understanding of methods is deepened in the lecture by practical exercises.<br>Qualification goals:<br>Students<br>- learn the practical mastery of artificial intelligence methods,<br>- acquire the ability to assess the differences between various model architectures and algorithms,<br>- can independently access and use suitable sources of information to solve problems,<br>- learn how to independently carry out the in-depth investigation of a topic based on primary and secondary literature,<br>- learn to follow current research trends and incorporate them into their work,<br>- can select and apply suitable solution concepts and strategies to a given problem. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-AIC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-AIS: AI Applications - Specialization** | Number of credit points (CP): 6 |
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| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>Artificial intelligence (AI) has opened up a wide range of new applications and is increasingly shaping everyday life. This module covers AI techniques and concepts in applications, such as computer vision, natural language processing (NLP) or digital health. Students acquire both theoretical and practical knowledge in the development of AI systems; for example, through various forms of machine learning or suitable optimization algorithms. Students gain experience in designing application-specific models and systems as well as in modeling domain-specific data. This module provides an in-depth understanding of various AI paradigms with regard to their strengths and weaknesses—as well as potential ethical or social opportunities and risks in the context of specific AI applications. The practical understanding of methods is deepened in the lecture by practical exercises.<br>Qualification goals:<br>Students<br>- learn the practical mastery of artificial intelligence methods,<br>- acquire the ability to assess the differences between various model architectures and algorithms,<br>- can independently access and use suitable sources of information to solve problems,<br>- learn how to independently carry out the in-depth investigation of a topic based on primary and secondary literature,<br>- learn to follow current research trends and incorporate them into their work,<br>- can select and apply suitable solution concepts and strategies to a given problem. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-AIC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-ALG: Algorithmics** | Number of credit points (CP): 6 |
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| Module type (compulsory or compulsory elective module): | Compulsory module/ compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module covers algorithm design and algorithm analysis in various areas. As part of these considerations, appropriate data structures are presented and analyzed. Focus topics include graph problems (e.g., path problems, flows), geometric problems (e.g., embeddings) or string problems (e.g., string matching algorithms). The core is mathematical analysis and formal proofs. Concrete proof strategies are presented and deepened.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- familiarize themselves with various algorithms for classical problems and their analyses;<br>- understand in detail the advantages and disadvantages of different algorithms for classical problems and the reasons for these differences;<br>- are able to independently analyze and develop algorithms within the presented areas;<br>- can fluently reason mathematically and express their ideas in written form as evidence;<br>- gain insight into the current state of research. |
| Partial module exams (number, form, scope): | Exam types:<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (50%) | - |

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|---|---|
| Frequency of offer: | WiSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-AMC: Advanced Machine Learning - Core** | Number of credit points (CP): 6 |
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| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module provides knowledge of advanced techniques and mathematical foundations of machine learning and artificial intelligence, including probabilistic learning, deep learning, reinforcement learning and semi-supervised learning. Content includes the optimization of machine learning processes as well as practical use cases in digital health, such as predictive modeling, recommendation systems, image and text analysis. It highlights challenges such as data bias and overfitting. Students also learn methods for model validation and performance evaluation. After completing the module, students should be able to develop new machine learning methods and find innovative problem solutions using machine learning.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- gain comprehensive knowledge of concepts, algorithms, and applications of machine learning,<br>- acquire the ability to recognize and analyze complex data patterns and to make predictions and decisions,<br>- can implement algorithms and train models in order to solve problems in digital health relevant-areas, such as image recognition, language processing, or financial analysis,<br>- deepen knowledge of statistical methods and optimization techniques that are essential for machine learning,<br>- can apply what they have learned and develop their own models in practical exercises and projects,<br>- gain in-depth knowledge needed to be successful in the rapidly evolving world of artificial intelligence and machine learning. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-AMD: Advanced Machine Learning - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module provides knowledge of advanced techniques and mathematical foundations of machine learning and artificial intelligence, including probabilistic learning, deep learning, reinforcement learning and semi-supervised learning. Content includes the optimization of machine learning processes as well as practical use cases in digital health, such as predictive modeling, recommendation systems, image and text analysis. It highlights challenges such as data bias and overfitting. Students also learn methods for model validation and performance evaluation. After completing the module, students should be able to develop new machine learning methods and find innovative problem solutions using machine learning.<br><br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- gain comprehensive knowledge of concepts, algorithms, and applications of machine learning,<br>- acquire the ability to recognize and analyze complex data patterns and to make predictions and decisions,<br>- can implement algorithms and train models in order to solve problems in digital health relevant-areas, such as image recognition, language processing, or financial analysis,<br>- deepen knowledge of statistical methods and optimization techniques that are essential for machine learning,<br>- can apply what they have learned and develop their own models in practical exercises and projects,<br>- gain in-depth knowledge needed to be successful in the rapidly evolving world of artificial intelligence and machine learning. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time<br>(in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-AMC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-AMS: Advanced Machine Learning - Specialization** | Number of credit points (CP): 6 |
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| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module provides knowledge of advanced techniques and mathematical foundations of machine learning and artificial intelligence, including probabilistic learning, deep learning, reinforcement learning and semi-supervised learning. Content includes the optimization of machine learning processes as well as practical use cases in digital health, such as predictive modeling, recommendation systems, image and text analysis. It highlights challenges such as data bias and overfitting. Students also learn methods for model validation and performance evaluation. After completing the module, students should be able to develop new machine learning methods and find innovative problem solutions using machine learning.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- gain comprehensive knowledge of concepts, algorithms, and applications of machine learning,<br>- acquire the ability to recognize and analyze complex data patterns and to make predictions and decisions,<br>- can implement algorithms and train models in order to solve problems in digital health relevant-areas, such as image recognition, language processing, or financial analysis,<br>- deepen their knowledge of statistical methods and optimization techniques that are essential for machine learning,<br>- can apply what they have learned and develop their own models in practical exercises and projects,<br>- gain in-depth knowledge needed to be successful in the rapidly evolving world of artificial intelligence and machine learning. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-AMC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-ASC: Algorithms and Security - Core** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module provides an introduction to the basics of IT security in the context of digital health. This includes identifying security risks, protecting against attacks and threats, ensuring data integrity and confidentiality, and implementing security policies and measures.<br>This module also provides an introduction to the basics of algorithms and data structures relevant to the digital health industry. This includes concepts such as sorting algorithms, search algorithms, graph algorithms and optimal algorithms.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- learn decision-making algorithms in medical diagnosis, prognosis and treatment planning using machine learning algorithms, decision trees, artificial intelligence and other techniques,<br>- master the processing and analysis of large data sets (big data) using techniques such as data mining, statistical analysis, pattern recognition and machine learning,<br>- deepen their knowledge of cryptography and data protection, encryption techniques, secure communication, digital signatures and anonymization methods,<br>- expand their knowledge of security in connected devices and systems, security risks and measures related to connected medical devices, wearables and other digital health systems. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-ASD: Algorithms and Security - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Partial module exams (number, form, scope): | Content:<br>This module deepens the topics of IT security in the context of digital health. In today's connected world, the security of sensitive health data is critical. This module provides students with advanced knowledge to identify security risks, defend against attacks and threats, ensure data integrity and confidentiality, and implement security policies and measures.<br>An important aspect of this module is the identification of complex security risks. Students learn to identify and analyze potential vulnerabilities and threats in digital health systems. These include, among others, insecure network communication, lack of access control, software and hardware vulnerability, inadequate encryption and social engineering attacks. Through a deeper understanding of these risks, students are able to take and develop appropriate protective measures. Algorithms play a crucial role here as they can be used to detect, analyze, and defend against threats and attacks.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- learn decision-making algorithms in medical diagnosis, prognosis and treatment planning using machine learning algorithms, decision trees, artificial intelligence and other techniques,<br>- master the processing and analysis of large data sets (big data) using techniques such as data mining, statistical analysis, pattern recognition and machine learning,<br>- deepen their knowledge of cryptography and data protection, encryption techniques, secure communication, digital signatures and anonymization methods,<br>- expand their knowledge of security in connected devices and systems, security risks and measures related to connected medical devices, wearables and other digital health systems. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time<br>(in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-ASC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-ASS: Algorithms and Security - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module deepens the topics of IT security in the context of digital health. In today's connected world, the security of sensitive health data is critical. The module provides students with further, in-depth knowledge to identify security risks, ward off attacks and threats, ensure data integrity and confidentiality, and implement security policies and measures.<br>An important aspect of this module is the identification of complex security risks. Students learn to identify and analyze potential, complex vulnerabilities and threats in digital health systems. These include, among others, insecure network communication, lack of access control, software and hardware vulnerability, inadequate encryption and social engineering attacks. Through a deeper and more advanced understanding of these risks, students are able to take and develop appropriate protective measures. Algorithms play a crucial role here as they can be used to detect, analyze and defend against threats and attacks.<br><br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- learn decision-making algorithms in medical diagnosis, prognosis and treatment planning using machine learning algorithms, decision trees, artificial intelligence and other techniques,<br>- master the processing and analysis of large data sets (big data) using techniques such as data mining, statistical analysis, pattern recognition and machine learning,<br>- deepen their knowledge of cryptography and data protection, encryption techniques, secure communication, digital signatures and anonymization methods,<br>- expand their knowledge of security in connected devices and systems, security risks and measures related to connected medical devices, wearables and other digital health systems. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-ASC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-ATC: Algorithm Theory - Core** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>In this module, approaches for solving NP-hard problems (e.g., approximation algorithms, parameterized algorithms) are discussed. The focus is on the mathematical version of the solution, especially algorithm analysis and algorithm design. Impossibility results complement the field of algorithm development.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- know approaches for solving NP-hard problems,<br>- know central impossibility results,<br>- understand in detail the advantages and disadvantages of the approach to solving NP-hard problems,<br>- can independently analyze and develop algorithms within the presented areas,<br>- deepen their ability to reason mathematically and write down their ideas as evidence,<br>- gain in-depth insights into the current state of research. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time<br>(in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-ATD: Algorithm Theory - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>In this module, approaches for solving NP-hard problems (e.g., approximation algorithms, parameterized algorithms) are discussed. The focus is on the mathematical version of the solution, especially algorithm analysis and algorithm design. Impossibility results complement the field of algorithm development.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- know approaches for solving NP-hard problems,<br>- know central impossibility results,<br>- understand in detail the advantages and disadvantages of the approach to solving NP-hard problems,<br>- can independently analyze and develop algorithms within the presented areas,<br>- deepen their ability to reason mathematically and write down their ideas as evidence,<br>- gain in-depth insights into the current state of research. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (50%) | - |

| | |
|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-ATS: Algorithm Theory - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>In this module, approaches for solving NP-hard problems (e.g., approximation algorithms, parameterized algorithms) are discussed. The focus is on the mathematical version of the solution, especially algorithm analysis and algorithm design. Impossibility results complement the field of algorithm development.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- know approaches for solving NP-hard problems,<br>- know central impossibility results,<br>- understand in detail the advantages and disadvantages of the approach to solving NP-hard problems,<br>- can independently analyze and develop algorithms within the presented areas,<br>- deepen their ability to reason mathematically and write down their ideas as evidence,<br>- gain in-depth insights into the current state of research. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-ATC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-C: Cryptography** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory module/Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module teaches the basics of cryptography. Methods for formulating security properties are introduced and the functionality of modern cryptographic methods explained. Symmetrical and asymmetrical methods and algorithms are presented and their properties analyzed. These include procedures such as pseudo-random functions and symmetric and public-key encryption to protect the confidentiality of information, as well as message authentication codes and digital signatures to protect integrity and authenticity. The number theoretic foundations required for asymmetric cryptography are examined. After completing the module, students should be able to understand the basic concepts and procedures of cryptography and be able to use them correctly.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- acquire a comprehensive understanding of the properties of various cryptographic methods (e.g., asymmetric and symmetric encryption, cryptographic hash functions),<br>- become versed in the basic principles of modern cryptography and complexity theory security<br>- gain an algorithmic and formal understanding in order to be able to analyze and understand security properties<br>- know the most important procedures for encryption, key exchange and signatures<br>- can decide which cryptographic procedures may be used for specific goals in practice<br>- gain in-depth insights into the current state of research. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer: | SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-CAC: Cyber Attack and Defense - Core** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module teaches basic concepts and methods for the attack and defense of systems and complex infrastructures. We consider the relevant phases of an attack as well as the commonly used methods. In addition, appropriate analysis and detection approaches are presented for the attack methods used, by which an attack can be identified in the corresponding phase, and options for preventing specific attacks considered.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- gain subject-specific theoretical and methodological knowledge;<br>- expand their professional judgment skills;<br>- develop discussion skills and techniques;<br>- gain experience in dealing with concepts and methods for defending systems and complex infrastructures;<br>- are able to independently develop and use suitable sources of information to solve problems;<br>- can assess the applicability of solution concepts and strategies to given problems;<br>- can select and apply suitable solution concepts and strategies to a given problem;<br>- gain the ability to present and defend their work,<br>- can critically examine solutions to problems developed by others and assess their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-CAD: Cyber Attack and Defense - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module teaches basic concepts and methods for the attack and defense of systems and complex infrastructures. We consider the relevant phases of an attack as well as the commonly used methods. In addition, appropriate analysis and detection approaches are presented for the attack methods used, by which an attack can be identified in the corresponding phase, and options for preventing specific attacks considered.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- gain subject-specific theoretical and methodological knowledge,<br>- expand their professional judgment skills,<br>- develop discussion skills and techniques,<br>- gain experience in dealing with concepts and methods for defending systems and complex infrastructures,<br>- are able to independently develop and use suitable sources of information to solve problems,<br>- can assess the applicability of solution concepts and strategies to given problems,<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- gain the ability to present and defend their work,<br>- can critically examine solutions to problems developed by others and assess their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-CAC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-CAS: Cyber Attack and Defense - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module teaches basic concepts and methods for the attack and defense of systems and complex infrastructures. We consider the relevant phases of an attack as well as the commonly used methods. In addition, appropriate analysis and detection approaches are presented for the attack methods used, by which an attack can be identified in the corresponding phase, and options for preventing specific attacks considered.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- gain subject-specific theoretical and methodological knowledge,<br>- expand their professional judgment skills,<br>- develop discussion skills and techniques,<br>- gain experience in dealing with concepts and methods for defending systems and complex infrastructures,<br>- are able to independently develop and use suitable sources of information to solve problems,<br>- can assess the applicability of solution concepts and strategies to given problems,<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- gain the ability to present and defend their work,<br>- can critically examine solutions to problems developed by others and assess their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-CAC is recommended |
| Department: | Digital Engineering |

| **HPI-CS-CPC: Advanced Cryptography and Protocols - Core** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>In this module, students gain knowledge of advanced techniques and concepts in the area of cryptography and communication protocols. Network and security protocols are analyzed and advanced methods of modern cryptography are discussed, such as zero-knowledge proofs, multi-party computation, threshold cryptography, and post-quantum security. Building on the fundamental results in these areas, students become versed in the design and analysis of the protocols, their functionality and applications in practice-relevant scenarios.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students...<br>- know advanced concepts and methods of cryptography and complex security protocols,<br>- can analyze complex cryptographic primitives and protocols and prove their correctness,<br>- are familiar with known attack methods and vulnerabilities and are able to examine given protocols for them,<br>- can analyze security protocols for vulnerabilities,<br>- are familiar with current research trends and developments in cryptography and have developed an awareness of the challenges and opportunities in this area,<br>- are able to communicate complex theoretical concepts and results to decision-makers in an understandable manner. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-CPD: Advanced Cryptography and Protocols - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>In this module, students gain knowledge of advanced techniques and concepts in the area of cryptography and communication protocols. Network and security protocols are analyzed and advanced methods of modern cryptography are discussed, such as zero-knowledge proofs, multi-party computation, threshold cryptography, and post-quantum security. Building on the fundamental results in these areas, students become versed in the design and analysis of the protocols, their functionality and applications in practice-relevant scenarios.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students...<br>- know advanced concepts and methods of cryptography and complex security protocols,<br>- can analyze complex cryptographic primitives and protocols and prove their correctness,<br>- are familiar with known attack methods and vulnerabilities and are able to examine given protocols for them,<br>- can analyze security protocols for vulnerabilities,<br>- are familiar with current research trends and developments in cryptography and have developed an awareness of the challenges and opportunities in this area,<br>- are able to communicate complex theoretical concepts and results to decision-makers in an understandable manner. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | (Contact time in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-CPC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-CPS: Advanced Cryptography and Protocols - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>In this module, students gain knowledge of advanced techniques and concepts in the area of cryptography and communication protocols. Network and security protocols are analyzed and advanced methods of modern cryptography are discussed, such as zero-knowledge proofs, multi-party computation, threshold cryptography, and post-quantum security. Building on the fundamental results in these areas, students become versed in the design and analysis of the protocols, their functionality and applications in practice-relevant scenarios.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students...<br>- know advanced concepts and methods of cryptography and complex security protocols,<br>- can analyze complex cryptographic primitives and protocols and prove their correctness,<br>- are familiar with known attack methods and vulnerabilities and are able to examine given protocols for them,<br>- can analyze security protocols for vulnerabilities,<br>- are familiar with current research trends and developments in cryptography and have developed an awareness of the challenges and opportunities in this area,<br>- are able to communicate complex theoretical concepts and results to decision-makers in an understandable manner. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-CPC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-CR: Critical Reading and Discussion** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory module |
| Content and qualification goals of the module: | Content:<br>This module deals with the compilation, analysis, evaluation, and presentation of current literature with a research focus on computer science. Accordingly, events in this module are assigned to specific tracks. Furthermore, the verbal presentation and discussion of content is at the level of current research. In this module, a great depth of understanding is achieved in a highly focused research area.<br>Qualification goals:<br>Students improve their methodological skills within their track.<br>Students<br>- practice reading and understanding current literature on a topic,<br>- can integrate various, sometimes (seemingly) contradictory information on a topic,<br>- develop their ability to present findings and connections in speech and writing,<br>- deepen their ability to argue and evaluate,<br>- gain in-depth insights into the current state of research. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Paper of at least 12 pages |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Critical Reading and Discussion (Seminar) | 4 | - | - | - |

| | |
|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | It is recommended that students first visit at least two compulsory modules of the track to which the respective course in this module is assigned. |
| Department: | Digital Engineering |

| **HPI-CS-DA: Data Analytics** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory module/ compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module teaches advanced techniques and concepts related to research in the areas of supervised learning, unsupervised learning, multivariate statistics and interactive data exploration, such as clustering, classification, regression and other machine learning methods. Students are exposed to the limits of basic methods for mastering large and complex data and taught new paradigms that scale with the size and complexity of the data. They are provided a profound, formal understanding of various data analysis paradigms. A practical understanding of the methods is deepened through exercises in empirical comparison that accompany the lectures.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- understand the need for advanced data analytics concepts,<br>- acquire knowledge of different methods for analyzing large and complex data sets such as clustering, classification, or regression,<br>- can assess these methods in terms of their effectiveness and applicability and compare them on a formal and empirical level,<br>- gain experience handling data analytics systems and tools,<br>- know which problems are currently open in the area of data analytics,<br>- have gained insights into current approaches of solutions in industrial and research projects and into the current state of research. |
| Partial module exams (number, form, scope): | Exam types:<br>Written exam, 90-120 mins.<br>Oral exam, 30-45 mins. |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-DAC: Data Systems - Core** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>A data-driven system benefits from the use of many heterogeneous data sources with complex content. The specialization area of data systems in the subject of of data engineering deals with methods, concepts, procedures, and techniques for systems that develop and use such data. Students learn the basic concepts and methods for representing, storing, processing and analyzing complex data such as trees, graphs and networks, execution data, event sequences, time series, texts and multimedia data. Topics such as specialized and complex query languages, special database concepts, modern hardware, or methods for processing data streams are also covered.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- gain subject-specific theoretical and methodological knowledge of the various data systems,<br>- master the representation, storage and analysis of, for example, graph or text data,<br>- expand their professional judgment skills,<br>- acquire the ability to independently develop and use suitable sources of information to solve problems,<br>- learn how to independently work on a topic based on primary and secondary literature,<br>- gain experience in formalizing and abstracting problems for various types of complex data. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-DAD: Data Systems - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module covers techniques and tools of data engineering in the specialization area of data systems. Module courses include those on the topic of text and multimedia data, event data, graphs or data streams. The module's focus is on current processes, techniques, and tools from science and industry. Students examine how data-driven IT systems deal with the challenges that complex data types pose to their collection, processing, storage, and analysis. Among the data types studied are trees, graphs and networks, execution data, event sequences, time series, text as well as image and audio data.<br>Qualification goals:<br>Students acquire detailed knowledge about the specialist topics covered in the module.<br>Students:<br>- gain subject-specific methodological and practical knowledge of various data systems,<br>- learn to process complex data types such as executive and multimedia data,<br>- expand their professional judgment skills,<br>- acquire the ability to solve problems of various types complex and to independently develop and use suitable sources of information,<br>- learn how to independently work on a topic based on primary and secondary literature,<br>- are able to follow current research trends and incorporate these into their work,<br>- can select and apply appropriate solutions concepts and strategies to a specific problem are able to follow current research trends and incorporate these into their work. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-DAC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-DAS: Data Systems - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module investigates current research questions and results in data engineering in the specialization area “data systems.” Students thereby examine the efficient and scalable collection, processing, storage and analysis of complex data, which require new and innovative approaches and systems beyond classic paradigms. The focus is on current research questions and results. Content covers the current state of research on topics such as stream processing, network science, natural language processing, multimedia analysis, computer vision, stream mining, graph synopsis and information retrieval for complex data types.<br>Qualification goals:<br>Students acquire detailed knowledge about the specialist topics covered in the module.<br>Students:<br>- work out the limitations and extensions of existing complex data systems,<br>- deal with new data technologies such as natural language processing or stream synopsis,<br>- learn the scientific analysis of current research questions in the area of data systems,<br>- are able to select and apply suitable solution concepts and strategies to a given problem,<br>- have the ability to follow current research trends on data systems and integrate them into their work,<br>- can independently access and evaluate scientific literature on specific topics,<br>- are experienced in formalizing and abstracting problems with various types of complex data,<br>- get to know criteria and principles of scientific writing,<br>- can critically examine solutions to problems developed by others and assess their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-DAC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-DEC: Application Development and Software Engineering - Core** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module provides an introduction to the fundamentals of software development, including the software life cycle, agile development methodologies, version control, testing and quality assurance, interoperability and data integration. It examines the issue of implementing interoperability in digital health applications to enable the exchange of data between different systems and devices.<br>Furthermore, participants gain an understanding of the practical implementation of software development in digital health. This includes the use of programming languages and frameworks to develop applications and implement features such as database access, user interfaces and interfaces. The module provides knowledge about identifying and recording requirements for digital health applications and provides an overview of the conception and design of the software architecture of these applications. This includes understanding user needs, creating requirements specifications and using modeling techniques, such as use cases or user stories.<br>Qualification goals:<br>Students acquire detailed knowledge about the specialist topics covered in the module.<br>Students:<br>- learn to develop and implement digital health applications,<br>- gain programming knowledge and techniques to create software solutions that meet the requirements of digital healthcare,<br>- expand their ability to design software architectures that can be used effectively in the digital healthcare industry,<br>- learn to select architectural patterns and organize the components of an application to create a scalable and maintainable solution,<br>- are able to apply the optimal techniques to integrate data from different healthcare sources and ensure interoperability between different systems,<br>- develop proficiency in working with databases and interfaces. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-DED: Application Development and Software Engineering - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module provides advanced knowledge of software development, including software life cycle, agile development methods, version control, testing and quality assurance, interoperability, and data integration. It deepens the implementation of interoperability in digital health applications to enable the exchange of data between different systems and devices.<br>This module also deepens the practical implementation of software development in digital health. This includes using programming languages and frameworks to develop more complex applications and to implement features such as database access, user interfaces and interfaces. The module provides deeper knowledge of identifying and recording requirements for digital health applications and offers a further overview of the conception and design of the software architecture of these applications. This includes in-depth understanding of user needs, creating requirements specifications and using modeling techniques such as use cases or user stories.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- practice developing and implementing digital health applications,<br>- gain advanced programming knowledge and techniques to create software solutions that meet the requirements of digital healthcare,<br>- expand their ability to design more complex software architectures that can be used effectively in the digital healthcare industry,<br>- practice selecting architectural patterns, analyzing and organizing the components of an application to create a scalable and maintainable solution,<br>- evaluate and apply the optimal techniques to integrate data from different sources in the health sector and to ensure interoperability between different systems,<br>- develop in-depth skills in working with databases and interfaces. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-DAC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-DES: Application Development and Software Engineering - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module provides advanced knowledge of software development, including software life cycle, agile development methods, version control, testing and quality assurance, interoperability, and data integration. It deepens the implementation of interoperability in digital health applications to enable the exchange of data between different systems and devices.<br>This module also deepens the practical implementation of software development in digital health. This includes using programming languages and frameworks to develop more complex applications and to implement features such as database access, user interfaces and interfaces. The module provides deeper knowledge of identifying and recording requirements for digital health applications and offers a further overview of the conception and design of the software architecture of these applications. This includes in-depth understanding of user needs, creating requirements specifications and using modeling techniques such as use cases or user stories.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- practice developing and implementing digital health applications,<br>- gain advanced programming knowledge and techniques to create software solutions that meet the requirements of digital healthcare,<br>- expand their ability to design more complex software architectures that can be used effectively in the digital healthcare industry,<br>- practice selecting architectural patterns, analyzing and organizing the components of an application to create a scalable and maintainable solution,<br>- evaluate and apply the optimal techniques to integrate data from different sources in the health sector and to ensure interoperability between different systems,<br>- develop in-depth skills in working with databases and interfaces. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-DEC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-DIC: Data Integration - Core** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory module |
| Content and qualification goals of the module: | Content:<br>A data-driven system is often based on data from various heterogeneous data sources with different data models, schema and data. Such data often needs to be collected, pre-processed and cleaned. Data integration is about making this data usable. The data integration methods include concepts for data selection, preprocessing (data preparation), analyzing the raw data (data profiling), data cleansing, as well as transformation and aggregation. The focus of this module is on the corresponding fundamental concepts and methods for the technical, structural and semantic development of diverse data sources for data-based systems.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- learn concepts and methods, for example in the areas of data preparation, data profiling and data cleansing,<br>- can assess the data quality of various data sources and models,<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- expand their professional judgment skills,<br>- acquire the ability to independently develop and use suitable sources of information to solve problems,<br>- learn about relevant analysis methods,<br>- evaluate data integration strategies for different requirements,<br>- recognize complex data development problems and are able to develop appropriate solution strategies,<br>- acquire technical language knowledge,<br>- expand their learning skills. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-DID: Data Integration - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>A data-driven system is often based on data from various heterogeneous data sources with different data models, schema and data. Such data often needs to be collected, pre-processed and cleaned. Data integration is about making this data usable. The data integration methods include concepts for data selection, preprocessing (data preparation), analyzing the raw data (data profiling), data cleansing, as well as transformation and aggregation. The focus of this module is on the corresponding fundamental concepts and methods for the technical, structural and semantic development of diverse data sources for data-based systems.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- learn concepts and methods, for example in the areas of data preparation, data profiling and data cleansing,<br>- can assess the data quality of various data sources and models,<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- expand their professional judgment skills,<br>- acquire the ability to independently develop and use suitable sources of information to solve problems,<br>- learn about relevant analysis methods,<br>- evaluate data integration strategies for different requirements,<br>- recognize complex data development problems and are able to develop appropriate solution strategies,<br>- acquire technical language knowledge,<br>- expand their learning skills. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-DIC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-DIS: Data Integration - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>A data-driven system is often based on data from various heterogeneous data sources with different data models, schema and data. Such data often needs to be collected, pre-processed and cleaned. Data integration is about making this data usable. The data integration methods include concepts for data selection, preprocessing (data preparation), analyzing the raw data (data profiling), data cleansing, as well as transformation and aggregation. The focus of this module is on the corresponding fundamental concepts and methods for the technical, structural and semantic development of diverse data sources for data-based systems.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- learn concepts and methods, for example in the areas of data preparation, data profiling and data cleansing,<br>- can assess the data quality of various data sources and models,<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- expand their professional judgment skills,<br>- acquire the ability to independently develop and use suitable sources of information to solve problems,<br>- learn about relevant analysis methods,<br>- evaluate data integration strategies for different requirements,<br>- recognize complex data development problems and are able to develop appropriate solution strategies,<br>- acquire technical language knowledge,<br>- expand their learning skills. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-DIC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-DM: Data Management and Data Science** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory module/compulsory elective module |
| Content and qualification goals of the module: | Contents:<br>Obtaining insights from large amounts of data and managing heterogeneous data sources are highly relevant topics for digital health. Therefore, the imparting of basic knowledge in the areas of data science and data management is essential. Data Science in Digital Health, as an interdisciplinary science at the intersection of statistics, machine learning and medicine, enables the generation of health-relevant insights from extensive health data. These can be used to answer research questions, make predictions, and provide recommendations for action. To ensure the accuracy of the answers generated, the quality, integrity, and reliability of the data and the methods used must be ensured. Data management in digital health includes aspects of organizing, structuring, storing, and access control for health data. This module provides an understanding of data science and data management as part of the analysis and evaluation of digital health data.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- gain subject-specific methodological and practical knowledge in data generation and data analysis in the field of digital health,<br>- understand the challenges of data management of health data (e.g., from clinical research processes),<br>- can use suitable methods to empirically investigate given problems and research questions, make predictions, and analyze causal questions,<br>- gain experience in dealing with big data (health data) and the appropriate tools,<br>- gain the ability to critically question and interpret the results of data analysis,<br>- are able to use appropriate methods to design databases, collect, store, and organize data, and ensure data quality and data protection<br>- learn statistical methods and machine learning algorithms to identify patterns and trends in the data and make predictions<br>- master the basics of clinical research and learn to make evidence-based decisions,<br>- gain insights into current solution approaches from industry and research projects and into the current state of research. |
| Partial module exams (number, form, scope): | Exam types:<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (50%) | - |

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|---|---|
| Frequency of offer: | SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-DS: Data Systems** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory module/compulsory elective module |
| Content and qualification goals of the module: | Contents:<br>Digitalization and increasing networking are generating new volumes of data whose characteristics and processing differ from previous data. These growing amounts of data, and the resulting analysis possibilities, require new techniques and methods for collecting, transforming and processing. This module teaches architectures and methods for the distributed, parallel processing of data, and addresses the challenges faced by scalable data processing systems. These include discussion of system architectures for handling data from heterogeneous sources (Variety), data with a high acquisition frequency and fast processing times (Velocity), and extensive data (Volume). In addition to a systematization of the systems and their intended uses, the focus of analysis is on characteristic system properties such as architecture, data structures, transactional behavior, scalability and distribution, implementation concepts and their classification in the state of the art.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- recognize the challenges of big data problems (volume, variety, velocity) and data engineering on IT systems,<br>- master the basic characteristics of big data and data engineering systems and their structure, and can incorporate these into development processes,<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- gain experience in dealing with software systems and tools and scalable system architectures,<br>- acquire the ability to evaluate and apply methods and procedures of parallel and distributed data processing,<br>- gain subject-specific theoretical, methodological, and practical knowledge,<br>- can independently access and use suitable sources of information to solve problems,<br>- gain insights into current solution approaches in industrial and research projects and into the current state of research. |
| Partial module exams (number, form, scope): | Exam types:<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (50%) | - |

| | |
|---|---|
| Frequency of offer: | WiSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-DSC: Dependable Systems - Core** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module teaches scientific concepts, methods and techniques for the development and operation of dependable systems.<br>Scientific concepts and methods for one or more aspects of reliability are covered, such as availability, reliability, safety, information security, and integrity. Throughout the module, students deal with, for example, concepts, methods and techniques for safety-critical systems, secure systems or reliable networks.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- gain subject-specific theoretical and methodological knowledge,<br>- expand their professional judgment skills,<br>- develop discussion skills and techniques,<br>- acquire experience in dealing with reliability in the development and operation of systems, and aspects of reliability regarding the tools used;<br>- are able to independently develop and use suitable sources of information to solve problems,<br>- can assess the applicability of solution concepts and strategies to given problems,<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- can present self-developed solutions to problems and defend their work,<br>- can critically question solutions to problems developed by others and check their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-DSD: Dependable Systems - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module provides advanced scientific concepts, methods and techniques, as well as current research questions and results, regarding the development and operation of dependable systems.<br>Advanced scientific concepts, methods and techniques, and current research questions are included for one or more of the fundamental aspects of reliability: such as, availability, reliability, safety, information security and integrity. For example, the module deals with advanced scientific concepts, methods and techniques and current research questions for safety-critical distributed systems, secure network systems and high-availability systems.<br>Qualification goals:<br>The students acquire further knowledge about the specialist topics covered in the module.<br>Students:<br>- gain further subject-specific theoretical and methodological knowledge,<br>- expand their professional judgment skills,<br>- practice discussion skills and techniques,<br>- acquire further experience in dealing with reliability in the development and operation of systems and aspects of reliability in terms of the tools used,<br>- are able to independently evaluate and use suitable sources of information to solve additional problems,<br>- can assess the applicability of solution concepts and strategies to given advanced problems;<br>- can evaluate and apply suitable solution concepts and strategies to a given advanced problem;<br>- can present self-developed solutions to further problems and defend them against critical objections,<br>- can critically question solutions developed by others for further problems and check their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-DSC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-DSS: Dependable Systems - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module provides advanced scientific concepts, methods and techniques, as well as current research questions and results, regarding the development and operation of dependable systems.<br>Advanced scientific concepts, methods and techniques, and current research questions are included for one or more of the fundamental aspects of reliability: such as, availability, reliability, safety, information security and integrity. For example, the module deals with advanced scientific concepts, methods and techniques and current research questions for safety-critical distributed systems, secure network systems and high-availability systems.<br>Qualification goals:<br>The students acquire further knowledge about the specialist topics covered in the module.<br>Students:<br>- gain further subject-specific theoretical and methodological knowledge,<br>- expand their professional judgment skills,<br>- practice discussion skills and techniques,<br>- acquire further experience in dealing with reliability in the development and operation of systems and aspects of reliability in terms of the tools used,<br>- are able to independently evaluate and use suitable sources of information to solve additional problems,<br>- can assess the applicability of solution concepts and strategies to given advanced problems;<br>- can evaluate and apply suitable solution concepts and strategies to a given advanced problem;<br>- can present self-developed solutions to further problems and defend them against critical objections,<br>- can critically question solutions developed by others for further problems and check their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-DSC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-IGC: HCI and Graphics - Core** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module teaches scientific concepts, methods and techniques of computer graphic systems and human computer interaction. Participants learn concepts for visualizing complex issues, such as software visualization and geovisualization, as well as novel concepts for the interaction between people and computers using different methods and devices.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- acquire subject-specific theoretical and methodological knowledge,<br>- expand their professional judgment competency,<br>- develop discussion skills and techniques,<br>- acquire experience in handling reliability in the development and operation of systems and, thereby, the tools implemented for aspects of reliability,<br>- are able to independently develop and use suitable sources of information to solve problems,<br>- can assess the applicability of solution concepts and strategies to given problems;<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- can present self-developed solutions to problems and defend their work,<br>- can critically examine solutions to problems developed by others and assess their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-IGD: HCI and Graphics - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>The module teaches advanced scientific concepts, methods and techniques of computer graphic systems and human computer interaction. In this way, concepts for visualizing complex issues, such as software visualization and geovisualization, as well as novel concepts for the interaction of people with computers using different methods and devices are deepened.<br>Qualification goals:<br>The students acquire further knowledge about the specialist topics covered in the module.<br>Students:<br>- acquire subject-specific theoretical and methodological knowledge,<br>- expand their professional judgment competency,<br>- develop discussion skills and techniques,<br>- acquire experience in handling reliability in the development and operation of systems and, thereby, the tools implemented for aspects of reliability,<br>- are able to independently develop and use suitable sources of information to solve problems,<br>- can assess the applicability of solution concepts and strategies to given problems;<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- can present self-developed solutions to problems and defend their work,<br>- can critically examine solutions to problems developed by others and assess their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-IGC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-IGS: HCI and Graphics - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>The module teaches advanced scientific concepts, methods and techniques of computer graphic systems and human computer interaction. In this way, concepts for visualizing complex issues, such as software visualization and geovisualization, as well as novel concepts for the interaction of people with computers using different methods and devices are deepened.<br>Qualification goals:<br>The students acquire further knowledge about the specialist topics covered in the module.<br>Students:<br>- acquire subject-specific theoretical and methodological knowledge,<br>- expand their professional judgment competency,<br>- develop discussion skills and techniques,<br>- acquire experience in handling reliability in the development and operation of systems and, thereby, the tools implemented for aspects of reliability,<br>- are able to independently develop and use suitable sources of information to solve problems,<br>- can assess the applicability of solution concepts and strategies to given problems;<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- can present self-developed solutions to problems and defend their work,<br>- can critically examine solutions to problems developed by others and assess their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-IGC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-IRP: Individual Research Project** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module deals with a selected, research-related question from the current research work carried out at the department of supervision. The question is analyzed, and a solution is designed for a sub-area, which is then implemented constructively, integrated into the research work of the department and scientifically documented. The solutions are always evaluated for their strengths and weaknesses. Through a comparative evaluation of the results with other solutions, algorithms, or systems, participants gain a deeper understanding of them in a theoretical and practical sense. Students gain extensive insights into the current research work being done in the department and participate in the development of new solutions. Work on the individual research project is carried out by the student as a single work.<br>Qualification goals:<br>Students improve their methodological skills within the respective subject area as well as their skills in scientific work.<br>They:<br>- train their reading and understanding of current scientific literature on a topic,<br>- practice the practical implementation of their ideas into provable or measurable solutions in the context of a research project;<br>- further develop their ability to present findings and connections verbally and in writing;<br>- deepen their ability to argue and evaluate in a balanced way,<br>- gain in-depth insight into the current state of research.<br>Students develop these skills through research-relevant content. By carrying out the project, students expand and (or) deepen the professional skills they already have.<br>This means that students have ready-to-use experiential knowledge for carrying out even more extensive projects in a research context.<br>To prepare for the project, students write an exposé (1 page max.) that contains the content, goals, and tasks, and the schedule of the project. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Paper (at least 12 pgs.) |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Seminar (Seminar) | 4 | - | - | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in at least two courses in the subject area is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-ISC: Intelligent Systems - Core** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module teaches the basic scientific concepts, methods and techniques for the development of intelligent distributed systems and programming languages (AI programming languages).<br>This includes concepts and methods for one or more fundamental aspects of artificial intelligence such as distributed AI, accuracy, and fault tolerance. This module therefore deals with aspects such as distributed systems for machine learning, probabilistic methods and hardware-specific AI algorithms.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- gain subject-specific theoretical and methodological knowledge,<br>- expand their professional judgment skills,<br>- develop discussion skills and techniques,<br>- gain experience in dealing with methods of machine learning and automatic decision-making and optimization as well as distributed algorithms of artificial intelligence and hardware-related programming,<br>- are able to independently develop and use suitable sources of information to solve problems,<br>- can assess the applicability of solution concepts and strategies to a given problem,<br>- can select and apply suitable solution concepts and strategies to a given problems,<br>- can present self-developed solutions to problems and defend their work,<br>- can critically question solutions to problems developed by others and check their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-ISD: Intelligent Systems - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory module |
| Content and qualification goals of the module: | Content:<br>This module teaches the basic scientific concepts, methods and techniques for the development of intelligent distributed systems and programming languages (AI programming languages).<br>This includes concepts and methods for one or more fundamental aspects of artificial intelligence such as energy efficiency and programmability. This module also deals with aspects such as probabilistic programming and hardware-specific AI algorithms.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- gain subject-specific theoretical and methodological knowledge,<br>- expand their professional judgment skills,<br>- develop discussion skills and techniques,<br>- gain experience in dealing with methods of machine learning and automatic decision-making and optimization as well as distributed algorithms of artificial intelligence and hardware-related programming,<br>- are able to independently develop and use suitable sources of information to solve problems,<br>- can assess the applicability of solution concepts and strategies to given problem,<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- can present self-developed solutions to problems and have the ability to defend their work,<br>- can critically question solutions to problems developed by others and check their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-ISC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-ISS: Intelligent Systems - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module teaches the basic scientific concepts, methods and techniques for the development of intelligent distributed systems and programming languages (AI programming languages).<br>This includes concepts and methods for one or more fundamental aspects of artificial intelligence such as energy efficiency and programmability. This module also deals with aspects such as probabilistic programming and hardware-specific AI algorithms.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- gain subject-specific theoretical and methodological knowledge,<br>- expand their professional judgment skills,<br>- develop discussion skills and techniques,<br>- gain experience in dealing with methods of machine learning and automatic decision-making and optimization as well as distributed algorithms of artificial intelligence and hardware-related programming,<br>- are able to independently develop and use suitable sources of information to solve problems,<br>- can assess the applicability of solution concepts and strategies to given problem,<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- can present self-developed solutions to problems and have the ability to defend their work,<br>- can critically question solutions to problems developed by others and check their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-ISC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-LAB: Computer Science Lab** | Number of credit points (CP): 12 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory module |
| Content and qualification goals of the module: | Content:<br>In the Computer Science Lab, students work together in a group on a selected, research-related question from a track in the degree program. The question is analyzed, and a solution is designed for a sub-area, which is then implemented constructively and scientifically documented. The solutions are always evaluated for their strengths and weaknesses. A practical understanding of them is deepened by a comparative evaluation with other<br>solutions, algorithms, or systems. Students thereby gain deep insights into the current research work being conducted in the tracks and subject areas, as well as participating in the development of new solutions. Accordingly, activities in this module are assigned to specific tracks. This module deepens the students' scientific training. The lab activity takes place in project groups, usually with at least three and a maximum of six members each. University lecturers from the Digital Engineering Faculty suggest projects from their area of work, design their content and support the students in their implementation.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- gain subject-specific theoretical, methodological, and practical knowledge,<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- learn how to independently work on a topic on the basis of primary and secondary literature,<br>- are able to independently access and evaluate scientific literature on individual topics,<br>- gain experience in formalizing and abstracting problems,<br>- practice putting criteria and principles of scientific writing into practice,<br>- gain skills in the area of project management by working in teams;<br>- gain sovereignty in the collaborative and divisional processing of tasks;<br>- learn how to systematically address research questions. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 12 pages, together with a presentation of research results (talk, 30-45 mins.) |
| Self-study time<br>(in hours [h]): | 240 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project activity (project) | 8 | - | - | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior successful participation in the modules intended as a prerequisite for the respective project activity is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-LSA: Large-Scale Systems Architectures** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory module/compulsory elective module |
| Content and qualification goals of the module: | Content:<br>A characteristic development in computer science is the trend towards ever larger problems that require ever larger systems. Classic examples are web search engines or video streaming farms; a modern example is the training of large machine learning models. Such applications require a corresponding infrastructure that must be efficient in several aspects (e.g., investment and operating costs, energy, administration effort, development effort).<br>This module primarily looks at such infrastructures from a technological perspective. A secondary view examines aspects of software development that are relevant for large applications on large infrastructures. Technological aspects begin with the system architecture of an individual system (e.g., addressing the question of why GPUs are relevant for typical ML applications), address the structure of a data center, and then questions of the management and operation of a cloud system. All phases of a life cycle from project planning, design, investment decisions, and operation are covered for both perspectives. Aspects such as robustness or energy efficiency are also taken into account.<br>Qualification goals:<br>Students acquire detailed knowledge and advanced skills in the specialist topics covered in the module.<br>Students<br>- gain advanced, subject-specific, theoretical and methodological knowledge,<br>- expand their professional judgment skills with the help of this knowledge,<br>- develop discussion skills and techniques based on this knowledge;<br>- acquire basic experience in dealing with the development and operation of systems and the techniques, challenges and tools used,<br>- are able to independently develop and use suitable sources of information to solve basic problems,<br>- can assess the applicability of solution concepts and strategies to given basic problems,<br>- can select and apply suitable solution concepts and strategies to a given advanced problem,<br>- can present self-developed solutions to advanced problems and have the ability to defend their work,<br>- can critically examine solutions to advanced problems developed by others and check their professional applicability. |
| Partial module exams (number, form, scope): | Exam types:<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer: | WiSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-ML: Machine Learning** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory module/compulsory elective module |
| Content and qualification goals of the module: | Contents:<br>This module teaches the basics of machine learning and artificial intelligence. Content includes machine learning methods as well as practical use cases in digital health, such as classification, distributed learning, predictive modeling, and transparent methods. Methods for validating machine learning procedures are covered. Emphasis is further placed on the preprocessing of data required for machine learning, such as data cleaning, feature extraction and selection. After completing the module, students should be able to find and implement innovative problem solutions using machine learning.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- learn concepts and methods,<br>- master the basics of machine learning and artificial intelligence in the context of digital health,<br>- learn relevant machine learning algorithms and techniques that can be applied in digital health to develop medical diagnoses, prognosis, and decision support systems,<br>- are able to collect, clean, and prepare data for healthcare machine learning to create high quality models,<br>- can develop, train and evaluate models for machine learning in healthcare. |
| Partial module exams (number, form, scope): | Exam types:<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (50%) | - |

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|---|---|
| Frequency of offer: | SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-MLC: Machine Learning - Core** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module teaches basic methods and concepts related to research in the areas of machine learning using non-probabilistic methods (neural networks, decision trees, core algorithms, and logical programming) in application areas that range from regression, classification, and ranking to reinforcement learning. It forges the link from mathematical modeling and the theory of learning to programming languages, programming language concepts, and energy-efficient hardware for modern machine learning. Furthermore, this module focuses on distributed methods that scale with the size and complexity of the data. Students gain an in-depth, formal understanding of various paradigms of machine learning. A practical understanding of the methods is provided in lecture-accompanying programming tasks and projects of machine learning algorithms in exercises.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- understand the necessity of mathematical concepts such as linear algebra, stochastics, statistics, as well as the need for system-related concepts such as computer architecture, distributed systems and programming language theory,<br>- are versed in methods for analyzing learning algorithms such as optimization methods (e.g., gradient methods),<br>- can assess these methods in terms of their effectiveness and applicability and derive, expand, and adapt them on a formal level,<br>- have gained experience in dealing with machine learning systems and tools,<br>- know which problems are the research focus of machine learning,<br>- have gained insights into current solution approaches in industrial and research projects and into the current state of research. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-MLD: Machine Learning - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module teaches basic methods and concepts related to research in the areas of machine learning using non-probabilistic methods (neural networks, decision trees, core algorithms, and logical programming) in application areas that range from regression, classification, and ranking to reinforcement learning. It forges the link from mathematical modeling and the theory of learning to programming languages, programming language concepts, and energy-efficient hardware for modern machine learning. Furthermore, this module focuses on distributed methods that scale with the size and complexity of the data. Students gain an in-depth, formal understanding of various paradigms of machine learning. A practical understanding of the methods is provided in lecture-accompanying programming tasks and projects of machine learning algorithms in exercises.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- understand the necessity of mathematical concepts such as linear algebra, stochastics, statistics, as well as the need for system-related concepts such as computer architecture, distributed systems and programming language theory,<br>- are versed in methods for analyzing learning algorithms such as optimization methods (e.g., gradient methods),<br>- can assess these methods in terms of their effectiveness and applicability and derive, expand, and adapt them on a formal level,<br>- have gained experience in dealing with machine learning systems and tools,<br>- know which problems are the research focus of machine learning,<br>- have gained insights into current solution approaches in industrial and research projects and into the current state of research. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-MLC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-MLS: Machine Learning - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module teaches basic methods and concepts related to research in the areas of machine learning using non-probabilistic methods (neural networks, decision trees, core algorithms, and logical programming) in application areas that range from regression, classification, and ranking to reinforcement learning. It forges the link from mathematical modeling and the theory of learning to programming languages, programming language concepts, and energy-efficient hardware for modern machine learning. Furthermore, this module focuses on distributed methods that scale with the size and complexity of the data. Students gain an in-depth, formal understanding of various paradigms of machine learning. A practical understanding of the methods is provided in lecture-accompanying programming tasks and projects of machine learning algorithms in exercises.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- understand the necessity of mathematical concepts such as linear algebra, stochastics, statistics, as well as the need for system-related concepts such as computer architecture, distributed systems and programming language theory,<br>- are versed in methods for analyzing learning algorithms such as optimization methods (e.g., gradient methods),<br>- can assess these methods in terms of their effectiveness and applicability and derive, expand, and adapt them on a formal level,<br>- have gained experience in dealing with machine learning systems and tools,<br>- know which problems are the research focus of machine learning,<br>- can analyze the current solution approaches in industrial and research projects and evaluate the current state of research. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-MLC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-MMC: Mathematical Modelling - Core** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module provides advanced knowledge of various mathematical models, especially stochastic and statistical models, as well as their in-depth application in various areas of computer science. Common and currently used models are examined and analyzed in greater detail. More advanced, specialized problems are discussed and techniques and algorithms for solving them are taught.<br>Students:<br>- have gained a comprehensive understanding of the properties of various advanced mathematical modeling,<br>- can analyze and evaluate complex techniques and algorithms based on the mathematical models used,<br>- are able to analyze advanced models at a theoretical level and extract structural properties using the appropriate analysis techniques,<br>- have gained in-depth subject-specific theoretical, methodological and practical knowledge,<br>- can independently develop and use suitable sources of information to solve further problems,<br>- know which specialized problems exist in the field of mathematical modeling and are currently open,<br>- have in-depth insight into current solutions in industry and research. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer:: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-MMD: Mathematical Modelling - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module provides advanced knowledge of various mathematical models, especially stochastic and statistical models, as well as their in-depth application in various areas of computer science. Common and currently used models are examined and analyzed in greater detail. More advanced, specialized problems are discussed and techniques and algorithms for solving them are taught.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- have gained a comprehensive understanding of the properties of various advanced mathematical modeling,<br>- can analyze and evaluate complex techniques and algorithms based on the mathematical models used,<br>- are able to analyze advanced models at a theoretical level and extract structural properties using the appropriate analysis techniques,<br>- have gained in-depth subject-specific theoretical, methodological and practical knowledge,<br>- can independently develop and use suitable sources of information to solve further problems,<br>- know which specialized problems exist in the field of mathematical modeling and are currently open,<br>- have in-depth insight into current solutions in industry and research. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-MMC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-MMS: Mathematical Modelling - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory module |
| Content and qualification goals of the module: | Content:<br>This module provides advanced knowledge of various mathematical models, especially stochastic and statistical models, as well as their in-depth application in various areas of computer science. Common and currently used models are examined and analyzed in greater detail. More advanced, specialized problems are discussed and techniques and algorithms for solving them are taught.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- have gained a comprehensive understanding of the properties of various advanced mathematical modeling,<br>- can analyze and evaluate complex techniques and algorithms based on the mathematical models used,<br>- are able to analyze advanced models at a theoretical level and extract structural properties using the appropriate analysis techniques,<br>- have gained in-depth subject-specific theoretical, methodological and practical knowledge,<br>- can independently develop and use suitable sources of information to solve further problems,<br>- know which specialized problems exist in the field of mathematical modeling and are currently open,<br>- have in-depth insight into current solutions in industry and research. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer:: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-MMC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-PMC: Probabilistic Machine Learning - Core** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>Modeling relationships between data objects using probabilistic methods makes it possible to derive predictions and make statements about their reliability. This is the basis for probabilistic and statistical learning methods. The focus of this module lies on bridging the gap between advanced theoretical concepts and application to real data, while taking scalability into account. Students consider, among others, Bayesian learning methods, graphical models, Markovian decision-making processes, and advanced statistical learning algorithms.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- learn advanced concepts and methods, for example in the areas of probabilistic modeling and statistical learning,<br>- are able to evaluate necessary preconditions and assumptions and check these on existing data,<br>- can select and apply suitable solution concepts and strategies to a given complex problem,<br>- can evaluate and implement the learned procedures in terms of software,<br>- expand their professional judgment skills,<br>- are able to independently evaluate and use suitable sources of information to solve complex problems,<br>- acquire further technical language knowledge,<br>- expand their learning skills. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-PMD: Probabilistic Machine Learning - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>Modeling relationships between data objects using probabilistic methods makes it possible to derive predictions and make statements about their reliability. This is the basis for probabilistic and statistical learning methods. The focus of this module lies on bridging the gap between advanced theoretical concepts and application to real data, while taking scalability into account. Students consider, among others, Bayesian learning methods, graphical models, Markovian decision-making processes, and advanced statistical learning algorithms.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- learn advanced concepts and methods, for example in the areas of probabilistic modeling and statistical learning,<br>- are able to evaluate necessary preconditions and assumptions and check these on existing data,<br>- can select and apply suitable solution concepts and strategies to a given complex problem,<br>- can evaluate and implement the learned procedures in terms of software,<br>- expand their professional judgment skills,<br>- are able to independently evaluate and use suitable sources of information to solve complex problems,<br>- acquire further technical language knowledge,<br>- expand their learning skills. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-PMC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-PMS: Probabilistic Machine Learning - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>Modeling relationships between data objects using probabilistic methods makes it possible to derive predictions and make statements about their reliability. This is the basis for probabilistic and statistical learning methods. The focus of this module lies on bridging the gap between advanced theoretical concepts and application to real data, while taking scalability into account. Students consider, among others, Bayesian learning methods, graphical models, Markovian decision-making processes, and advanced statistical learning algorithms.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- learn advanced concepts and methods, for example in the areas of probabilistic modeling and statistical learning,<br>- are able to evaluate necessary preconditions and assumptions and check these on existing data,<br>- can select and apply suitable solution concepts and strategies to a given complex problem,<br>- can evaluate and implement the learned procedures in terms of software,<br>- expand their professional judgment skills,<br>- are able to independently evaluate and use suitable sources of information to solve complex problems,<br>- acquire further technical language knowledge,<br>- expand their learning skills. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-PMC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-PSC: Provable Security - Core** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Contents:<br>This module teaches various cryptographic primitives and their correct use in complex systems and protocols. Common and currently used cryptographic algorithms (e.g., asymmetric and symmetric cryptographic methods, cryptographic hash functions) are examined in greater detail. In addition, various methods of cryptanalysis and their mathematical foundations are discussed.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- have a comprehensive understanding of the properties of various cryptographic primitives,<br>- can assess the security of complex systems and protocols based on the cryptographic algorithms used and identify vulnerabilities,<br>- are able to design secure systems and protocols at a theoretical level using the appropriate cryptographic primitives,<br>- have gained subject-specific theoretical, methodological and practical knowledge,<br>- can independently develop and use suitable sources of information to solve problems,<br>- know which problems are currently open in the field of cryptography,<br>- have insight into current solution approaches in industrial and research projects and into the current state of research. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-PSD: Provable Security - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Contents:<br>This module provides in-depth knowledge of cryptography. Particular attention is paid to the design and analysis of provable secure protocols for real-world applications. It provides an expanded understanding of the fundamental results of the field, such as homomorphic encryption, zero-knowledge proofs, elliptic curve cryptography, and post-quantum cryptography.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- can independently develop complex cryptographic protocols from learned primitives,<br>- can analyze given and self-developed cryptographic primitives and protocols and prove their correctness,<br>- are versed in known attack methods and vulnerabilities and can examine given protocols for them,<br>- are versed in current research trends and developments in cryptography and develop an awareness of the challenges and opportunities in this area,<br>- are able to communicate complex theoretical concepts and results to decision-makers in an understandable manner. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-PSC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-PSS: Provable Security - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Contents:<br>This module provides in-depth knowledge of cryptography. Particular attention is paid to the design and analysis of provable secure protocols for real-world applications. It provides an expanded understanding of the fundamental results of the field, such as homomorphic encryption, zero-knowledge proofs, elliptic curve cryptography, and post-quantum cryptography.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- can independently develop complex cryptographic protocols from learned primitives,<br>- can analyze given and self-developed cryptographic primitives and protocols and prove their correctness,<br>- are versed in known attack methods and vulnerabilities and can examine given protocols for them,<br>- are versed in current research trends and developments in cryptography and develop an awareness of the challenges and opportunities in this area,<br>- are able to communicate complex theoretical concepts and results to decision-makers in an understandable manner. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-PSC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-RE: Research Methods & Ethics** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory module |
| Content and qualification goals of the module: | Contents:<br>This module deals with selected topics from the areas of epistemology, philosophy of science, and ethics, each with a connection to computer science. The focus here is on scientific practice, such as data use, scientific institutions (conferences, journals, peer reviews, citations, etc.), guidelines for good scientific practice, topic identification, experiment design, evaluation, and presentation.<br>Qualification goals:<br>The students improve their methodological skills at a research level.<br>Students:<br>- gain knowledge of the institutions of modern science and how they interconnect,<br>- understand ethical problems related to scientific activity,<br>- develop their skills related to scientific methods, for example experiments,<br>- deepen their ability to express arguments in written and graphical form,<br>- gain insight into modern scientific architecture. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Paper (at least 12 pgs.) |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Lecture or seminar (lecture or seminar) | 4 | - | Interim presentation (15 min.) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-S: Network Security** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory module/compulsory elective module |
| Content and qualification goals of the module: | Contents:<br>An increasing number of attacks attempt to compromise individual systems or networked infrastructures. This module first looks at the relevant characteristics of different systems and networks in order to identify and categorize attack vectors or potential vulnerabilities. Students become versed in design principles, security mechanisms and vulnerabilities of network and communication systems—from the data transmission layer to the application layer. In this way, it is possible to consider various theoretical security concepts and measures, as well as to examine their practical implementation for specific attack vectors.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- familiarize themselves with relevant characteristics and security concepts of common systems and networks, as well as potential vulnerabilities,<br>- are able to independently analyze systems and networks using appropriate methods at a theoretical level and identify potential attack vectors,<br>- evaluate described security measures in the context of various threats and attacks,<br>- gain experience in dealing with systems and tools that make it possible to analyze security measures and identify potential attack vectors,<br>- know which problems in the area of systems and network security are relevant and currently open,<br>- gain insights into current solution approaches in industrial and research projects and into the current state of research. |
| Partial module exams (number, form, scope): | Exam types:<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-SDC: Systems Development Techniques and Tools - Core** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>The module includes:<br>- Deepening of basic programming paradigms (e.g., object-oriented, functional, logical, ... or imperative, declarative, prompt-based, ...)<br>- Deepening of iterative, exploratory, user-oriented techniques for design, implementation, maintenance, and assessment<br>- Design, implementation, application and assessment of domain-specific (high-level) programming languages<br>- Design, implementation, application and assessment of execution environments for universal and (domain) specific programming languages<br>- Expansion, use and assessment of programmable, partly endlessly running, self-sustaining systems<br>- Design, implementation, application and assessment of tools to support iterative, exploratory, user-oriented techniques for design, implementation and maintenance and assessment.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- acquire subject-specific theoretical and methodological knowledge to expand their professional judgment skills as well as the development of discussion skills and the associated discussion techniques,<br>- gain experience in dealing with the development and operation of systems and the techniques, challenges and tools used,<br>- are able to independently develop and use suitable sources of information to solve problems,<br>- can assess the applicability of solution concepts and strategies to given fundamental problems,<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- can present self-developed solutions to problems and defend their work against critical objections,<br>- can critically question solutions to problems developed by others and check their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-SDD: Systems Development Techniques and Tools - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>The module covers further aspects from the following subject areas and places emphasis on problems that require a deeper understanding of the paradigms/languages/systems/tools/use cases covered. Furthermore, prevalent compromises of modern paradigms/languages/systems are analyzed in detail; their core ideas are isolated and classified into the appropriate historical context using scientific methods.<br>The module includes:<br>- Deepening of basic programming paradigms (e.g., object-oriented, functional, logical, ... or imperative, declarative, prompt-based, ...)<br>- Deepening of iterative, exploratory, user-oriented techniques for design, implementation/maintenance and assessment<br>- Design, implementation, application and assessment of domain-specific (high-level) programming languages<br>- Design, implementation, application and assessment of execution environments for universal and (domain) specific programming languages<br>- Expansion, use and assessment of programmable, partly endlessly running, self-sustaining systems<br>- Design, implementation, application and assessment of tools to support iterative, exploratory, user-oriented techniques for design, implementation/maintenance and assessment.<br>Qualification goals: The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- acquire subject-specific theoretical and methodological knowledge to expand their professional judgment skills as well as the development of discussion skills and the associated discussion techniques,<br>- gain experience in dealing with the development and operation of systems and the techniques, challenges and tools used,<br>- are able to independently develop and use suitable sources of information to solve problems,<br>- can assess the applicability of solution concepts and strategies to given fundamental problems,<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- can present self-developed solutions to problems and defend their work against critical objections;<br>- can critically question solutions to problems developed by others and check their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time<br>(in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-SDC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-SDO: Systems Development and Operations** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory module/compulsory elective module |
| Content and qualification goals of the module: | Content:<br>The module teaches advanced scientific concepts, methods and techniques for one or more fundamental aspects of the design, development and operation of IT systems. These include, for example, requirements for IT systems, process-oriented IT systems, domain models, architectures, and variants. Among other topics, this module focuses on advanced concepts, methods, and techniques for the manual, semi-automatic, or automatic consideration of design decisions during development or adaptation decisions during operation. These can be presented through methods and techniques of process mining, methods or techniques for easily adaptable systems or self-adaptive systems, for example.<br>Qualification Goals:<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- gain advanced subject-specific theoretical and methodological knowledge,<br>- expand their professional judgment skills,<br>- develop discussion skills and techniques,<br>- acquire basic experience in dealing with the development and operation of systems and the tools used,<br>- develop and use suitable sources of information to independently solve fundamental problems;<br>- assess the applicability of solution concepts and strategies to given fundamental problems;<br>- acquire the ability to select and apply suitable solution concepts and strategies to a given advanced problem;<br>- present self-developed solutions to advanced problems and defend them against critical objections;<br>- can critically question solutions to advanced problems developed by others and check their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer: | SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-SDS: Systems Development Techniques and Tools - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Contents:<br>This module deals with advanced and in-depth aspects from the following subject areas. In doing so, it places emphasis on problems that require a deeper understanding of the paradigms/languages/systems/tools/use cases covered. Furthermore, prevalent compromises of modern paradigms/languages/systems are analyzed in detail, their core ideas are isolated and classified into the appropriate historical context using scientific methods.<br>- Deepening of basic programming paradigms (e.g., object-oriented, functional, logical, ... or imperative, declarative, prompt-based, ...)<br>- Deepening and specializing in iterative, exploratory, user-oriented techniques for design, implementation/maintenance and assessment<br>- Design, implementation, application and assessment of domain-specific (high-level) languages<br>-Further design, implementation, application and assessment of specialized execution environments for universal and (domain) specific programming languages<br>- Expansion, use and assessment of programmable, sometimes endlessly running, self-sustaining complex systems<br>- Design, implementation, application and assessment of specialized tools to support iterative, exploratory, user-oriented techniques for design, implementation/maintenance and assessment.<br>Qualification goals: The students acquire further and in-depth knowledge of the specialist topics covered in the module.<br>Students:<br>- gain detailed, in-depth subject-specific theoretical and methodological knowledge to expand their professional judgment skills as well as the application of discussion skills and associated discussion techniques,<br>- deepen and expand experience in the development and operation of systems and the techniques, challenges and tools used;<br>- evaluate and independently use appropriate sources of information to solve complex problems;<br>- assess the applicability of specialized solution concepts and strategies for given complex problems,<br>- acquire the ability to evaluate and apply suitable solution concepts and strategies to a given complex, specialized problem,<br>- present self-developed solutions to complex, specialized problems and have the ability to defend their work,<br>- can critically question solutions to complex problems developed by others and check their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-SDC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-SIC: Systems Infrastructure - Core** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module addresses a system's core aspects from a technological perspective. The focus is on different sub-areas of large-scale system architectures. Technical and technological interactions at different system levels are emphasized. This can range from the consideration of a single computer and its internal architecture, to operating systems and virtualization, to distributed and networked systems. In comparison to corresponding courses in the bachelor's degree programs, the thematic demands here are higher, the treatment is deeper in terms of subject matter (e.g., by including optimality proofs in system considerations), and the approach is more comprehensive, with a greater emphasis on cross-relationships between individual system levels.<br>- Deepening of basic programming paradigms (e.g., object-oriented, functional, logical, ... or imperative, declarative, prompt-based, ...)<br>- Deepening and specializing in iterative, exploratory, user-oriented techniques for design, implementation/maintenance and assessment<br>- Design, implementation, application and assessment of domain-specific (high-level) languages<br>- Further design, implementation, application and assessment of specialized execution environments for universal and (domain) specific programming languages<br>- Expansion, use and assessment of programmable, sometimes endlessly running, self-sustaining complex systems<br>- Design, implementation, application and assessment of specialized tools to support iterative, exploratory, user-oriented techniques for design, implementation/maintenance and assessment.<br>Qualification goals:<br>The students acquire further and in-depth knowledge of the specialist topics covered in the module.<br>Students:<br>- gain in-depth and further subject-specific theoretical and methodological knowledge to expand their professional judgment skills as well as the application of discussion skills and associated discussion techniques,<br>- deepen and expand their experience in dealing with the development and operation of systems and the techniques, challenges and tools used,<br>- evaluate and use appropriate sources of information to independently solve complex problems,<br>- assess the applicability of specialized solution concepts and strategies for given complex problems,<br>- evaluate and apply suitable solution concepts and strategies to a given complex, specialized problem,<br>- can present self-developed solutions to complex, specialized problems and have the ability to defend their work,<br>- can critically question solutions to complex problems developed by others and check their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

| | |
|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-SID: Systems Infrastructure - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>In this module, technical sub-areas of a system are treated from a technological perspective with a high level of detail. The focus is on different sub-areas of large-scale systems architectures. Emphasis is placed on complex technical and technological relationships at different system levels. This can range from the consideration of a single computer and its internal architecture, to operating systems and virtualization, to distributed and networked systems.<br>Qualification goals:<br>The students acquire further and in-depth knowledge of the specialist topics covered in the module.<br>Students:<br>- gain in-depth, advanced subject-specific theoretical and methodological knowledge to expand their professional judgment skills as well as the application of discussion skills and the associated discussion techniques,<br>- deepen and expand experience in dealing with the development and operation of systems and the techniques, challenges and tools used,<br>- acquire the ability to independently evaluate and use appropriate sources of information to solve complex problems,<br>- can assess the applicability of specialized solution concepts and strategies for given complex problems,<br>- can evaluate and apply suitable solution concepts and strategies to a given complex, specialized problem,<br>- can present self-developed solutions to complex, specialized problems and have the ability to defend their work,<br>- can critically question solutions to complex problems developed by others and check their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-LSA or HPI-CS-SIC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-SIS: Systems Infrastructure - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>In this module, technical sub-areas of a system are treated from a technological perspective with a high level of detail. The focus is on different sub-areas of large-scale systems architectures. Emphasis is placed on complex technical and technological relationships at different system levels. This can range from the consideration of a single computer and its internal architecture, to operating systems and virtualization, to distributed and networked systems.<br>Qualification goals:<br>The students acquire further and in-depth knowledge of the specialist topics covered in the module.<br>Students:<br>- gain in-depth, advanced subject-specific theoretical and methodological knowledge to expand their professional judgment skills as well as the application of discussion skills and the associated discussion techniques,<br>- deepen and expand experience in dealing with the development and operation of systems and the techniques, challenges and tools used,<br>- acquire the ability to independently evaluate and use appropriate sources of information to solve complex problems,<br>- can assess the applicability of specialized solution concepts and strategies for given complex problems,<br>- can evaluate and apply suitable solution concepts and strategies to a given complex, specialized problem,<br>- can present self-developed solutions to complex, specialized problems and have the ability to defend their work,<br>- can critically question solutions to complex problems developed by others and check their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Projektseminar/Seminar/Vorlesung (Vorlesung oder Seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-LSA or HPI-CS-SIC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-SSC: Systems Security - Core** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module addresses fundamental methods and approaches for developing secure applications and systems. Security measures and concepts are examined for various categories of applications, systems, and networks. Students consider various methods of analysis that make it possible to identify and analyze vulnerabilities and attack vectors on a theoretical as well as a practical level.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- gain subject-specific theoretical and methodological knowledge,<br>- expand their professional judgment skills,<br>- develop discussion skills and techniques,<br>- gain experience in the handling of security measures and concepts as well as analysis methods for vulnerabilities and attack vectors,<br>- acquire the ability to independently develop and use suitable sources of information to solve problems,<br>- can assess the applicability of solution concepts and strategies to given problems,<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- can present self-developed solutions to problems and have the ability to defend their work,<br>- gain the ability to critically question solutions to problems developed by others and check their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-CS-SSD: Systems Security - Deep Dive** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module addresses fundamental methods and approaches for developing secure applications and systems. Security measures and concepts are examined for various categories of applications, systems, and networks. Students consider various methods of analysis that make it possible to identify and analyze vulnerabilities and attack vectors on a theoretical as well as a practical level.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- gain subject-specific theoretical and methodological knowledge,<br>- expand their professional judgment skills,<br>- develop discussion skills and techniques,<br>- gain experience in the handling of security measures and concepts as well as analysis methods for vulnerabilities and attack vectors,<br>- acquire the ability to independently develop and use suitable sources of information to solve problems,<br>- can assess the applicability of solution concepts and strategies to given problems,<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- can present self-developed solutions to problems and have the ability to defend their work,<br>- gain the ability to critically question solutions to problems developed by others and check their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-SSC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-SSS: Systems Security - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module addresses fundamental methods and approaches for developing secure applications and systems. Security measures and concepts are examined for various categories of applications, systems, and networks. Students consider various methods of analysis that make it possible to identify and analyze vulnerabilities and attack vectors on a theoretical as well as a practical level.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- gain subject-specific theoretical and methodological knowledge,<br>- expand their professional judgment skills,<br>- develop discussion skills and techniques,<br>- gain experience in the handling of security measures and concepts as well as analysis methods for vulnerabilities and attack vectors,<br>- acquire the ability to independently develop and use suitable sources of information to solve problems,<br>- can assess the applicability of solution concepts and strategies to given problems,<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- can present self-developed solutions to problems and have the ability to defend their work,<br>- gain the ability to critically question solutions to problems developed by others and check their professional suitability. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (at least 50%) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | Prior participation in HPI-CS-SSC is recommended. |
| Department: | Digital Engineering |

| **HPI-CS-STO: Stochastics** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory module/compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module covers concepts from mathematical probability theory. It includes both discrete probability theory and continuous, especially random, processes. Applications essential to computer science are examined (e.g., hashing, random walks). The focus is on mathematical analysis.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students<br>- get to know various classical statements and situations in the field of probability theory, as well as their analyses,<br>- understand problems and pitfalls when dealing with probabilities,<br>- can independently model and analyze situations with uncertainties,<br>- are able to solve problems with uncertainties,<br>- gain insights into the current state of research. |
| Partial module exams (number, form, scope): | Exam types:<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Exercises (50%) | - |

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|---|---|
| Frequency of offer: | SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-DHBMHS: Fundamentals of Healthcare Systems** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory module/compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module provides the basics of international health systems, as well as the specific requirements and special characteristics required for the area of digital health.<br>Qualification goals:<br>Students acquire a broad background knowledge of health systems.<br>Students:<br>- gain subject-specific theoretical, methodological, and practical knowledge,<br>- learn how to independently work on a topic based on primary and secondary literature,<br>- acquire the ability to independently access and evaluate scientific literature on individual topics,<br>- learn and practice basic academic skills. |
| Partial module exams (number, form, scope): | Exam types:<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | - | - |

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|---|---|
| Frequency of offer: | WiSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-DHBMPM: Introduction to Principles in Medicine** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory module/compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module teaches selected foundations and concepts from various areas of medicine and skills for documenting medical issues that are essential in understanding and applying requirements in the area of Digital Health.<br>Qualification goals:<br>Students acquire a broad background knowledge of health systems.<br>Students:<br>- gain subject-specific theoretical, methodological, and practical knowledge,<br>- learn how to independently work on a topic based on primary and secondary literature,<br>- gain the ability to independently access and evaluate scientific literature on individual topics,<br>- learn and practice basic academic skills. |
| Partial module exams (number, form, scope): | Exam types:<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Seminar/ lecture (lecture or seminar) | 4 | - | - | - |

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|---|---|
| Frequency of offer: | WiSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-PSK-DS: Design Thinking - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module teaches advanced approaches and principles, techniques, and methods of design thinking—a user-centered concept for designing innovations, business models, and strategic futures. The design thinking process combines methods and tools from the areas of design, engineering, and business administration. User orientation is combined with the perspective of technological feasibility and economic sustainability. The team-based approach not only relies on individual creativity but—in particular—on collaboration. In this module, central areas of application are developed, discussed, and practiced together with project partners based on specific project questions in advanced design studios. The module also provides in-depth discourse, methods, and reflections in order to examine how the integration of human-centered design (HCD) and design thinking can be made sustainable and effective in various strategic fields of action.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- gain further subject-specific theoretical and methodological knowledge,<br>- can develop and try out their creativity,<br>- can present completed tasks and defend their work,<br>- practice advanced methods and techniques,<br>- practice working on and integrating delimited contributions independently in group work,<br>- practice working together in teams and dealing with complex issues collaboratively,<br>- practice teamwork and collaborative problem-solving,<br>- practice conflict skills in a team,<br>- learn advanced approaches to leadership skills,<br>- gain experience in assuming responsibility.<br><br>Depending on the language of instruction, this module is held in German or English. The teaching language will be announced in sufficient time before the start of the respective course. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper, at least 12 pages<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Oral exam, 30-45 minutes |
| Self-study time<br>(in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Interim presentation (15 minutes) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-PSK-DT: Design Thinking** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module teaches advanced approaches and principles, techniques, and methods of design thinking—a user-centered concept for designing innovations, business models, and strategic futures. The design thinking process combines methods and tools from the areas of design, engineering, and business administration. User orientation is combined with the perspective of technological feasibility and economic sustainability. The team-based approach not only relies on individual creativity but—in particular—on collaboration. In this module, central areas of application are developed, discussed, and practiced together with project partners based on specific project questions in advanced design studios. The module also provides in-depth discourse, methods, and reflections in order to examine how the integration of human-centered design (HCD) and design thinking can be made sustainable and effective in various strategic fields of action.<br>Students:<br>- gain further subject-specific theoretical and methodological knowledge,<br>- can develop and try out their creativity,<br>- can present completed tasks and defend their work,<br>- practice advanced methods and techniques,<br>- practice working on and integrating delimited contributions independently in group work,<br>- practice working together in teams and dealing with complex issues collaboratively,<br>- practice teamwork and collaborative problem-solving,<br>- practice conflict skills in a team,<br>- learn advanced approaches to leadership skills,<br>- gain experience in assuming responsibility.<br><br>Depending on the language of instruction, this module is held in German or English. The teaching language will be announced in sufficient time before the start of the respective course. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper of at least 12 pages<br>Paper of at least 8 pages, together with a presentation of research results (20-45 mins.)<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Interim presentation (15 minutes) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-PSK-EI: Entrepreneurship und Innovation** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module provides fundamental, practical and theoretical knowledge in the areas of entrepreneurship, technology, and innovation management. Students learn and practice entrepreneurial thought and action. They learn to solve problems, generate ideas and, from them, business models. Students learn about the challenges of starting a business and receive the motivation to found a startup themselves. The module also covers instruments from the field of empirical social research: business modeling, design thinking, lean start-up, and strategic technology foresight.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- gain subject-specific theoretical and methodological knowledge,<br>- learn a science-oriented way of thinking and proceeding,<br>- work on specific problems in a team,<br>- can develop and try out their creativity,<br>- can present completed tasks and defend their work,<br>- learn to work on specific contributions independently in group work,<br>- practice teamwork and problem-solving,<br>- practice conflict skills in a team,<br>- learn approaches to leadership skills,<br>- gain experience in assuming responsibility.<br><br>Depending on the language of instruction, this module is held in German or English. The teaching language will be announced in sufficient time before the start of the respective course. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper, (at least 12 pages)<br>Paper, (at least 8 pages) together with a presentation of research results (20-45 mins.)<br>Written exam, (90-120 minutes) |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format)) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Interim presentation (15 minutes) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-PSK-ES: Entrepreneurship - Specialization** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content<br>This module provides fundamental, practical and theoretical knowledge in the areas of entrepreneurship, technology, and innovation management. Students learn and practice entrepreneurial thought and action. They learn to generate creative ideas, transform them into successful business models and communicate them successfully to an audience. The module takes a deep dive into both the challenges as well as the opportunities of founding a company, including new types of companies. Students will be motivated to found a startup themselves.<br><br>Qualification goals<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- gain subject-specific theoretical and methodological knowledge,<br>- learn a science-oriented way of thinking and proceeding,<br>- work on specific problems in a team,<br>- can develop and try out their creativity,<br>- can present completed tasks and defend their work,<br>- learn to work on specific contributions independently in group work,<br>- practice teamwork and problem-solving,<br>- practice conflict skills in a team,<br>- learn approaches to leadership skills,<br>- gain experience in assuming responsibility.<br><br>Depending on the language of instruction, this module is held in German or English. The teaching language will be announced in sufficient time before the start of the respective course. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper, (at least 8 pages) together with a presentation of research results (20-45 minutes)<br>Written exam, (90-120 minutes)<br>Oral exam, (30-45 minutes) |
| Self-study time<br>(in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Interim presentation (15 minutes) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-PSK-LC: Law and Compliance** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module provides an overview of legal issues as well as compliance principles and standards in the IT industry. This includes legal issues when creating and using software systems—such as the handling of personal data, liability, copyright, and licensing. These are viewed within a national and international framework. The learning goal is to recognize legal dangers and prevent them from occurring and to act in a legally secure and compliant manner.<br>Qualification goals:<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- gain subject-specific theoretical, methodological and practical knowledge,<br>- can select and apply suitable solution concepts and strategies to legal questions,<br>- expand their professional judgment skills,<br>- can address risks through the collection and use of data in a qualified manner,<br>- gain experience in the formalization and abstraction of problems,<br>- are able to independently access and evaluate scientific literature on individual topics.<br><br>Depending on the language of instruction, this module is held in German or English. The teaching language will be announced in sufficient time before the start of the respective course. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper, (at least 12 pages)<br>Paper, (at least 8 pages) together with a presentation of research results (20-45 minutes)<br>Written exam, (90-120 minutes) |
| Self-study time<br>(in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Interim presentation (15 minutes) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-PSK-ML: Management und Leadership** | Number of credit points (CP): 6 |
|---|---|
| Content and qualification goals of the module: | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module teaches management skills that are necessary for planning and managing complex IT or big data projects, as well as general skills in the area of management and strategic business management.<br>The offerings include those in areas of methodological skills, action skills, social skills, and personal skills.<br>Qualification goals<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- gain subject-specific theoretical and methodological knowledge,<br>-gain knowledge of topics such as continuous strategic and organizational change and change management,<br>- gain experience in assuming responsibility,<br>- gain experience in self-organization,<br>- acquire planning skills,<br>- gain gender and diversity competence,<br>- learn how to manage and work in teams as well as how to deal with problems and complex tasks that occur in collaborative work,<br>- practice conflict skills in a team,<br>- learn approaches to leadership and management skills,<br>- train endurance.<br><br>Depending on the language of instruction, this module is held in German or English. The teaching language will be announced in sufficient time before the start of the respective course. |
| Partial module exams (number, form, scope) | Exam types:<br>Paper, (at least 8 pages) together with a presentation of research results (20-45 minutes)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time<br>(in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Interim presentation (15 minutes) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |

| **HPI-PSK-TC: Technology Communication and Transfer** | Number of credit points (CP): 6 |
|---|---|
| Module type (compulsory or compulsory elective module): | Compulsory elective module |
| Content and qualification goals of the module: | Content:<br>This module teaches different types of oral and written communication skills that play a role in various professional contexts of digital engineering in science and business. The focus is always on communicating specialist knowledge verbally and in writing to different target groups. The module covers aspects of the preparation and implementation of (scientific) presentations and lectures. Students learn pitch and presentation techniques, and techniques in communication management and writing. Students also learn how written communication differs from communication in a "live" situation, and how to optimally convey content in different media.<br>Qualification goals<br>The students acquire detailed knowledge of the specialist topics covered in the module.<br>Students:<br>- gain subject-specific theoretical and methodological knowledge,<br>- can select and apply suitable solution concepts and strategies to a given problem,<br>- practice communicating appropriately in various professional contexts, especially given the prior knowledge of the interaction partners,<br>- practice communication skills,<br>- learn presentation techniques in physical and digital contexts,<br>- practice teamwork and problem-solving,<br>- practice conflict management skills in a team.<br><br>Depending on the language of instruction, this module is held in German or English. The teaching language will be announced in sufficient time before the start of the respective course. |
| Partial module exams (number, form, scope): | Exam types:<br>Paper, (at least 8 pages) together with a presentation of research results (20-45 minutes)<br>Written exam, 90-120 minutes<br>Oral exam, 30-45 minutes |
| Self-study time (in hours [h]): | 120 |

| Courses (teaching format) | Contact time (in semester hours) | Supplementary exam requirements (number, form, scope) | | Course accompanying module (partial) exam (s) (number, form, scope) |
|---|---|---|---|---|
| | | For completion of module | For admission to module exam | |
| Project seminar/seminar/ lecture (lecture or seminar) | 4 | - | Interim presentation (15 minutes) | - |

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|---|---|
| Frequency of offer: | WiSe and SoSe |
| Prerequisite: | None |
| Department: | Digital Engineering |