Computer Science
- Courses & projects in English -

1. **Elective courses** in the fields of:
    a) Data Science and Artificial Intelligence
    b) Systems and Software Engineering
    c) Cyber-physical and Embedded Systems
    d) Open Communication Systems

2. **Elective team projects** in the fields of:
    a) Data Science and Artificial Intelligence
    b) Systems and Software Engineering

3. **Individual research projects:**
    a) Multi-Agent Research Simulation (MARS Group)
    b) Smart Sensing
    c) Data Science

Elective courses and elective team projects are offered in the summer semester (April – July) only. Individual research projects can be completed in winter and summer semester.

NOTE: Students can also choose software and hardware courses from the Information Engineering programme.

Department of Computer Science (November 2023)

1. Elective Modules

Each semester, the Department of Computer Science offers elective modules (6 ECTS credits) in four different areas. An elective module is made up of a lecture and a lab. These modules are graded. Modules are offered in the following four elective areas:

a) Data Science and Artificial Intelligence
b) Systems and Software Engineering
c) Cyber-physical and Embedded Systems
d) Open Communication Systems

Each semester students can choose from a list of elective modules in each area. The exact content of the modules can change from one year to the next and the final list of elective modules is published three months before the start of the upcoming summer semester. At least one module will be available in each elective area each summer semester.

As part of your application to HAW Hamburg, please write the elective area(s) in your learning agreement from which you would like to choose a module or modules. Once the list of elective modules has been decided for your chosen semester, your Student Exchange Coordinator will contact you, so you can finalise your choice of elective modules.

2. Elective Team Projects

Each semester, the Department of Computer Science offers their students elective team projects (9 ECTS credits) in two elective areas. An elective team project is a collaborative semester-long project, where teams of five to six students work independently, developing for example, an android app or control software for autonomous vehicles. The elective team projects are graded with pass/fail. The elective areas are:

a) Data Science and Artificial Intelligence
b) Systems and Software Engineering

3. Individual Research Projects

Students can also choose to complete an individual semester-long research project (6 ECTS) in one of the following research areas of the Department of Computer Science. Students can acquire extra credit, for example, by publishing a paper based on their research (maximum total of 9 ECTS). The individual research projects are graded with pass/fail.

a) Multi-Agent Research Simulation (MARS Group)
b) Smart Sensing
c) Data Science

Elective Area #1: Data Science and Artificial Intelligence

Degree Programme: Computer Science Bachelor	**Lecturers:** various lecturers	
Work load: 180 hrs	**Lecture hours per week:** 2 + 2 hrs labs	**ECTS Credits:** 6

Area objectives:

"Data Scientist: The Sexiest Job of the 21st Century" – Harvard Business Review. A data scientist must have the ambition, intuition, and curiosity to not only solve problems as they are presented, but also to identify and specify problems themselves. Intellectual curiosity and the ability to experimentation require a fusion of analytical and creative thinking. Employers are currently seeking candidates who can ask the "right" questions to form intelligent hypotheses and explore data using basic statistical methods and machine learning models. After all, those who can efficiently identify patterns and dependencies can make faster and more informed decisions, design processes more effectively and save costs.

On completion, students will have the ability to:

- understand essential mathematical principles from the fields of stochastics, analysis and linear algebra
- apply methods for data collection, preparation and visualization
- formulate hypotheses and perform statistical analyses on data
- apply selected methods from the fields of data mining, machine learning and artificial intelligence to data from different domains
- understand the concepts of data governance, data ethics and privacy
- On completion, students will have the ability to:
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Area Contents:

- Machine Learning and Artificial Intelligence
- Digital twins
- Data analysis
- Neural networks
- Convolutional networks (CNN) and deep learning methods
- Implementation with Python
- Agent-based simulations
- Multi-agent systems
- Social networks
- Swarm intelligence
- Statistics, correlation analysis
- Open data and big data
- Data classification, clustering and mining
- Data base
- Analysis, simulation and visualization of data
- Reinforcement Learning
- Machine Learning methods for signals

About didactics and work load distribution:

- Lecture: Tuition in seminars, whiteboard, slides, computer simulation, presentation, homework
- Laboratory: Laboratory- and computer practical course
- Attendance: 72h, individual study: 108h

Requirements for participation:

- Strong maths and programming skills
- Self-study
- Active teamwork

Course language:

English

Type of exam:

written exam / oral exam / presentation / term paper etc.

Requirements for credit point allocation:

- Active participation in lectures and lab
- Give presentation and write term paper
- Passing labs and exam

Literature:

- Steven Skiena, “Data Science Design Manual”, Springer
- Henk Tijms, “Understanding Probability”, Cambridge University Press
- Daniel Keim, Jörn Kohlhammer, Geoffrey Ellis, and Florian Mansmann, "Visual Analytics"
- J. Han, M. Kamber, “Data Mining. Concepts and Techniques”
- “Deep Learning. The comprehensive handbook: fundamentals, current techniques and algorithms, new research approaches”, by Ian Goodfellow , Yoshua Bengio, et al.
- Scientific primary literature (books, conference proceedings, journal papers etc.)

Elective Area #2: Systems and Software Engineering

Degree Programme: Computer Science Bachelor	**Lecturers:** various lecturers	
Work load: 180 hrs	**Lecture hours per week:** 2 + 2 hrs labs	**ECTS Credits:** 6

Area objectives:

Systems and software engineering is an interdisciplinary field of engineering and its management which focuses on how to analyze, design, integrate, implement, and manage complex systems over their life cycles. While system engineering incorporates both hardware and software components, software engineering focuses on the software of a system.

On completion, students will have the ability to:

- develop complex IT systems in different domains
- understand and optimize modern development processes
- apply various V&V (Verification and Validation) methods to improve system quality
- work in agile teams

Area Contents:

- Frontend and backend of SAP Systems
- 3D Computer graphics
- Games Engine
- Enterprise Architecture Management
- Process management and process intelligence
- Quality assurance
- Testing of SW systems
- Validation and Verification methods
- Advanced programming paradigms
- Web-browser technologies
- App development
- Cloud computing
- Computer Science and Cooperate Social Responsibility (CSR)
- Ethics in Computer Science
- Developing Simulation Software
- Agile project management with Scrum
- Case studies

About didactics and workload distribution:

- Lecture: Tuition in seminars, whiteboard, slides, computer simulation
- Laboratory: Laboratory- and computer practical course
- Attendance: 72h, individual study: 108h

Requirements for participation:

- Strong programming skills in OO languages
- Knowledge about software engineering disciplines
- Knowledge about modelling languages e.g. UML, State Machines
- Self-study
- Active teamwork

Course language:

English

Type of exam:

written exam / oral exam / presentation / term paper etc.

Requirements for credit point allocation:

- Active participation in lectures and lab
- Passing lab requirements and exam

Literature:

- Agile Model-Based Systems Engineering Cookbook, Bruce Powel Douglass, 2021, ISBN 1838985832
- Software Engineering, Ian Sommerville, Pearson Education, 2021. ISBN: 0133943038
- Software Testing Foundations, Andreas Spillner, 2021, ISBN 1933952083
- Scientific primary literature (books, conference proceedings, journal papers etc.)

Elective Area #3: Cyber-physical and Intelligent Systems

Degree Programme: Computer Science Bachelor	**Lecturers:** various lecturers	
Work load: 180 hrs	**Lecture hours per week:** 2 + 2 hrs labs	**ECTS Credits:** 6

Area Objectives:

A cyber-physical system (CPS) is a network of IT and software components with mechanical and electronic parts that communicate via a data infrastructure such as the Internet. A cyber-physical system is characterized by its high degree of complexity, reaching from the networking of embedded systems such as industry automation systems in apple farms through communication networks in autarkic underwater robotics.

On completion, students will have the ability to:

- evaluate cyber-physical systems.
- develop intelligent systems like robots and industry production systems.
- understand the various intelligent sensors systems and apply them on different systems.
- interoperate and connect subsystems.
- learn about process intelligence.

Area Contents:

- Applications for autonomous systems
- Modern sensor technologies
- Raspberry-Pi
- BeagleBone Black
- Intelligent sensor technologies
- Autonomous driving
- Managing sensor farms
- Robotics
- Classification and object recognition with MobileNet and SSD
- Smart home systems
- Industrial robotic systems
- Adaptive distributed systems
- Real-time programming and concurrent programming
- Real-time operating systems
- C, C++, Python programming

About didactics and work load distribution:

- Lecture: Tuition in seminars, whiteboard, slides, computer simulation
- Laboratory: Laboratory- and computer practical course
- Attendance: 72h, individual study: 108h

Requirements for participation:

- Strong programming skills
- Knowledge about operating systems
- Self-study
- Active teamwork

Course language:

English

Type of exam:

written exam / oral exam / presentation / term paper etc.

Requirements for credit point allocation:

- Active participation in lectures and lab
- Passing lab requirements and exam

Literature:

- Schwaiger, R.; Steinwendner, J.: Neuronale Netze programmieren mit Python. Rheinwerk Computing
- Alpaydin, E.: Introduction to Machine Learning, MIT Press, 2020, ISBN: 0262043793
- Scientific primary literature (books, conference proceedings, journal papers etc.)
- www.tensorflow.org

Elective Area #4: Open Communication Systems

Degree Programme: Computer Science Bachelor	**Lecturers:** various lecturers	
Work load: 180 hrs	**Lecture hours per week:** 2 + 2 hrs labs	**ECTS Credits:** 6

Area objectives:

The Open Systems Interconnection model (OSI model) is a conceptual model that describes the universal standard of communication functions of a telecommunication system. Interoperability and cybersecurity play an important role in diverse communication systems containing.

On completion, students will have the ability to:

- Be familiar with methods for constructing secure protocols for protecting distributed systems and know practically important protocols such as Transport Layer Security (TLS) as well as Kerberos.
- Analyze different communication protocols in modern network technologies.
- Get an insight into the standardization work.
- Understand security models and security properties of cryptographic methods and be able to assess their strength.
- Know attack techniques in networks / distributed systems and the use of cryptographic measures to defend against such attach techniques.

Area Topics:

- Internet of Things (IoT) and its operating system (RIOT)
- Development with IoT devices
- Communication between sensor nodes
- Various protocols and their standards (e.g. TLS, TCP, SCTP, IPv6)
- Interface programming
- M2M communications
- Energy harvesting
- IT security
- Structure of public key infrastructure (KPI)
- Safety and Security in open communication systems
- National Security Agency (NSA)
- Cryptographic methods
- Digitalization and Ethics in Internet
- Web Services
- Various simulation and framework tools

About didactics and workload distribution:

- Lecture: Tuition in seminars, whiteboard, slides, computer simulation, presentation, homework
- Laboratory: Laboratory- and computer practical course
- Attendance: 72h, individual study: 108h

Requirements for participation:

- Strong programming skills
- Self-study
- Knowledge about OSI reference model
- Active teamwork

Course language:

English

Type of exam:

written exam / oral exam / presentation / term paper etc.

Requirements for credit point allocation:

- Active participation in lectures and lab
- Passing lab requirements and exam

Literature:

Scientific primary literature (books, conference proceedings, journal papers etc.)

Elective Team Projects (PO)

Degree Programme: Computer Science Bachelor	**Responsible Lecturer:** Various lecturers

Work load: 270 hrs	**Lecture hours per week:** 6 hrs team work	**ECTS Credits:** 9

Area objectives:

The student will work in a larger team on a predefined IT project. At the start of the semester the project goal will be presented by the lecturer and the students will work on the project in teams of 4-6 people. In order to run the project successfully, software engineering principles must be applied. The project progress will be supervised by the lecturer and lab assistants. At the end of the semester, the results will be presented to a larger audience.

On completion, students will have the ability to:

- solve IT-specific problems, taking into account limited resources (time, staff, tools, etc.)
- specify requirements, to model systems,
- set goals and plan projects,
- ensure quality,
- pre- and post-calculate the time required,
- provide comprehensible documentation,
- work in teams with developers and (if possible) users,
- present work results,
- lead and moderate meetings,
- resolve conflicts,
- evaluate work results.

About didactics and workload distribution:

Attendance: 72h, Team work: 108h

Requirements for participation:

- Strong programming skills in programming
- Experience in software engineering and project management
- Self-study
- Active teamwork

Team language:

English

Type of exam:

Project presentation, paper work etc.

Research Area #1: MARS - Modelling & Simulation (RLab1)

Degree Programme: Computer Science Bachelor	**Lecturer:** Prof. Dr. Thomas Clemen	
Work load: 270 hrs	**Hours per week:** 6 hrs research work	**ECTS Credits:** 6 (9)*

Students will be part of the MARS research group (https://mars-group.org/) of Prof. Dr. Thomas Clemen. They will work on an individual research and development project suitable to their level.

A major objective of this module is to learn how to complete collaborative research in a larger team.

Self-learning materials and coaching will be provided to students during the semester. A highly experienced team is also available to support students.

Area objectives:

- modelling and simulation
- conceptional modelling
- select the appropriate simulation framework
- verification and validation

MARS GROUP

The student has the opportunity to work on the interdisciplinary research projects:

- ESIDA: Epidemiological Surveillance
- SmartOpenHamburg
- MARS Urban simulation

About workload distribution:

Attendance: 72h, Research work: 108h

* Students can acquire up to 9 credits in total if they publish their research.

Requirements for participation:

- Strong programming skills
- Research work and self-study

Type of pass:

Project presentation, research paper publications etc.

Team language:

English

Research Area #2: Smart Sensing (RLab2)

Degree Programme: Computer Science Bachelor	**Lecturer:** Prof. Dr. Tim Tiedemann	
Work load: 270 hrs	**Lecture hours per week:** 6 hrs research work	**ECTS Credits:** 6 (9*)

Students will be part of the research group of Prof. Dr. Tim Tiedemann. They will work on an individual research and development project suitable to their level.

A major objective of this module is to learn how to complete collaborative research in a larger team.

Self-learning materials and coaching will be provided to students during the semester. A highly experienced team is also available.

Area objectives:

- intelligent sensing
- machine learning
- sensor data processing
- smart robotics
- intelligent transport systems
- hardware acceleration
- bio robotics

Students have the opportunity to work on the following current interdisciplinary research projects topics:

- AuTagBeoFisch - An underwater diving robot
- Smart Recycling
- RoLand - A semi-autonomous fruit harvesting system
- i-Lum - Airborne urban mobility

About workload distribution:

Attendance: 72h, Research work: 108h

* Students can acquire up to 9 credits in total if they publish their research.

Requirements for participation:

- Strong programming skills
- Fundamental knowledge in data science
- Research work and self-study

Type of grading:

Project presentation, research paper publications etc.

Course language:

English

Research Area #3: Data Science (RLab3)

Degree Programme: Computer Science Bachelor	**Lecturer:** Prof. Dr. Marina Tropmann-Frick	
Work load: 270 hrs	**Lecture hours per week:** 6 hrs research work	**ECTS Credits:** 6 (9)

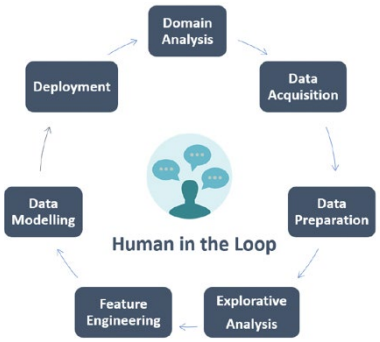
Students will be part of the Data Science research group of Prof. Dr. Marina Tropmann-Frick. They will work on an individual research and development project suitable to their level.

A major objective of this module is to learn how to complete collaborative research in a larger team.

Self-learning materials and coaching will be provided to students during the semester. A highly experienced team is also available.

Area objectives:

- Data Management, Engineering and Analysis
- Predictive and Visual Analytics
- Explainable AI / Machine Learning
- Human in the Loop
- Privacy and Ethics
- Decision support



data science lifecycle

Students have the opportunity to work on the following current interdisciplinary research projects topics:

- Pharmacovigilance,
- Statistical methods in medicine (small vs. big data),
- Disaster management with optimization techniques, predictions, decision support,
- Smart Mobility with test site for intelligent campus mobility,
- DigEco
- Data analytics / predictive analytics / predictive maintenance / text analytics.

About workload distribution:

Attendance: 72h, Research work: 108h

* Students can acquire up to 9 credits in total if they publish their research.

Requirements for participation:

- Strong programming skills
- Fundamental knowledge in data science
- Research work and self-study

Team language:

English

Type of grading:

Project presentation, documentation, research paper publications etc.