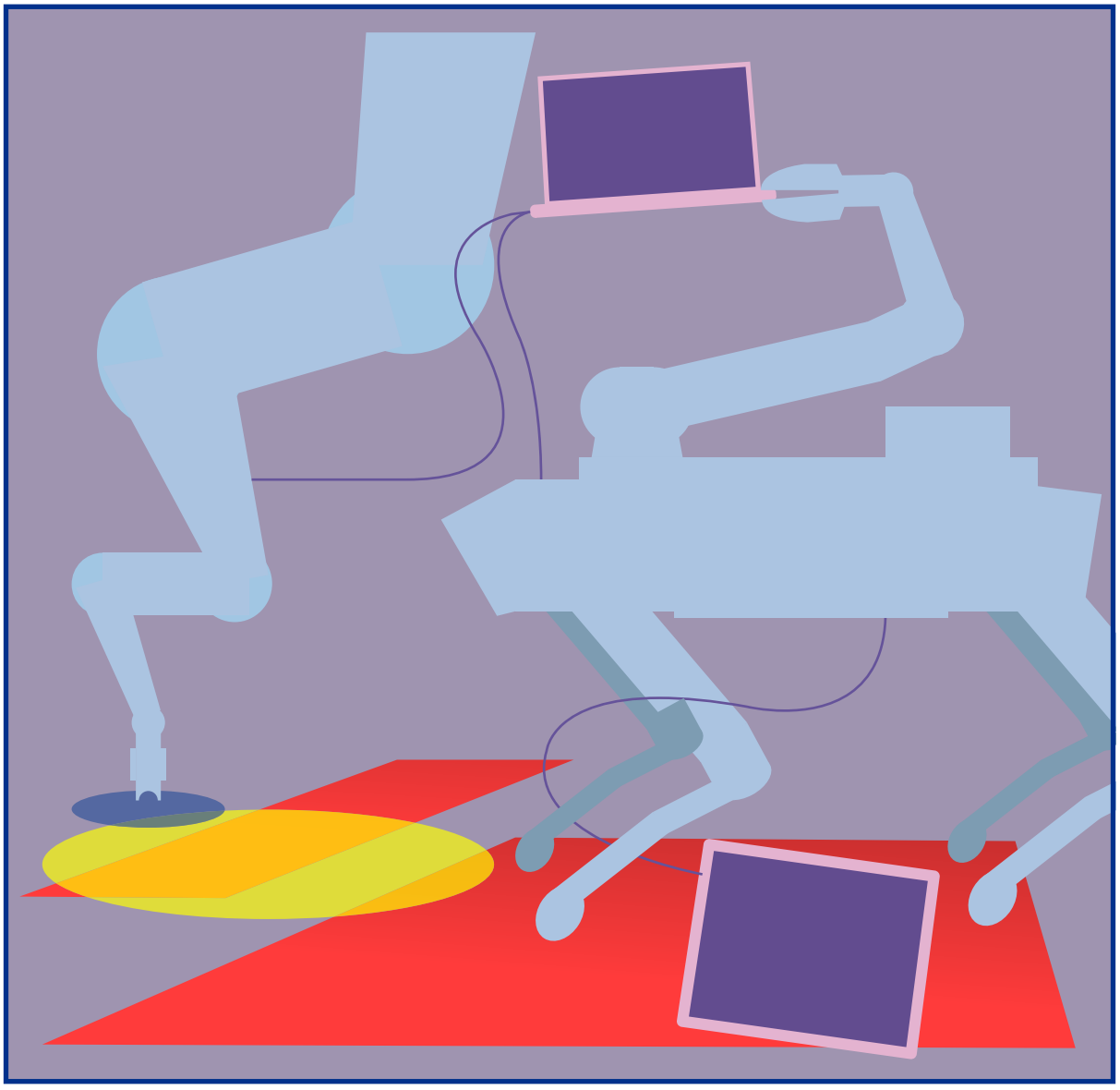
# Course Catalogue
## AI Driven Mechatronics and Robotics
### Master of Science



Leibniz Universität Hannover

Leibniz Universität Hannover

# Module catalog for PO 2024

Study guide for the degree program
AI-driven Mechatronics and Robotics
with the degree
Master of Science

**Summer semester 2026**

Impressum

## Herausgeber

Fakultät für Maschinenbau der Gottfried Wilhelm Leibniz Universität Hannover

Sachbearbeitung: Anke Tatzko, M. Sc.
Studiensekretariat: Gabriele Schnaidt

Adresse: An der Universität 1, 30823 Garbsen
Telefon: +49 (0)511 762-4165
Fax: +49 (0)511 762-2763
E-Mail: studienberatung@maschinenbau.uni-hannover.de

Greetings

# Dear Students

with this study guide for the AI-driven Mechatronics and Robotics Master's degree program, we would like to provide you with an important tool for planning and structuring your studies. The study guide is updated and published at the beginning of each semester by the Office of the Dean of Studies at the Faculty of Mechanical Engineering. It contains information on the structure of the degree course and the module catalog with module descriptions.

In the following, we will first explain the structure of the AI-driven Mechatronics and Robotics degree program. You will find an overview of the Master's curriculum as well as a list of the areas of expertise and elective options. The modules are assessed according to the ECTS* credit point system (ECTS-LP) and consist of lectures, exercises, projects, practicals and laboratory work. The Master's degree also includes a dissertation, which consolidates the qualifications for scientific work acquired in the Bachelor's degree in preparation for the final Master's dissertation.

In the Master's program, you must take elective and optional modules, which you can choose according to your interests. This results in a variety of subject combinations that allow you to tailor your studies to your interests.

Finally, some well-intentioned advice: it is important to proceed in a structured manner in order to study successfully. Therefore, set yourself various milestones for your course of study and ensure that you earn the number of credit points planned for each semester. The module catalog and the general course catalog will help you select and schedule the modules you need to take. You can also train other skills, such as foreign language skills, and work on your soft skills. If you take the extensive range of courses carefully, an education at Leibniz Universität Hannover will give you excellent preparation for your future career.

If required, the Office of the Dean of Studies will support you in planning and organizing your studies. Do not hesitate to take advantage of the opportunity to discuss your questions about your studies in a counseling session. You will also find support on study-related issues from experienced students on the student council or the academic staff at the institutes.

We wish you an exciting and successful course of study.

Your

Prof. Dr.-Ing. M. Wurz

Prof. Dr.-Ing. B. Wicht

*European Credit Transfer System

## Module catalog, study guide of the Faculty of Mechanical Engineering

## Greetings

## Structure of the degree program AI-driven Mechatronics and Robotics



## Master of Science .....

## Notes on this module catalog

This module catalog applies to students who started their studies in the winter semester 2025/26. They study according to the examination regulations that come into force on 01.10.2025 (PO 2024).

The Dean's Office of Mechanical Engineering creates the module catalog together with the institutes and module coordinators. The assignment of modules to the corresponding competence areas of the Master's degree program is binding. This means that you can only receive credit for courses in your degree program that have been assigned to the modules attended in this catalog.

## Additional information

At the beginning of each semester, the Dean's Office of Mechanical Engineering provides detailed information about the structure and organization of the degree course as part of the "StudiStart!" event. The dates for "StudiStart!" are announced on the faculty homepage under "Studium" → 'Im Studium' → "Erstsemesterbegrüßung und StudiStart!", on Instagram and via StudIP. In addition, the Student Advisory Service will be happy to help and advise you under "Kontakte und Sprechzeiten" → "Contacts and office hours" during general office hours.

This module catalog is supplemented by a tutorial and laboratory catalog. In addition, the AG Study Information publishes a semester booklet (for the Master's degree) for the AI-driven Mechatronics and Robotics course every semester, which contains detailed organizational information for the respective semester. You can obtain the booklets online on the faculty homepage under "Studium" → "Studiengänge" → "Masterstudiengänge" → "AI- driven Mechatronics and Robotics M. Sc.".

The website of the Faculty of Mechanical Engineering not only provides detailed information about studying AI-driven Mechatronics and Robotics and the examination regulations. They also provide a wide range of insights into the faculty's activities.

Another point of contact for help with your studies is the hall communities in the IK House (Ilse Knott-ter Meer House) on the Mechanical Engineering campus.

## Structure of the AI-driven Mechatronics and Robotics degree program at Leibniz Universität Hannover

The Faculty of Mechanical Engineering at Leibniz Universität Hannover offers an internationally recognized degree, the Master of Science, in accordance with the examination regulations (PO 2024).

The degree program consists of modules and courses. Modules are the most important component of your studies, they combine thematically or content-wise similar and related courses. To successfully complete the course, you must pass all modules. Teaching takes place in courses such as lectures, tutorials, seminars, laboratories, excursions and tutorials.

Lectures and tutorials teach the theoretical basics, which you then deepen during the course of your studies in practicals, experimental labs and project work. You will acquire key skills in tutorials.

In principle, you are free to decide the order in which you attend the individual courses.

## Study abroad

We encourage you to complete part of your studies abroad. Studying abroad offers a unique opportunity to get to know different learning systems, cultures, knowledge systems and people. You can find more detailed information on this and how we can support you in your planning under "Studium" → "Internationales" on the faculty homepage. If you have any further questions, the Study Abroad Advisory Service of the Faculty of Mechanical Engineering and the International Office will be happy to help. You can also complete your internship abroad. The Office of the Dean of Studies will also be happy to advise you on this. Fortunately, the faculty also welcomes many students from abroad. Your most important contacts are the International Office and the Student Advisory Service for Mechanical Engineering.

# Examinations

For successfully passed examinations and coursework (tutorials, labs, practicals, excursions, etc.) you will receive credit points according to ECTS (ECTS-LP), 1 ECTS-LP corresponds to approximately 30 hours of work. The examination for a course is usually taken at the end of the semester. However, there are also examinations during the semester. Examinations are graded. Coursework, on the other hand, is not graded, but must be attended.

## Registration and deregistration of examinations

If you wish to take an examination, you must register for the relevant examination during the registration period at the Examinations Office. Subsequent registration is only possible in exceptional cases. You must register for all examinations online. If you do not wish to take part in an examination, you must deregister independently in the system or in writing to the examiner within the deadline specified for the type of examination without giving reasons. If you fail to do so, the examination will be assessed as "failed" in future. Further details are regulated in § 13 and § 15 of the model examination regulations valid from the winter semester 2022/2023. This period is valid for all winter and summer semesters from winter semester 2022/2023 until further notice.

**Registration and Examination Periods**

| | Winter semester | Summer semester |
|---|---|---|
| **CRE registration** | 15.10. - 31.10. | 15.04. - 30.04. |
| **CRE period** | 01.11. - 28.02. | 01.05. - 31.08. |
| **Exam registration** | 15.11. - 30.11. | 15.05. - 31.05. |
| **Exam period** | 15.12. - 14.04. | 15.06. - 14.10. |

CRE = Course-related Examination (German: VbP)

### Failure to pass and exmatriculation

By the end of the second semester (without leave of absence), you must have successfully completed and passed at least 20 ECTS credits from the total range of coursework and examinations for this degree program. If the deadline is exceeded, § 8 Para. 2 applies.

You should complete an average of 30 ECTS-LP per semester.

In the event of difficulties with your studies, please contact the Student Advisory Service as soon as possible in order to resolve such problems in advance!

## Competence development in the AI-driven Mechatronics and Robotics degree program

As part of the Bologna Process, the German Rectors' Conference created a qualifications framework in 2005 to establish a system of comparable degrees. It creates specific profiles that make it easier to compare the skills taught and acquired. This is intended to shift the focus from inputs (course content, admission criteria, length of studies) to outcomes (learning outcomes, acquired competencies and skills).

The competence profiles, which are mapped in the course and module catalogs, show what students can expect in the course and which competences and skills they can acquire in this course.

The competence profile is divided into five competence areas, in turn subdivided into four to five core competences. These competencies were assessed by the lecturers for their courses in a comprehensive survey on a percentage basis.

# Master of Science

The Master of Science (M.Sc.) represents an advanced professional qualification. A Bachelor of Science in an engineering degree, a Bachelor of Engineering or a comparable degree is required for admission to the Master's degree program. Further details can be found in the admission regulations. The standard period of study for the Master's degree course is 4 semesters.

## Main study program

You can study much more freely in the Master's program than in the Bachelor's program; there are only four compulsory courses.

## Key competencies

In the key competencies area, you will build on your Bachelor's knowledge of scientific work, the relationship between science and practice and techniques for collaboration. Furthermore, as part of the Studium Generale, you have the opportunity to choose an additional module from the entire range of courses offered by Leibniz Universität Hannover and thus broaden your horizons beyond engineering topics.

## Master thesis

Finally, your Master's thesis demonstrates that you can apply the content of the other areas of competence and combine them in a meaningful way. The basic structure of a Master's thesis is similar to that of a Bachelor's thesis, but it covers a much broader topic and requires greater specialization.

Literature research: First you determine the current state of research and technology.

Project: Based on the state of the art, you carry out a project independently. Depending on the type of work, this may include design tasks, planning, experiments or concepts. The exact content of the project depends on the specific task and therefore differs from job to job.

Documentation: After completing the project, you document the process and the results in writing and interpret them on a scientific basis.

# Structure of the Master's degree program PO 2024

Degree programme AI driven Mechatronics and Robotics (M. Sc.)
Examination regulation 2024

| | 1./2. Semester | 1./2. Semester | 3. Semester | 4. Semester |
|---|---|---|---|---|
| 1–5 | Robotics I (5 CP) | Data- and AI-driven Methods in Engineer-ing (5 CP) | Student Research Project or Project Work or 2 Modules: Practical knowledge for tech-startup-founders and Student Ac-celerator- Engineering Innovations (10 CP) | Master Thesis (29 CP) + Presentation (1 CP) |
| 6–10 | Data- and Learning Based Control (5 CP) | German Language for Studies and Career (5 CP) | | |
| 11–20 | Compulsory Electives (20 CP) | | Advanced Internship 16 weeks (20 CP) **or** Advanced Internship 12 weeks (15 CP) and Studium generale (5 CP) | |
| 21–30 | Electives (20 CP) | | | |
| CP | 30 | 30 | 30 | 30 |
| | Wintersemster | Summersemester | Wintersemster | Summersemester |

| Color Key | | |
|---|---|---|
| Compulsory Modules | Compulsory Elective Modules | Key skills |
| Study Research/ Project Work | Elective Modules | Masterthesis |

https://www.maschinenbau.uni-hannover.de

# Compulsory and elective modules

| List of compulsory elective and elective modules | | | |
|---|---|---|---|
| **Wahlpflichtmodule** | | | |
| **Wintersemester** | **ECTS** | **Sommersemester** | **ECTS** |
| Deep Learning Foundations | 5 | Artificial Intelligence I | 5 |
| Electrical Machines and Drives | 5 | Robotergestützte Montageprozesse | 5 |
| Introduction to Mechanical Vibrations | 5 | Robotics II | 5 |
| Micro- and Nanosystems | 5 | Technoökonomische Analyse von Wasserstoffenergiesystemen | 5 |
| Nonlinear Control | 5 | | |
| Robotergestützte Montageprozesse | 5 | | |
| Slam and Path Planning | 5 | | |
| **Wahlmodule** | | | |
| **Wintersemester** | **ECTS** | **Sommersemester** | **ECTS** |
| AI applications in metallurgy | 5 | Atrificial Intelligence for Production Engineering | 5 |
| Atrificial Intelligence for Production Engineering | 5 | Automated Machine Learning | 5 |
| Artificial Intelligence II | 5 | Biomedizinische Technik II | 5 |
| Artificial intelligence in propulsion system development for sustainable mobility | 5 | Computational Argumentation | 5 |
| AutoML Lab | 6 | Design and Simulation of optomechatronic Systems | 5 |
| Computational Biomechanics | 5 | Engineering Dynamics and Vibrations | 5 |
| Data-driven parameter and model identification | 5 | Hybrid Artificial Intelligence | 5 |
| Electrical Energy Storage | 5 | Image Analysis I | 5 |
| Environmental Sustainability Assessment I | 5 | International Sustainable Product Development Project (ISPDP) | 5 |
| GIS and Remote Sensing | 5 | Model Predictive Control | 5 |
| Grundlagen der Data Science | 5 | MOOC Aircraft Engines | 3 |
| Hardware- accelerated Communication Systems | 5 | Project: Machine Learning | 6 |
| Image Analysis II | 5 | Recursive State Estimation for dynamic Systems | 5 |
| Image Sequence Analysis | 5 | | |
| International Sustainable Product Development Project (ISPDP) | 5 | | |
| Interpretable Machine Learning | 5 | | |
| Introduction to Natural Language Processing | 5 | | |
| Laser Scanning – Modelling and Interpretation | 5 | | |

| Wahlmodule | | | |
|---|---|---|---|
| **Wintersemester** | **ECTS** | **Sommersemester** | **ECTS** |
| MOOC Aircraft Engines | 3 | | |
| Multi-Agent Interactions and Games | 5 | | |
| Optical Measurement Technology | 5 | | |
| Photogrammetric Computer Vision | 5 | | |
| Power Electronics | 5 | | |
| Project: Machine Learning | 6 | | |
| Scientific Machine learning | 2 | | |
| Sensors and Nanosensors – Measuring non-electrical quantities | 5 | | |
| Sustainable Combustion | 5 | | |

# Types of Examinations

| Types of Examinations |
| --- |
| Bachelor's and Master's theses (BA, MA) |
| Term paper (HA) |
| Written examination (K) and multiple-choice examination (KA) |
| Oral examination (MP) |
| Internship report (PB) |
| Project-oriented examination form (PJ) |
| Term paper (ST) |
| Course-accompanying examination (VbP). The VbP accompanies the semester and serves as a container for many other forms of examination (see FAQ 3.2). |
| Academic achievement and examination performance (SL, PL) |

**Further explanations in the examination regulations**

Appendix 2 Examination forms

Appendix 2.1 Definition of Examination forms

# Modules and Courses

The courses are arranged alphabetically according to compulsory, compulsory elective and elective modules.

# Modul: Data- and AI-driven Methods in Engineering

**Module:** Data- and AI-driven Methods in Engineering

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Pflicht | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| SoSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 2. Semester | **Admission SoSe:** | 2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam | 5 | 60 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 42 h |
| **Self-study time** | 108 h |
| **Module coordinator** | Prof. Dr.-Ing. Thomas Seel |
| **Lecturer** | Prof. Dr.-Ing. Thomas Seel |
| **Institute** | Institut für Mechatronische Systeme |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Data- and AI-driven Methods in Engineering - Vorlesung | 2 | Written exam |
| Data- and AI-driven Methods in Engineering - Übung | 1 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Basics in Machine Learning and Programming |

**Qualification goals**

The module teaches how to tap the potential of data- and AI-driven methods for problem solving in engineering applications and focuses in particular on how these methods can be used to design, analyze and optimize sustainable engineering systems and processes. Examples include intelligent energy management, predictive maintenance or sustainable process design, which can be achieved, for example, by the use of machine learning methods in optimization problems or complex data analysis or by using cognitive decision making and planning algorithms.

After successfully completing the module, students will be able to

- understand and tap the potential of data- and AI-driven methods in engineering applications and to apply them in relevant use cases,
- choose the right method for a given problem and to make application-specific adjustments while taking reliability, explainability and other relevant qualities into account,
- understand the roles of prior knowledge and data, and to leverage that understanding to obtain well-performing data- and AI-driven solutions.

**Contents**

Specifically, the following concepts and methods are taught and discussed in the context of engineering applications:

- Overview and Classification of Problems and Methods
    - Summary of Fundamental Machine Learning and AI Methods and Concepts
    - Overview of Sustainable Engineering Applications and Use Cases
- Important Overarching Concepts
    - Sim-to-real-Gap, Transfer Learning, Domain Adaptation
    - Hybrid Methods and Physics-informed Machine Learning
    - Semi-Supervised Learning, Active Learning, Incremental Learning, Online-Learning
- Explainability, Safety, Security, Reliability, Resilience
- Data- and AI-driven Methods in Simulation and Optimization

# Modul: Data- and AI-driven Methods in Engineering

**Module:** Data- and AI-driven Methods in Engineering

- Machine Learning Methods for Complex Optimization
- Surrogate Models in Simulation and Model Order Reduction
- Kriging and Gaussian Processes for Engineering Applications
- Data- and AI-driven Methods in Data Analysis and Decision Making
- Data Mining in Engineering Applications
  - Predictive Maintenance, data-driven Digital Twins
  - AI-driven Decision Making, Planning, Expert Systems
- Data- and AI-driven Methods for Physical Interaction
  - Bayesian Methods for Sensor/Information Fusion
  - Learning and Control in Dynamical Systems
- Collective Learning and Swarm Intelligence

**Special features**

The main programming exercises (90 min each) take place bi-weekly. In the remaining time slots (weeks without main programming exercise), optional formats to support teaching are offered (e.g., programming office hours, journal club).

**Literature**

S. L. Brunton and J. N. Kutz, Data-Driven Science and Engineering. Cambridge University Press, 2019. E. Alpaydin, Maschinelles Lernen, 3rd ed. Berlin, Boston: De Gruyter Oldenbourg, 2022. J. R. R. A. Martins and A. Ning, Engineering Design Optimization. Cambridge University Press, 2022.

**Applicability in other degree programs**

Biomedizintechnik M.Sc.; Maschinenbau M.Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Nachhaltige Ingenieurwissenschaft M.Sc.; Nanotechnologie M.Sc.; Produktion und Logistik M.Sc.; Wirtschaftsingenieur M.Sc.;

# Modul: Data- and Learning - Based Control

**Module:** Data- and Learning -Based Control

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Pflicht | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1. Semester | **Admission SoSe:** | 1. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam | 4 | 90 min | graded |
| SL | Term paper | 1 | Programming exercise | ungraded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 42 h |
| **Self-study time** | 108 h |
| **Module coordinator** | Prof. Dr.-Ing. Matthias Müller |
| **Lecturer** | Dr. Victor Lopez<br>Prof. Dr.-Ing. Matthias Müller |
| **Institute** | Institut für Regelungstechnik |
| **Faculty** | Fakultät für Elektrotechnik und Informatik |

| Structure of the module | | |
|---|---|---|
| **Title and form of the course** | **Semester hours** | **Ep / Aa** |
| Data- and Learning - Based Control - Vorlesung | 2 | Written exam |
| Data- and Learning - Based Control - Hörsaalübung | 1 | Term paper |

| **Requirements for participation:** | **Recommended for participation:** |
|---|---|
| none | Model Predictive Control, Nonlinear Control |

**Qualification goals**

The students are familiar with state-of-the art methods for data- and learning-based control as well as the underlying theory. They are able to implement the presented methods and can read and discuss publications on past and ongoing research in this field.

**Contents**

In this course, different data- and learning-based control design techniques are considered. Data-based approaches compute controllers directly from the available input and output data, without the intermediate step of identifying a model of the system. In particular, we will discuss virtual reference feedback tuning, control design based on Willems fundamental lemma, and the data informativity framework. In learning-based control, some machine learning technique is employed to learn a model of the system (or unknown parts thereof) or directly a suitable controller. Within this course, we will in particular consider approaches from reinforcement learning, using Gaussian Processes, and neural networks.

**Special features**

The main programming exercises take place bi-weekly. In the remaining time slots (weeks without main programming exercise), optional formats to support teaching are offered (e.g., programming office hours, journal club).

**Literature**

none

**Applicability in other degree programs**

Biomedizintechnik M.Sc.; Maschinenbau M.Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017;

# Modul: German Language for Studies and Career

**Module:** German Language for Studies and Career

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Pflicht | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| SoSe/WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| | | | | |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 0 h |
| **Self-study time** | 150 h |
| **Module coordinator** | |
| **Lecturer** | |
| **Institute** | |
| **Faculty** | |

| Structure of the module | | |
|---|---|---|
| **Title and form of the course** | **Semester hours** | **Ep / Aa** |
| | | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | none |

| |
|---|
| **Qualification goals** |
| **Contents** |
| **Special features** |
| **Literature** |
| **Applicability in other degree programs** |

# Modul: Robotics I

**Module:** Robotics I

| Type of module | | Area of competence | | | | | |
|---|---|---|---|---|---|---|---|
| Pflicht | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam | 4 | 90 min | graded |
| SL | Labor | 1 | Lab | ungraded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Prof. Dr.-Ing. Thomas Seel |
| **Lecturer** | Prof. Dr.-Ing. Thomas Seel |
| **Institute** | Institut für Mechatronische Systeme |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Robotics I - Vorlesung | 2 | Written exam |
| Robotics I - Übung | 1 | Labor |
| Robotics I - Labor | 1 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Control engineering; Multibody systems; Engineering mechanics |

**Qualification goals**

After successfully completing the module, students will be able to

•describe serial robots mathematically (coordinate transformations, direct and inverse kinematics, Jacobian matrix, kinematically redundant robots, path planning, dynamics),
•control serial robots with high accuracy (single-axis control, multi-axis control, impedance control, admittance control),
•and to adapt them to applications.

The methodological knowledge required for this is covered in the lecture and deepened by means of exercises, so that independent scientific work is possible.

**Contents**

The content of the course is modern methods of robotics, focusing in particular on issues of (differential) kinematic and dynamic modeling as well as current path planning approaches and (advanced) control engineering methods.

**Special features**

The module is taught by IMES (Faculty of Mechanical Engineering) in the winter semester and by IRT (Faculty of Electrical Engineering and Computer Science) in the summer semester. The module consists of a lecture, a lecture hall exercise, a computer exercise (coursework) and a voluntary additional course (remote laboratory). The written examination (4 ECTS) is independent of the computer exercise (1 ECTS). However, participation in the computer exercise is required to obtain the fifth credit point. If only one of the two assessments (written exam or computer exercise) is passed, the outstanding assessment can be made up in the following semester. The grade applies to the entire module (5 ECTS). The module can only be completed once the coursework has been passed.

**Literature**

Lecture notes; further secondary literature will be made available in StudIP during the course.

**Applicability in other degree programs**

# Modul: Student Accelerator- Innovation

**Module:** Student Accelerator- Innovation

| Modultyp | | | Kompetenzbereich | | | | |
|---|---|---|---|---|---|---|---|
| Pflicht | | | | | | | |
| **Angebot im** | **Dauer** | **Sprache** | **ECTS** | **Empfohlen ab** | | | |
| WiSe/SoSe | 1 Semester | Deutsch | 5 | **Zulassung WiSe:** | . Semester | **Zulassung SoSe:** | . Semester |

| Prüfungsleistungen (PL) / Studienleistung (SL) | | | | |
|---|---|---|---|---|
| **Art** | | **ECTS** | **Dauer / Umfang** | **Notenskala** |
| SL | Präsentation | 5 | Ideenpapier (Businessplan) + Abschlusspräsentation | unbenotet |

| | |
|---|---|
| **Workload** | 150 h |
| **Präsenzstudienzeit** | 14 h |
| **Selbststudienzeit** | 136 h |
| **Modulverantwortliche-r** | Dr.- Ing. Simon Ehlers |
| **Dozent-in** | Dr.- Ing. Simon Ehlers |
| **Institut** | Institut für Mechatronische Systeme |
| **Fakultät** | Fakultät für Maschinenbau |

| Aufbau des Moduls | | |
|---|---|---|
| **Veranstaltungstitel und Form** | **SWS** | **PL / SL** |
| Student Accelerator- Innovation - Vorlesung | 1 | Präsentation |

| Voraussetzungen für die Teilnahme: | Empfohlen für die Teilnahme: |
|---|---|
| keine | Besuch der Veranstaltung "Gründungspraxis für Technologie Start-ups" von Starting Business. Ingenieurstechnische Gründungsidee bzw. Idee eines neuen Produktes / Dienstleistung (wenn auch nur in groben Zügen)<br>Teilnahme an einem Start-up Lab oder ähnliches |

**Qualifikationsziele**

Das Modul vermittelt praktische Erfahrungen im Bereich Entrepreneurship und richtet sich an Studierende, die Interesse an einer ingenieurswissenschaftlichen Ausgründung nach oder während ihres Studiums haben.

Nach erfolgreicher Absolvierung des Moduls sind die Studierenden in der Lage,
- einen Businessplan aufzustellen
- haben ein Funktionsmuster für ein Produkt entwickelt,
- kennen Grundlagen des Design Thinkings
- können Grundlagen der Produktzulassung erläutern
- können Grundlagen der unternehmerischen Finanzplanung erklären
- Kunden- und Marktanalyse, Wettbewerbsanalyse beschreiben
- kennen Grundlagen von Marketing und Vertrieb

**Inhalte**

- unternehmensspezifische Herangehensweisen für Start-ups.
- nicht nur ingenieurswissenschaftliche Aufgaben im Fokus stehen
- agile Entwicklung, Patentwesen, Finanzen und Marktanalyse

**Besonderheiten**

Die Veranstaltung kann nur in Absprache mit dem betreuenden Professor nach erfolgreichem erstem Pitch belegt werden. Selbstständige praktische Mitarbeit wird vorausgesetzt. Die Durchführung als Team von bis zu 4 Personen ist möglich.

**Literatur**

Blank: Das Handbuch für Startups Osterwalder: Business Model Generation: Ein Handbuch für Visionäre, Spielveränderer und Herausforderer Hirth: Planungshilfe für technologieorientierte Unternehmensgründungen

# Modul: Artificial Intelligence I

**Module:** Artificial Intelligence I

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahlpflicht | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| SoSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam | 5 | 90 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Prof. Dr. Wolfgang Nejdl |
| **Lecturer** | Prof. Dr. Wolfgang Nejdl |
| **Institute** | Institut für Data Science |
| **Faculty** | Fakultät für Elektrotechnik und Informatik |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Artificial Intelligence I - Vorlesung | 2 | Written exam |
| Artificial Intelligence I - Übung | 2 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Basic knowledge of computer science, algorithms and data structures. |

**Qualification goals**

The students have learned the basics of modern Artificial Intelligence (AI) and some of its most representative applications.

**Contents**

i) Introduction to AI
ii) Constraint Satisfaction Problems
iii) Problem solving by searching
iv) Markov Decision Processes
v) Reinforcement Learning.

**Special features**

none

**Literature**

Stuart Russell, Peter Norvig: Artificial Intelligence: A Modern Approach.

**Applicability in other degree programs**

# Modul: Deep Learning Foundations

**Module:** Deep Learning Foundations

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahlpflicht | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam | 5 | 90 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Prof. Dr. Sandipan Sikdar |
| **Lecturer** | Prof. Dr. Sandipan Sikdar |
| **Institute** | Institut für Data Science |
| **Faculty** | Fakultät für Elektrotechnik und Informatik |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Deep Learning Foundations - Vorlesung | 2 | Written exam |
| Deep Learning Foundations - Übung | 2 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| keine | Machine learning basics |

**Qualification goals**

Students learn and implement state-of-the-art deep neural network architectures.

**Contents**

Tentative plan: Machine learning basics, Neural networks, generative models, Generative adversarial networks, Variational autoencoders, Diffusion models, Normalizing flow, Neural ODE.

**Special features**

Dieses Modul ist Bestandteil der Leibniz AI-Academy. Weitere Informationen auf https://www.ai-academy.uni-hannover.de/de

**Literature**

Deep Learning by Ian Goodfellow et. al.

**Applicability in other degree programs**

# Modul: Electrical Machines and Drives

**Module:** Electrical Machines and Drives

| Type of module | | | Area of competence | | | | |
|---|---|---|---|---|---|---|---|
| Wahlpflicht | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Oral exam | 5 | 30 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Dr.-Ing. Eva Maria Bresemann |
| **Lecturer** | Dr.-Ing. Eva Maria Bresemann |
| **Institute** | Institut für Antriebssysteme und Leistungselektronik |
| **Faculty** | Fakultät für Elektrotechnik und Informatik |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Electrical Machines and Drives - Vorlesung | 2 | Oral exam |
| Electrical Machines and Drives - Übung | 1 | |
| Electrical Machines and Drives - Labor | 1 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | none |

**Qualification goals**

**Contents**

This lecture gives a basic overview of electrical machine types with special emphasis on small motors and servo drives with an output power smaller than 1 kW. This includes knowledge on construction, in-service behaviour and control as well as application range and economic importance of these motors. The lecture is designed for developers of drive systems and for users of small electrical machines in order to support them in the choice of a motor in a specific case of operation.

**Special features**

none

**Literature**

Stölting, Kallenbach, Amrhein: Handbook of Fractional-Horsepower Drives, Springer Verlag.

**Applicability in other degree programs**

# Modul: Introduction to Mechanical Vibrations

**Module:** Introduction to Mechanical Vibrations

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahlpflicht | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam | 5 | 90 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Dr.-Ing. Matthias Wangenheim |
| **Lecturer** | Dr.-Ing. Matthias Wangenheim |
| **Institute** | Institut für Dynamik und Schwingungen |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Introduction to Mechanical Vibrations - Vorlesung | 2 | Written exam |
| Introduction to Mechanical Vibrations - Übung | 2 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| keine | Statics, Elastostatics, Kinematics, Kinetics (Technische Mechanik 1 - 3) |

**Qualification goals**

In this module, we give an introduction into the linear vibrations of mechanical systems.

After successful participation, our students will be able toset up linearized equations of motion for single-degree-of-freedom (SDOF) systems characterize the properties of free vibrations by means of eigenvalues determine system responses for harmonic, periodic and transient excitation propose appropriate measures to improve the system's dynamical performance understand the properties of solutions of partial differential equations describing continuum vibrations

**Contents**

- Free and forced vibrations of single-degree-of-freedom (SDOF) systems
- SDOF systems with damping
- System response functions in frequency and time domain
- Periodic and transient excitation of SDOF systems
- Systems with two degrees of freedom
- Vibration absorbers and tuned mass dampers
- Introduction to systems with multiple degrees of freedom (MDOF)
- Vibrations of strings, rods, shafts and beams

**Special features**

Integrated course containing lecture (2h) and tutorials (2h). Contents equal to German course „Technische Mechanik IV" taught in summer term.

**Literature**

Gross et al.: Engineering Mechanics 3. Dynamics. Springer
Inman: Engineering Vibration. Prentice Hall
Meirovitch: Fundamentals of Vibrations. McGraw-Hill
Tong: Theory of Mechanical Vibration, Literary Licensing, LL

# Modul: Introduction to Mechanical Vibrations

**Module:** Introduction to Mechanical Vibrations

| Applicability in other degree programs |
| --- |
| Computational Methods in Engineering M.Sc.; Mechatronik B.Sc.; |

# Modul: Micro- and Nanosystems

**Module:** Micro- and Nanosystems

| Type of module | | | Area of competence | | | | |
|---|---|---|---|---|---|---|---|
| Wahlpflicht | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam | 5 | 90 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 42 h |
| **Self-study time** | 108 h |
| **Module coordinator** | Prof. Dr.-Ing. Marc-Christopher Wurz |
| **Lecturer** | Prof. Dr.-Ing. Marc-Christopher Wurz |
| **Institute** | Institut für Mikroproduktionstechnik |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Micro- and Nanosystems - Vorlesung | 2 | Written exam |
| Micro- and Nanosystems - Übung | 1 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| keine | Mikro- und Nanotechnologie |

**Qualification goals**

The module teaches about the most important application areas of micro- and nano technology.

After successfully completing the module, students will be able to

- explain the term microtechnology and highlight its central advantages,
- distinguish between micro- and nanotechnology,
- explain relevant process technologies,
- explain the basic functionality of different sensors, actuators and generators - this includes the underlying material properties which are exploited for the respective effects,
- select suitable effects and operating principles for given application examples.

**Contents**

A microtechnical system has the following components: micro sensor technology, micro actuating elements, microelectronics.
Furthermore, the active principle and construction of micro components as well as requirements of system integration will be explained.
Nanosystems usually use quantum mechanical effects. An example will be the display of the employment of nanotechnology in various areas.

**Special features**

This lecture is given in English. The Module is equivalent to the module Mikro- und Nanosysteme, therefore credit can only be given for one.

**Literature**

- Corrêa Alegria, F. A. (2022). Sensors And Actuators. World Scientific.
- Fraden, J. (2010). Handbook of modern sensors : physics, designs, and applications (Fourth edition). Springer.
- Jain, V. K. (2022). Solid state physics (Third edition). Springer. - Ripka, P. (2021). Magnetic Sensors and Magnetometers. Second Edition. Artech.
- Yang, B., Liu, H., Liu, J., & Lee, C. (2015). Micro and nano energy harvesting technologies. In Artech House

# Modul: Micro- and Nanosystems

**Module:** Micro- and Nanosystems

| |
|---|
| microelectromechanical systems library. Artech House. |
| **Applicability in other degree programs** |
| Energietechnik M.Sc.; Maschinenbau M.Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Nachhaltige Ingenieurwissenschaft B.Sc.; Nanotechnologie B.Sc.; Produktion und Logistik B.Sc.; |

# Modul: Nonlinear Control

**Module:** Nonlinear Control

| Type of module | Area of competence |
|---|---|
| Wahlpflicht | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) |

| Offer in | Duration | Language | ECTS | Recommended from | | | |
|---|---|---|---|---|---|---|---|
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

**Examination performance (Ep) / Academic achievement (Aa)**

| Kind | | ECTS | Duration / Scope | Grading scale |
|---|---|---|---|---|
| PL | Written exam | 4 | 120 min | graded |
| SL | Academic achievement | 1 | Laboratory | ungraded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 42 h |
| **Self-study time** | 108 h |
| **Module coordinator** | Prof. Dr.-Ing. Matthias Müller |
| **Lecturer** | Prof. Dr.-Ing. Matthias Müller |
| **Institute** | Institut für Regelungstechnik |
| **Faculty** | Fakultät für Elektrotechnik und Informatik |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Nonlinear Control - Vorlesung | 2 | Written exam |
| Nonlinear Control - Hörsaalübung | 1 | Academic achievement |

| Requirements for participation: | Recommended for participation: |
|---|---|
| keine | Automatic Control Engineering I and II |

**Qualification goals**

This course covers modern analysis and controller design methods for nonlinear systems.
After this course, students should be able to identify and analyze nonlinear control problems, select suitable control approaches, carry out a controller design and implementation.

**Contents**

- Lyapunov stability
- Input-to-state stability
- Control Lyapunov functions
- Backstepping
- Sliding-mode control
- Input-Output linearization

- Passivity and Dissipativity
- Passivity-based controller desig

**Special features**

For this course, a course credit must be taken (laboratory).

# Modul: Nonlinear Control

**Module:** Nonlinear Control

| Literature |
| --- |
| none |
| **Applicability in other degree programs** |
| Maschinenbau M.Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Wirtschaftsingenieur M.Sc.; |

# Modul: Robotergestützte Montageprozesse

**Module:** Robot-assisted assembly processes

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahlpflicht | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe/SoSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam / Oral exam | 5 | 120 min / 20 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 84 h |
| **Self-study time** | 66 h |
| **Module coordinator** | Prof. Dr.-Ing. Annika Raatz |
| **Lecturer** | Prof. Dr.-Ing. Annika Raatz |
| **Institute** | Institut für Montagetechnik und Industrierobotik |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Robotergestützte Montageprozesse - Vorlesung | 2 | Written exam / Oral exam |
| Robotergestützte Montageprozesse - Hörsaalübung | 2 | |
| Robotergestützte Montageprozesse - Tutorium | 2 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Programmierkenntnisse. Vorkenntnisse im Bereich der Robotik: Industrieroboter für die Montagetechnik oder Robotik 1 / 2. |

**Qualification goals**

The module teaches the theoretical and practical basics of implementing robot-assisted assembly using a realistic problem as an example.
After successfully completing the module, students will be able to

- design and lay out a robot-assisted assembly cell for a specific application,
- simulate assembly processes using Visual Components software,
- program different robots using manufacturer-specific software (e.g., Kuka WorkVisual, ABB RobotStudio),
- understand and apply the basics of PLC programming (e.g., Siemens STEP 7),
- solve problems (with regard to automated assembly tasks) within a team.

**Contents**

- Setting up an assembly cell
- Simulating an assembly process
- Sensor integration
- Robot programming (Kuka and ABB)
- PLC programming (Siemens STEP 7)

**Special features**

Die Zahl der Teilnehmenden ist auf 20 Personen beschränkt. 10 Plätze für Bachelorstudierende und 10 Plätze für Masterstudierende. Die Zuweisung erfolgt im Losverfahren.

**Literature**

keine

**Applicability in other degree programs**

Maschinenbau B.Sc.; Maschinenbau M.Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Nachhaltige Ingenieurwissenschaft M.Sc.; Produktion und Logistik M.Sc.; Wirtschaftsingenieur M.Sc.;

# Modul: Robotics II

**Module:** Robotics II

| Type of module | | | Area of competence | | | | |
|---|---|---|---|---|---|---|---|
| Wahlpflicht | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| SoSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam | 5 | 90 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 42 h |
| **Self-study time** | 108 h |
| **Module coordinator** | Prof. Dr.-Ing. Thomas Seel |
| **Lecturer** | M. Sc. Jan Piosik |
| **Institute** | Institut für Mechatronische Systeme |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Robotics II - Vorlesung | 2 | Written exam |
| Robotics II - Übung | 1 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Robotics I; Control engineering; Multibody systems |

**Qualification goals**

The module deals with new developments in the field of robotics.

After successfully completing the module, students will be able to

- model and analyze parallel kinematic machines (structures and design criteria, inverse and direct kinematics, dynamics, redundancy and performance characteristics),
- define optimization problems and apply identification algorithms (linear and non-linear optimization methods, optimal excitation),
- set up visual servoing approaches (2.5D and 3D methods, camera calibration),
- model and evaluate machine learning methods (definitions, basic ideas, different methods).

**Contents**

- Calculation of the kinematics and dynamics of parallel structures
- Linear and non-linear methods for identifying key system parameters
- Methods for image-based control
- Basic ideas of machine learning based on practical issues related to robotics

**Special features**

In addition to the lecture and tutorial, a laboratory is offered to deepen the content covered. The lab is accessed via remote control so that the experiments can be carried out on your own PC at any time.

**Literature**

Lecture notes, further secondary literature will be provided during the course.

**Applicability in other degree programs**

# Modul: SLAM and Path Planning

**Module:** SLAM and Path Planning

| Modultyp | | | Kompetenzbereich | | | | |
|---|---|---|---|---|---|---|---|
| Wahlpflicht | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | |
| **Angebot im** | **Dauer** | **Sprache** | **ECTS** | **Empfohlen ab** | | | |
| WiSe | 1 Semester | Deutsch | 5 | **Zulassung WiSe:** | 1/2. Semester | **Zulassung SoSe:** | 1/2. Semester |

| Prüfungsleistungen (PL) / Studienleistung (SL) | | | | |
|---|---|---|---|---|
| **Art** | | **ECTS** | **Dauer / Umfang** | **Notenskala** |
| PL | Muendliche Pruefung | 4 | 15 min | benotet |
| SL | Studienleistung | 1 | Programmierübung | unbenotet |

| | |
|---|---|
| **Workload** | 150 h |
| **Präsenzstudienzeit** | 56 h |
| **Selbststudienzeit** | 94 h |
| **Modulverantwortliche-r** | apl. Prof. Dr.-Ing. Claus Brenner |
| **Dozent-in** | apl. Prof. Dr.-Ing. Claus Brenner |
| **Institut** | Institut für Kartographie und Geoinformatik |
| **Fakultät** | Fakultät für Bauingenieurwesen und Geodäsie |

| Aufbau des Moduls | | |
|---|---|---|
| **Veranstaltungstitel und Form** | **SWS** | **PL / SL** |
| SLAM and Path Planning - Vorlesung | 2 | Muendliche Pruefung |
| SLAM and Path Planning - Hörsaalübung | 2 | Studienleistung |

| Voraussetzungen für die Teilnahme: | Empfohlen für die Teilnahme: |
|---|---|
| none | none |

**Qualifikationsziele**

This lecture imparts the basic principles about localization, mapping and simultaneous localization and mapping (SLAM), as well as basic methods for path planning. After successful completion of the lecture, students are able to explain the principles and algorithms in SLAM and path planning. They can implement selected methods and are thus able to understand modules of available robotics packages.

**Inhalte**

Robot motion model. Laserscanning and landmark detection. Positioning using estimation of a similarity transform. Iterative closest point method. Bayes filter. Parametric filters and the Kalman filter. Variances and error ellipses. Extended (EKF) and multidimensional Kalman filter. Histogram- and particle filter. EKF SLAM. Rao-Blackwellized particle filter SLAM (FastSLAM). Path planning: Dijkstra and A* algorithms, potential functions, path planning in the kinematic state space. In the exercises, most of the algorithms will be programmed in the programming language Python.

**Besonderheiten**

Online-Course, Lecture is given in Englisch

**Literatur**

S. Thrun, W. Burgard, D. Fox, Probabilistic Robotics, MIT Press, 2005. H. Choset u.a., Principles of Robot Motion, Theory, Algorithms, and Implementations, MIT Press, 2005.

# Modul: SLAM and Path Planning

**Module:** SLAM and Path Planning

| Verwendbarkeit in anderen Studiengängen |
| --- |
| Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; |

# Modul: Technoökonomische Analyse von Wasserstoffenergiesystemen

**Module:** Techno-Economic Analysis of Hydrogen Energy Systems

| Modultyp | | Kompetenzbereich | | | | | |
|---|---|---|---|---|---|---|---|
| Wahlpflicht | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | | |
| **Angebot im** | **Dauer** | **Sprache** | **ECTS** | **Empfohlen ab** | | | |
| SoSe | 1 Semester | Englisch/Deutsch | 5 | **Zulassung WiSe:** | 1/2. Semester | **Zulassung SoSe:** | 1/2. Semester |

| Prüfungsleistungen (PL) / Studienleistung (SL) | | | | |
|---|---|---|---|---|
| **Art** | | **ECTS** | **Dauer / Umfang** | **Notenskala** |
| PL | Hausarbeit | 3 | Report (8-12) pp + presentation | benotet |
| SL | Projektorientierte Prüfungsform | 2 | 20 min | unbenotet |

| | |
|---|---|
| **Workload** | 150 h |
| **Präsenzstudienzeit** | 42 h |
| **Selbststudienzeit** | 108 h |
| **Modulverantwortliche-r** | Prof. Dr.-Ing. Markus Richter |
| **Dozent-in** | Prof. Dr.-Ing. Markus Richter |
| **Institut** | Institut für Thermodynamik |
| **Fakultät** | Fakultät für Maschinenbau |

**Aufbau des Moduls**

| Veranstaltungstitel und Form | SWS | PL / SL |
|---|---|---|
| Technoökonomische Analyse von Wasserstoffenergiesystemen - Vorlesung | 2 | Hausarbeit |
| Technoökonomische Analyse von Wasserstoffenergiesystemen - Übung | 1 | Projektorientierte Prüfungsform |

| Voraussetzungen für die Teilnahme: | Empfohlen für die Teilnahme: |
|---|---|
| none | Successful completion of Bachelor modules in Technical Thermodynamics (mandatory), Heat & Mass Transfer, and Process Engineering |

**Qualifikationsziele**

Upon successful completion of the module, students are able to:
- describe and compare the most important hydrogen production, densification, storage and transport technologies,
- perform energy and material balances for hydrogen systems,
- model simple hydrogen densification and regasification processes using process simulation software,
- apply established cost estimation techniques (Guthrie, Turton, CEPCI) and calculate CAPEX and OPEX,
- determine the Levelized Cost of Hydrogen Transport (LCoHT) and carry out sensitivity analyses,
- critically evaluate scientific literature and industrial case studies in the hydrogen economy,
- independently develop a simplified techno-economic study of a hydrogen value chain and present the results clearly.

**Inhalte**

The module provides a comprehensive introduction to the techno-economic analysis of hydrogen-based energy systems with focus on production (electrolysis, SMR+CCS), densification (liquefaction, compression), long-distance transport (LH2, LOHC, ammonia), storage, regasification and final utilization. Students learn to apply thermodynamic fundamentals, process simulation tools (Aspen Plus, DWSIM or equivalent) and established cost estimation methods (CAPEX/OPEX, LCoHT, WACC, CEPCI) to real hydrogen value chains. Core topics include:

1. Hydrogen value chains and color codes
2. Production technologies and efficiencies
3. Densification cycles (Claude, mixed refrigerant)
4. Storage and transport options (LH2, ammonia, LOHC)
5. Process simulation and energy balances
6. Techno-economic assessment methods
7. Levelized Cost of Hydrogen Transport (LCoHT)
8. Sensitivity and scenario analysis

# Modul: Technoökonomische Analyse von Wasserstoffenergiesystemen

**Module:** Techno-Economic Analysis of Hydrogen Energy Systems

The module is accompanied by a hands-on software workshop and a final group project based on a simplified real-world hydrogen export / import corridor.

**Besonderheiten**

• The module is taught in English and German.
• A couple of computer-based workshops (DWSIM + Excel + Matlab with AI) are integrated.
• Each group (3–5 students) needs to develop a hydrogen densification cycle using DWSIM as a middle-class project.
• The final project (group work, 3–5 students) consists of a written report (8–12 pages) and an oral presentation (12 min + discussion).

**Literatur**

• Restelli, F.; Spatolisano, E.; Pellegrini, L.A.; Roccaro, E.; Lainati, A. (2024) Liquefied hydrogen value chain: A detailed techno-economic evaluation for its application in the industrial and mobility sectors, Int. J. Hydrogen Energy — DOI: 10.1016/j.ijhydene.2023.10.107.
• IEA (2024) Global Hydrogen Review 2024, International Energy Agency — Web: https://www.iea.org/reports/global-hydrogen-review-2024
• IRENA (2020) Green Hydrogen Cost Reduction: Scaling up electrolysers to meet the 1.5°C climate goal (and follow-up reports) — PDF/Web: https://www.irena.org/publications/2020/Dec/Green-hydrogen-cost-reduction
• Turton, R.; Shaeiwitz, J.A.; Bhattacharyya, D.; Whiting, W.B. (5th ed., 2021) Analysis, Synthesis, and Design of Chemical Processes, Pearson — ISBN: 9780137459483.
• Cardella, U.; Decker, L.; Klein, H. (2017) Economically viable large-scale hydrogen liquefaction, IOP Conf. Ser.: Mater. Sci. Eng., 171:012013 — DOI: 10.1088/1757-899X/171/1/012013.
• Hydrogen Council (2022) Global Hydrogen Flows — Web: https://hydrogencouncil.com/en/global-hydrogen-flows/

**Verwendbarkeit in anderen Studiengängen**

Maschinenbau M.Sc.; Nachhaltige Ingenieurwissenschaft M.Sc.;

# Modul: AI applications in metallurgy

**Module:** AI applications in metallurgy

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Term paper | 4 | 15 - 20 pages | graded |
| SL | Academic achievement | 1 | Programming | ungraded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 42 h |
| **Self-study time** | 108 h |
| **Module coordinator** | Prof. Dr. Demircan Canadinc |
| **Lecturer** | Prof. Dr. Demircan Canadinc |
| **Institute** | Institut für Werkstoffkunde |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| AI applications in metallurgy - Vorlesung | 2 | Term paper |
| AI applications in metallurgy - Hörsaalübung | 1 | Academic achievement |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Werkstoffkunde I und II |

**Qualification goals**

The module will use several examples of artificial intelligence methods to predict new alloy systems that meet a given set of requirements. Upon completion, students will be able to (i) use machine learning principles to tackle different material design challenges; (ii) construct databases for material design and similar tasks; (iii) select the optimal mathematical method and appropriate algorithms for specific material design tasks and subsequently suitable alloy systems, (iv) develop solutions for material design problems.

**Contents**

(i) Allgemeine Informationen zur künstlichen Intelligenz, "Big Data" und maschinellem Lernen; (ii) Anwendungen von künstlicher Intelligenz in der Werkstoffkunde; (iii) aktuelle Herausforderungen bei der Entwicklung neuer Legierungen; (iv) Fallbeispiele der Nutzung von künstlicher Intelligenz für das Design von neuen Formgedächtnislegierungen, High-Entropy-Legierungen und Implantatmaterialien

**Special features**

As part of the lecture, compulsory semester-long programming tasks are set to consolidate the course content.

**Literature**

Lecture notes and latest articles from the relevant literature.

**Applicability in other degree programs**

Maschinenbau M.Sc.;

# Modul: Artificial Intelligence for Production Engineering

**Module:** Artificial Intelligence for Production Engineering

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| SoSe/WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Klausur mit Antwortwahlverfahren | 5 | Online Klausur | unbenotet |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 28 h |
| **Self-study time** | 122 h |
| **Module coordinator** | Prof. Dr.-Ing. Berend Denkena |
| **Lecturer** | Prof. Dr.-Ing. Berend Denkena |
| **Institute** | Institut für Fertigungstechnik und Werkzeugmaschinen |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Artificial Intelligence for Production Engineering - Vorlesung | 1 | Klausur mit |
| Artificial Intelligence for Production Engineering - Übung | 1 | Antwortwahlverfahren |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Belegung der Kurse: Artificial Intelligence 1, Machine Learning |

**Qualification goals**

Das Modul vermittelt einen praxisnahen Einblick in die Anwendungen von Methoden der Künstlichen Intelligenz in der Produktion. Nach erforlgreichem Abschluss des Moduls sind die Studierenden in der Lage:
- die Schritte der Machine-Learning-Pipeline zu erläutern und deren Bedeutung für Produktionsprozesse zu erklären,
- Datenquellen aus der Fertigungstechnik zu identifizieren,
- Unterschiede zwischen verschiedenen Modellen zu erklären und deren Einsatz im Produktionskontext zu interpretieren,
- Methoden der Datenvorverarbeitung und Modellbildung anzuwenden und auf konkrete Produktionsdaten zu übertragen,
- Machine-Learning-Modelle zu implementieren, auszuführen und deren Ergebnisse zu interpretieren.

**Contents**

- Einführung in produktionstechnische Prozesse und Fragestellungen:
- Datenerfassung
- Datenvorverarbeitung und Feature Engineering
- Modellierung und Evaluierung
- KI-gestützte Prozessplanung
- KI-gestützte Pozessüberwachung
- KI-gestützte Prozesskettenplanung

Module: Modul 1 - Intoduction; Module 2 - Data Acquisition; Module 3 - Data Preprocessing and Feature Engineering; Module 4 - Modeling and Evaluation; Module 5 - Use Case: Process Planning; Module 6 - Use Case: Process Monitoring; Module 7 - Use Case: Process Chains; Module 8 - Use Case: Model Evaluation

**Special features**

Dieses Modul ist Bestandteil der Leibniz AI-Academy. Weitere Informationen auf https://www.ai-academy.uni-hannover.de/de/. Es handelt sich um einen Online Kurs im Selbststudium. Es findet keine zusätzliche Vorlesung in Präsenz statt.

**Literature**

Denkena, Berend; Toenshoff, Hans Kurt: Spanen – Grundlagen, Springer Verlag Heidelberg, 3. Auflage 2011.
Brecher, Christian; Weck, Manfred : Werkzeugmaschinen Fertigungssysteme 3 - Mechatronische Systeme,

# Modul: Artificial Intelligence for Production Engineering

**Module:** Artificial Intelligence for Production Engineering

| |
|---|
| Steuerungstechnik und Automatisierung, Springer Verlag Heidelberg, 9. Aulage 2021 |
| **Applicability in other degree programs** |
| Maschinenbau M.Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Nachhaltige Ingenieurwissenschaft M.Sc.; Produktion und Logistik M.Sc.; |

# Modul: Artificial Intelligence II

**Module:** Artificial Intelligence II

| Type of module | | | Area of competence | | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam | 5 | 90 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Prof. Dr. Wolfgang Nejdl |
| **Lecturer** | Prof. Dr. Wolfgang Nejdl |
| **Institute** | Institut für Data Science |
| **Faculty** | Fakultät für Elektrotechnik und Informatik |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Artificial Intelligence II - Vorlesung | 2 | Written exam |
| Artificial Intelligence II - Übung | 2 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | none |

**Qualification goals**

The students know the basics of modern artificial intelligence (AI) and some of their most important ones representative applications, building on what they have learned in Artificial Intelligence (I).

**Contents**

i) Bayesian Networks
ii) Hidden Markov Models
iii) Machine Learning
iv) Advanced Topics of AI

**Special features**

none

**Literature**

Stuart Russell, Peter Norvig: Artificial Intelligence: A Modern Approach.

**Applicability in other degree programs**

# Modul: Artificial intelligence in propulsion system development for sustainable mobility

**Module:** Artificial intelligence in propulsion system development for sustainable mobility

| Type of module | | Area of competence | | | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Oral exam | 5 | 20 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Dr.-Ing. Reza Rezaei |
| **Lecturer** | Dr.-Ing. Reza Rezaei |
| **Institute** | Institut für Technische Verbrennung |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Artificial intelligence in propulsion system development for sustainable mobility - Vorlesung | 2 | Oral exam |
| Artificial intelligence in propulsion system development for sustainable mobility - Praktikum | 1 | |
| Artificial intelligence in propulsion system development for sustainable mobility - Exkursion | 1 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Internal Combustion Engines I, Basic mechatronic knowledge of drive technology |

**Qualification goals**

The module teaches the fundamentals of the virtual development of alternative drives and the use of intelligent methods in the automotive industry for sustainable mobility in a practice-oriented manner. After successfully completing the module, students will be able to:
* classify current trends in the automotive industry,
* describe and differentiate between sustainable CO2-neutral drive concepts,
* explain the characteristics of alternative drive systems at both component and overall system level,
* explain the virtual development process in the automotive industry from hardware design to field testing
* use common simulation tools and innovative model-based approaches to design and evaluate drive concepts,
* optimize drive systems with the help of AI and machine learning,
* to classify further applications such as data science, condition-based maintenance (CBM) and autonomous driving based on real industrial projects.

**Contents**

An overview of current trends in the automotive industry will be given. The CO2-neutral drive concepts from H2-combustion to electrification are briefly presented. The focus is on the use of novel model-based approaches including machine learning for the design and evaluation of new drive concepts based on real examples. The methodology aims to understand the system behaviour and model it using innovative methods in order to optimize it with AI or machine learning methods and then test the drive concept virtually. Other applications such as data science, condition-based maintenance (CBM), autonomous driving, etc. will be presented using real industrial examples. There will be guest lectures from the “University of Alberta (Canada) Energy Mechatronics Lab.”
• Presentation of the model-based development process from concept to series production, including function development and control
• Presentation of current simulation chain with focus on 0D/1D simulation, in particular GT-Suite incl. artificial intelligence
• Two workshops (exercises) on using the simulation tool chain. During the lecture period, licenses such as GT-Suite,

# Modul: Artificial intelligence in propulsion system development for sustainable mobility

**Module:** Artificial intelligence in propulsion system development for sustainable mobility

| |
|---|
| Simulink, etc. are provided<br>• Practical examples from real industrial projects on the use of model-based development and AI for drive system development drive system development<br>• Theoretical background of modeling, design method, AI, etc.<br>• Processing of a project work for the independent use of the modeling tool chain for a practice-relevant question question |
| **Special features** |
| Participation in an excursion to IAV at the Gifhorn site (time frame: 1 day) is required. The excursion includes a visit to IAV test benches, technical presentations, insight into various products, etc., including follow-up work |
| **Literature** |
| none |
| **Applicability in other degree programs** |
| Energietechnik M.Sc.; Maschinenbau M.Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Nachhaltige Ingenieurwissenschaft M.Sc.; Wirtschaftsingenieur M.Sc.; |

# Modul: Automated Machine Learning

**Module:** Automated Machine Learning

| Type of module | | | Area of competence | | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| SoSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Oral exam | 5 | | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Prof. Dr. rer. nat. Marius Lindauer |
| **Lecturer** | Prof. Dr. rer. nat. Marius Lindauer |
| **Institute** | Institut für Künstliche Intelligenz |
| **Faculty** | Fakultät für Elektrotechnik |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Automated Machine Learning - Vorlesung | 2 | Oral exam |
| Automated Machine Learning - Übung | 2 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Basics in Machine Learning; Basics and hands-on in Deep Learning; hands-on experience in Python |

**Qualification goals**

Students learn the basic principles of automatic machine learning (both for traditional machine learning and for deep learning). They will be able to explain methods of hyperparameter optimization and neural network search and apply them to new problems. In particular, they can practically apply these methods to optimize the performance of machine learning algorithms on feature-based data, image data as well as time series data.

**Contents**

1. Design spaces in ML
2. Experimentation and visualization
3. Hyperparameter optimization (HPO)
4. Bayesian optimization
5. Other black-box techniques
6. Speeding up HPO with multi-fidelity optimization
7. Architecture search I + II
8. Meta-Learning
9. Dynamic Configuration
10. Beyond AutoML: algorithm configuration and control

**Special features**

From WS 23/24 without SL. Multiple-choice quizzes (at least 50% correct answers) must be passed as a necessary condition for passing. The performance can be achieved either gradually per week in the lecture or at the end of the lecture period as a one-off written test. In preparation for the oral exam, a final project must be completed.

**Literature**

Automated Machine Learning Methods, Systems, Challenges Herausgeber: Hutter, Frank, Kotthoff, Lars, Vanschoren, Joaquin (Eds.) https://www.springer.com/de/book/9783030053178
Further literature recommendations will be announced in the lecture.

**Applicability in other degree programs**

Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017;

# Modul: AutoML Lab

**Module:** AutoML Lab

| Type of module | | | Area of competence | | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 6 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| SL | Project-oriented form of examination | 6 | 80 % Homework, Prasentation | ungraded |

| | |
|---|---|
| **Workload** | 180 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 124 h |
| **Module coordinator** | Prof. Dr. rer. nat. Marius Lindauer |
| **Lecturer** | Prof. Dr. rer. nat. Marius Lindauer |
| **Institute** | Institut für Künstliche Intelligenz |
| **Faculty** | Fakultät für Elektrotechnik |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| AutoML Lab - Labor | 4 | Project-oriented form of examination |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | To attend the lecture, it is strongly recommended to have a basic knowledge of the following areas have:<br>* AI<br>* Machine learning<br>* Optional: AutoML lecture |

**Qualification goals**

Students have learned how automatic machine learning is applied to new problems in practice. This includes both hyperparameter optimization and architecture search of neural networks. They can apply existing AutoML tools, extend them and implement basic approaches themselves.

**Contents**

1. Introduction to AutoML basics
2. Existing tools
3. Hyperparameter optimization
4. Neural architecture search
5. Final project + Hackathon

**Special features**

Participation limited to 20 persons. Block event.

**Literature**

Methods, Systems, Challenges. Herausgeber: Hutter, Frank, Kotthoff, Lars, Vanschoren, Joaquin (Eds.)
https://www.springer.com/de/book/9783030053178

**Applicability in other degree programs**

# Modul: Biomedizinische Technik II

**Module:** Biomedical Engineering II

| Modultyp | | Kompetenzbereich | | | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | | |
| **Angebot im** | **Dauer** | **Sprache** | **ECTS** | **Empfohlen ab** | | | |
| SoSe | 1 Semester | Deutsch/Englisch | 5 | **Zulassung WiSe:** | 1/2. Semester | **Zulassung SoSe:** | 1/2. Semester |

| Prüfungsleistungen (PL) / Studienleistung (SL) | | | | |
|---|---|---|---|---|
| **Art** | | **ECTS** | **Dauer / Umfang** | **Notenskala** |
| PL | Muendliche Pruefung | 5 | ca. 30 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Präsenzstudienzeit** | 42 h |
| **Selbststudienzeit** | 108 h |
| **Modulverantwortliche-r** | Dr.- Ing. Ricarda Brunotte |
| **Dozent-in** | Dr.- Ing. Ricarda Brunotte |
| **Institut** | Institut für Mehrphasenprozesse |
| **Fakultät** | Fakultät für Maschinenbau |

**Aufbau des Moduls**

| Veranstaltungstitel und Form | SWS | PL / SL |
|---|---|---|
| Biomedizinische Technik II - Vorlesung | 2 | Muendliche Pruefung |
| Biomedizinische Technik II - Übung | 1 | |

| Voraussetzungen für die Teilnahme: | Empfohlen für die Teilnahme: |
|---|---|
| none | Biomedizinische Technik I |

**Qualifikationsziele**

Das Modul vermittelt spezifische Kenntnisse über medizintechnische Geräte und Systeme zur Diagnose und Therapie von Krankheitsbildern. Nach erfolgreicher Absolvierung des Moduls sind alle Studierenden in der Lage:

- Die Funktionsprinzipien von Diagnose- und Therapiesystemen zu erläutern.
- Eine anwendungsbezogene Auswahl der geeigneten Verfahren zu Diagnose und Therapie zu treffen.
- Optimierungspotential aktueller Diagnose- und Therapiesysteme zu erkennen.
- Konzepte für neuartige Systeme zu erarbeiten.

**Inhalte**

- Geschichtliche Entwicklung der Biomedizinischen Technik
- Funktionsweisen bildgebender diagnostischer Geräte wie EKG, EEG, EMG, Ultraschall, CT und Röntgen
- Therapieverfahren, wie Herzunterstützungssysteme
- Herstellungsverfahren, wie Stent-Herstellungsverfahren
- Aktuelle Entwicklungen und Innovationen, wie Cochlea-Implantat-Chirurgie

**Besonderheiten**

Die Veranstaltung beinhaltet Vorlesungen von anerkennen externen Dozenten und Dozentinnen aus der Industrie und Wissenschaft.

**Literatur**

Vorlesungs-Handouts Lehrbuchreihe Biomedizinische Technik: Morgenstern U., Kraft M.: Band 1 - Biomedizinische Technik - Faszination, Einführung, Überblick. Berlin, Boston: De Gruyter, 2014. ISBN 978-3-11-025218-7 Werner J.: Band 9 - Biomedizinische Technik - automatisierte Therapiesysteme. Berlin, Boston: De Gruyter, 2014. ISBN 978-3-11-025213-2

**Verwendbarkeit in anderen Studiengängen**

Biomedizintechnik M.Sc.; Maschinenbau M.Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Nanotechnologie M.Sc.; Wirtschaftsingenieur M.Sc.;

# Modul: Computational Argumentation

**Module:** Computational Argumentation

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| SoSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Oral exam | 5 | | benotet |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Prof. Dr. Henning Wachsmuth |
| **Lecturer** | Prof. Dr. Henning Wachsmuth |
| **Institute** | Institut für Künstliche Intelligenz |
| **Faculty** | Fakultät für Elektrotechnik |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Computational Argumentation - Vorlesung | 2 | Oral exam |
| Computational Argumentation - Übung | 2 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Required:<br>- Basics of statistics.<br>- Knowledge of programming.<br><br>Recommended:<br>- Any course on machine learning or artificial intelligence.<br>- Master's course: Statistical Natural Language Processing (preferred).<br>- Bachelor's course: Introduction to Natural Language Processing (alternatively). |

**Qualification goals**

Argumentation is an integral part of both professional and everyday communication. Whenever a topic or question is subject to controversy, people consider arguments to form opinions, to make decisions, or to convince others of a certain stance. In the last years, the computational analysis and synthesis of natural language argumentation has become an emerging research area, due to its importance for the next generation of web search engines and intelligent personal assistants. Based on statistical natural language processing techniques, computational argumentation covers the mining of arguments from natural language text, the assessment of stance argument quality, as well as the generation of new claims and arguments. The students learn both fundamentals from argumentation theory and state-ofthe-art methods from computational argumentation. Assignments deepen the understanding of the methods.

**Contents**

- Introduction to Computational Argumentation.
- Basics of Natural Language Processing.
- Basics of Argumentation.
- Argument Mining.
- Argument Assessment.
- Argument Generation.
- Applications of Computational Argumentation.
- Conclusion.

# Modul: Computational Argumentation

**Module:** Computational Argumentation

| **Special features** |
| --- |
| none |
| **Literature** |
| Manfred Stede and Jodi Schneider. Argumentation Mining. Synthesis Lectures on Human Language Technologies 40, Morgan & Claypool, 2018. - Daniel Jurafsky and James H. Martin. 2009. Speech and Language Processing: An Introduction to Natural Language Processing, Speech Recognition, and Computational Linguistics. Prentice-Hall, 2nd edition. Free draft of third edition: https://web.stanford.edu/ ~jurafsky/slp3/ |
| **Applicability in other degree programs** |

# Modul: Computational Biomechanics

**Module:** Computational Biomechanics

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam | 5 | 90 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Dr.-Ing. Meisam Soleimani |
| **Lecturer** | Dr.-Ing. Dustin Roman Jantos |
| **Institute** | Institut für Kontinuumsmechanik |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Computational Biomechanics - Vorlesung | 2 | Written exam |
| Computational Biomechanics - Hörsaalübung | 2 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| keine | Technische Mechanik II, Finite Elemente I Kontinuumsmechanik I |

**Qualification goals**

This course is aimed at providing basic and solid concepts in biomechanics with focus on various physiological systems, including the musculoskeletal system (growth and remodeling in muscle, bone), the cardiovascular system (arteries, aneurysms, Atherosclerosis, Dissection, blood circulation) and computational methods used for the simulation of biomechanical phenomena.
The ultimate objective of this course is to prepare the students with hands-on skills using computational packages and software to solve biomechanical problems. This course is generally suitable for MS, and PhD students in mechanical engineering department whose major is computational biomechanics. Hence, it is suitable for those who are interested in practicing a carrier or research (probably PhD programs) in computational mechanics with a biomedical application. The students are strongly recommended that they would consider prerequisites of this course prior to registering for that.

After completing this course, students are capable of:

- understanding the theory behind mechanics of biological materials including large deformations, soft tissue and material damaging
- unsterstanding basics in anatomy and physiology of the musculoskeletal system as well as experimental methods
- apply numerical methods as the finite element method for biological materials

**Contents**

- A recap on continuum solid mechanics as the mathematical framework in this course
- A brief review of anatomy and physiology of the musculoskeletal system, a range of modelling and experimental methods applied to them.
- Biomechanical constitutive models for soft tissues in the context of isotropic as well as anisotropic hyper-elasticity
- Application of non-elastis constitutive models such as growth, viscoelasticity, and damage in biological tissues
- An overview of the state-of-the-art mathematical model for pathological condition in soft tissues (As an example the focus will be on Atherosclerosis, Dissection and Aneurism in arteries)
- Thoughts and considerations regarding the numerical simulation of biological processes in a FEM framework

# Modul: Computational Biomechanics

**Module:** Computational Biomechanics

| Special features |
| --- |
| keine |
| **Literature** |
| 1. An Introduction to Biomechanics: Solids and Fluids, Analysis and Design, J.D. Humphrey and SL O'Rourke. Springer (2015). 2. Biomechanics of Soft Tissue in Cardiovascular Systems, Gerhard A. Holzapfel & Ray W. Ogden, Springer (2003). 3. The Mathematics and Mechanics of Biological Growth, Alain Goriely, Springer (2016). |
| **Applicability in other degree programs** |
| Biomedizintechnik M.Sc.; Maschinenbau B.Sc.; Maschinenbau M.Sc.; |

# Modul: Data-driven parameter and model identification

**Module:** Data-driven parameter and model identification

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam / Oral exam | 5 | 90 min/20 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Dr.-Ing. Hendrik Geisler |
| **Lecturer** | Dr.-Ing. Dustin Roman Jantos<br>Prof. Dr.-Ing. habil. Philipp Junker |
| **Institute** | Institut für Kontinuumsmechanik |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Data-driven parameter and model identification - Vorlesung | 2 | Written exam / Oral exam |
| Data-driven parameter and model identification - Hörsaalübung | 2 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Technische Mechanik I - IV |

**Qualification goals**

The ability to obtain reliable models of mechanical systems from experimental data is an elementary competence for analyzing, predicting and optimizing real phenomena. The lecture presents methods for determining material parameters and analytical models from experimental data. The focus of the lecture are modern data-driven methods and machine learning methods.
A practical hands-on exercise is offered. In the exercise, the students themselves will generate experimental data themselves and apply the thought methods.
Planned are
- tensile experiments on a material testing machine for the determination of material parameters
- the use of contactless deformation measurement to determine material models
- the determination of system models of vibrating systems from video files.

After successfully completing the module, students will be able to
- design and carry out experiments for parameter and model identification
- apply data-driven methods such as sparse regression and machine learning and critically evaluate the results
- assess when and how model assumptions can be replaced by data-driven methods

**Contents**

- Parameter identification of material models
- Experimental design for robust parameter and model identification
- Optimization methods
- Model identification of material models
- Uncertainty quantification
- Model identification of mechanical systems
- Machine learning as a model-free method
- Physics-informed machine learning

# Modul: Data-driven parameter and model identification

**Module:** Data-driven parameter and model identification

| **Special features** |
| --- |
| The participants carry out their own experiments for parameter and model identification. |
| **Literature** |
| Data-Driven Science and Engineering: Machine Learning, Dynamical Systems, and Control von Steven Brunton und Nathan Kutz |
| **Applicability in other degree programs** |
| Nachhaltige Ingenieurwissenschaft M.Sc.; Produktion und Logistik M.Sc.; |

# Modul: Design and Simulation of optomechatronic Systems

**Module:** Design and Simulation of Optomechatronic Systems

| Type of module | | | Area of competence | | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| SoSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam | 5 | 90 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 42 h |
| **Self-study time** | 108 h |
| **Module coordinator** | Prof. Dr.-Ing. Roland Lachmayer |
| **Lecturer** | Dr.-Ing. Tobias Biermann<br>M. Sc. Malte Falkner |
| **Institute** | Institut für Produktentwicklung und Gerätebau |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Design and Simulation of optomechatronic Systems - Vorlesung | 2 | Written exam |
| Design and Simulation of optomechatronic Systems - Hörsaalübung | 1 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| keine | keine |

**Qualification goals**

The development of optomechatronic systems requires a profound understanding of physical principles as well as the ability to integrate optical, mechanical, and electronic components. Through the use of simulation tools and systematic development processes, students learn to design innovative solutions and make technically sound decisions.

In the module Design and Simulation of Optomechatronic Systems, students acquire the ability to methodically analyze complex optical systems, apply suitable modeling and simulation tools, and integrate both technical and design requirements into interdisciplinary development processes. They learn to purposefully select optical components, understand their interactions, and develop innovative solutions for optical applications.

After completing the module, students are able to:
- analyze and model optical systems regarding their function, structure, and requirements.
- select appropriate optical materials and manufacturing technologies for specific applications.
- apply optical simulation software for the calculation and optimization of systems.
- integrate light sources, sensors, and measurement instruments into optomechatronic systems

**Contents**

- Fundamentals of light propagation, optical components, and optomechatronic systems
- Introduction to the physiology of human vision and its significance for technical applications
- Modeling and simulation of optical systems using specialized software
- Overview of light sources, sensors, and measurement techniques in optical applications
- Systematic development and analysis of optomechatronic applications (e.g., vehicle headlights, LIDAR, spectroscopy)

**Special features**

Lecture and exercise will be held in English. Alongside the exercise there will be an optional project. Der alte Name des Moduls lautet Konstruktion Optischer Systeme.

# Modul: Design and Simulation of optomechatronic Systems

**Module:** Design and Simulation of Optomechatronic Systems

| Literature |
| --- |
| Umdruck zur Vorlesung |
| **Applicability in other degree programs** |
| Maschinenbau M.Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Optical Technologies M.Sc.; Optische Technologien M.Sc.; |

# Modul: Electrical Energy Storage

**Module:** Electrical Energy Storage

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Oral exam | 5 | | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Dr. -Ing. Boris Bensmann |
| **Lecturer** | Dr.-Ing. Astrid Lilian Bensmann<br>Dr. -Ing. Boris Bensmann |
| **Institute** | Institut für Elektrische Energiesysteme |
| **Faculty** | Fakultät für Elektrotechnik und Informatik |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Electrical Energy Storage - Vorlesung | 2 | Oral exam |
| Electrical Energy Storage - Übung | 1 | |
| Electrical Energy Storage - Labor | 1 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | none |

**Qualification goals**

This course imparts knowledge on the selection and application of electrical energy storage. Successfully completing the modules of this course provide:

- an overview of important electrical energy storage application areas and their associated business models
- the ability to calculate important parameters of storage characteristics and storage applications
- knowledge of important storage technologies, explaining their function, and familiarity with their properties and fields of application
- the ability to describe/explain the operational behaviour of energy storages based on a simulation model (Unified Energy Model) and how to effectively use the model to calculate storage application (using MS Excel)
- an understanding of the basic energy storage operation concepts and the ability to formulate basic strategies for selected applications
- an overview of the approaches for technology selection and dimensioning

**Contents**

Electrical energy storage application areas and their associated business models, storage characteristics and applications,important storage technologies, operational behaviour of energy storages, basic energy storage operation concepts.

**Special features**

none

**Literature**

A. Hauer, J. Quinnell, E. Lävemann: Energy Storage Technologies - Characteristics, Comparison, and Synergies, in: Transition to Renewable Energy Systems, ed. D. Stolten, Wiley-VCH, Weinheim 2013

**Applicability in other degree programs**

# Modul: Engineering Dynamics and Vibrations

**Module:** Engineering Dynamics and Vibrations

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| SoSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam | 5 | 90 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 42 h |
| **Self-study time** | 108 h |
| **Module coordinator** | Dr.-Ing. Matthias Wangenheim |
| **Lecturer** | Dr.-Ing. Matthias Wangenheim |
| **Institute** | Institut für Dynamik und Schwingungen |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Engineering Dynamics and Vibrations - Vorlesung | 2 | Written exam |
| Engineering Dynamics and Vibrations - Hörsaalübung | 1 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| keine | Engineering Mechanics: Statics, Kinematics, Kinetics, Introduction to Mechanical Vibrations |

**Qualification goals**

If completed successfully, students are capable of
- Utilizing the terms natural frequencies, mode shapes, modal transformation in the correct manner
- Describing MDOF systems in the form of matrix differential equations
- Interpreting MDOF systems with respect to mode shapes, rigid body modes and effects like tuned mass damping
- Assessing critical operational states of machines and other dynamical systems like resonances, or instability regions
- Calculating transfer functions for MDOF systems
- Explaining the advantages to handle MDOF systems in modal space including proportional damping

**Contents**

Learning Objectives: In this module knowledge is imparted and consolidated in the field of describing and solving dynamical problems in systems with multiple degrees of freedom (MDOF).
- Single degree of freedom systems: natural frequencies, transfer function
- Natural frequencies und mode shapes of systems with multiple degrees of freedom
- Rigid body modes
- Initial value problem
- Modal transformation
- Modal/proportional damping
- Modal decoupling

**Special features**

Integrated course containing lecture and tutorials. Contents equal to German course "Maschinendynamik" taught in winter term.
Either the module Engineering dynamics and vibrations or Machine dynamics can be loaded. One of the two must be taken as a compulsory module in the Master of Mechanical Engineering. It is not possible to have both modules recognized.

**Literature**

Gross et al.: Engineering Mechanics 3. Dynamics. Springer
Inman: Engineering Vibration. Prentice Hall

# Modul: Engineering Dynamics and Vibrations

**Module:** Engineering Dynamics and Vibrations

| |
|---|
| Meirovitch: Fundamentals of Vibrations. McGraw-Hill<br>Tong: Theory of Mechanical Vibration, Literary Licensing, LLC |
| **Applicability in other degree programs** |
| Computational Methods in Engineering M.Sc.; Maschinenbau M.Sc.; |

# Modul: Environmental Sustainability Assessment I

**Module:** Environmental Sustainability Assessment I

| Type of module | | | Area of competence | | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Term paper | 5 | 20 content pages + illustrations etc. | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 42 h |
| **Self-study time** | 108 h |
| **Module coordinator** | Dr.-Ing. Sebastian Spierling |
| **Lecturer** | Dr.- Ing. Venkateshwaran Venkatachalam |
| **Institute** | Institut für Kunststoff- und Kreislauftechnik |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Environmental Sustainability Assessment I - Vorlesung | 3 | Term paper |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | none |

**Qualification goals**

The module provides knowledge about sustainability assessment (especially the environmental aspects) of products, processes and technologies. The methods as well as practical applications and areas of use will be explained.

After successfully completing the module, students will be able to
- define and explain terms in the field of sustainability,
- name methods for assessing sustainability,
- explain how to carry out a life cycle assessment according to ISO 14040/44,
- define balance sheet boundaries according to requirements,
- analyze life cycle assessments for products and processes,
- define methods for Design for Recycling/Ecodesign and Circular Economy.

**Contents**

- Sustainability, Sustainable Development Goals (SDG's) and sustainability assessment
- Methods for assessing the different dimensions of sustainability
- Procedure for conducting a life cycle assessment according to ISO 14040/44 (target and study framework, functional units, system boundaries, life cycle inventory and data collection, impact assessment (midpoint and endpoint), evaluation, scenario and sensitivity analyses)
- Evaluation of LCA results
- Case studies on life cycle assessments (especially with focus on plastics)
- Overview of available software systems and databases
- Life cycle assessments at the interface to Design for Recycling/Ecodesign/Circular Economy

**Special features**

Term paper as examination performance. Attention: In winter semster the lecture will take place in english (Sustainability assessment I). In summer the course will be tought in german (Nachhaltigkeitsbewertung I). Please notice: the number of participants is limited to 25.

**Literature**

Life Cycle Assessment Theory and Practice (ISBN 978-3-319-56475-3)

# Modul: Environmental Sustainability Assessment I

**Module:** Environmental Sustainability Assessment I

| |
|---|
| Life Cycle Assessment Handbook: A Guide for Environmentally Sustainable Products (ISBN 1118528271)<br>Life Cycle Assessment (LCA) A Guide to Best Practice (ISBN 978-3-527-32986-1)<br>EcoDesign Von der Theorie in die Praxis (ISBN 978-3-540-75437-4)<br>Design for Sustainability (ISBN 9780429456510) |
| **Applicability in other degree programs** |
| Elektro- und Informationstechnik B.Sc.; Elektro- und Informationstechnik M.Sc.; Energietechnik M.Sc.; Maschinenbau M.Sc.; Produktion und Logistik M.Sc.; Wirtschaftsingenieur M.Sc.; |

# Modul: GIS and Remote Sensing

**Module:** GIS and Remote Sensing

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam | 3 | 90 min | graded |
| SL | anerkannte Übung | 2 | wöchentlich | benotet |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Prof. Dr.-Ing. habil. Monika Sester |
| **Lecturer** | M. Sc. Ning Qian |
| **Institute** | Institut für Kartographie und Geoinformatik |
| **Faculty** | Fakultät für Bauingenieurwesen und Geodäsie |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| GIS and Remote Sensing - Vorlesung | 2 | Written exam |
| GIS and Remote Sensing - Hörsaalübung | 2 | anerkannte Übung |

| Requirements for participation: | Recommended for participation: |
|---|---|
| keine | Mathematik, Technische Mechanik, Wärmeübertragung, Thermodynamik |

**Qualification goals**

The modul introduces the underlying principles and methods about Geographical Information Systems (GIS) and Remote Sensing. The overall focus is on spatial data, which are relevant to any environmental planning and management tasks. In this module the students will obtain an overview over the most important basics and applications of GIS and remote sensing. They will learn to work with GIS software (e.g. ArcGIS) and apply it to their spatial problems. In the end the students will have understood the central methodologies and will be able to make use of the employed techniques. By independently preparing and then presenting the lab work they will further develop their learning strategies and presentation skills. Upon completion of the module, students are able to apply GIS software and remote sensing techniques for analyses and manipulation of space related data from ground observation and remote sensing.

**Contents**

1. Geographical Information Systems: - data modelling: geometric, thematic, topologic - data analysis and geoprocessing - cartography: graphical variables, generalization, presentation - data capture, topography: digital elevation models, data interpolation, geomorphology - visualization, presentation and analysis: 2D, 3D, terrain Besides the theoretical lectures, there will be practical excercises to learn and train the GIS-skills. 2. Remote Sensing - basics: electromagnetic spectrum, interaction of electromagnetic waves and materials , limits of resolution, digital images - sensors: multi-spectral satellite sensors, hyper-spectral sensors, airborne laser scanning, synthetic aperture radar - processing: generation of thematic maps: classification of land cover using pattern recognition methods, determination of digital height models, in particular from laser scanner and radar data.

**Special features**

Studienleistung (weitere Informationen erfolgen im Kurs)

**Literature**

Jones, C., 1999. Geographical Information Systems and Computer Cartography Logman. T. Lillesand, R. Kiefer, 2015. Remote sensing and image interpretation.

**Applicability in other degree programs**

Nachhaltige Ingenieurwissenschaft B.Sc.; Nachhaltige Ingenieurwissenschaft M.Sc.;

# Modul: Grundlagen der Data Science

**Module:** Fundamentals of Data Science Foundation

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam | 5 | 90 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Prof. Dr. rer. nat. Marius Lindauer |
| **Lecturer** | Prof. Dr. rer. nat. Marius Lindauer |
| **Institute** | Institut für Künstliche Intelligenz |
| **Faculty** | Fakultät für Elektrotechnik |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Grundlagen der Data Science - Vorlesung | 2 | Written exam |
| Grundlagen der Data Science - Übung | 2 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Fundamentals of probability theory |

**Qualification goals**

In the Era of Big Data, one of the emerging requirements for any scientist is the ability to effectively and critically work with data, i.e., collect and extract data, create surveys, transform the data, apply mathematical models on the data, and visualize the important aspects. In fact, the Society of Computer Science (Gesellschaft der Informatik) has coined the term “data literacy” to describe various competencies in this regard. In the same spirit, the goal of this course is to teach non-computer scientists the foundational concepts of data science. Students will learn to analyze data for the purpose of understanding and describing real-world phenomena.
The students will obtain skills in data-centric programming and statistical inference. Furthermore, the students will gain hands-on experience on daily challenges of a data scientist with best-practice approaches for data collection and preparation. Finally, we will discuss ethical and social aspects of data science.
The course consists of a standard lecture and lab work. During the lecture the important concepts are introduced. In the lab sessions, students will be guided in practical programming exercises. In addition, the students receive bi-weekly assignments that follow-up on the lab exercises. The successful participation in the assignments is a pre-requisite to take part in the final written exam.

**Contents**

- Data Sampling and Probability
- Data Preparation
- Visualizations
- Introduction to Modeling
- Learning Paradigms
- Classification
- Deep Learning
- Feature Engineering
- Bias and Variance
- Evaluation
- Automated Machine Learning
- Conclusion and Ethics

# Modul: Grundlagen der Data Science

**Module:** Fundamentals of Data Science Foundation

| **Special features** |
| --- |
| This module is part of the Leibniz AI Academy. Further information on https://www.ai-academy.uni-hannover.de/de/. |
| **Literature** |
| - https://www.inferentialthinking.com/chapters/01/1/intro.html<br>- https://www.textbook.ds100.org/intro.html |
| **Applicability in other degree programs** |

# Modul: Hardware-accelerated Communication Systems

**Module:** Hardware-accelerated Communication Systems

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Oral exam | 5 | 20 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Prof. Dr. Amr Rizk |
| **Lecturer** | Prof. Dr. Amr Rizk |
| **Institute** | Institut für Kommunikationstechnik |
| **Faculty** | Fakultät für Elektrotechnik und Informatik |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Hardware-accelerated Communication Systems - Vorlesung | 2 | Oral exam |
| Hardware-accelerated Communication Systems - Übung | 2 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| keine | Basic Knowledge of Communication Systems, Networks and Operating System is recommended.<br>Experience in programming with C/C++ and Python is recommended |

**Qualification goals**

The goal of this lecture is that the students
- understand the basics of hardware acceleration of protocol-based communication systems and its applications- have an overview of methods for domain specific programming for the communication control plane and the communication data plane- recognize possible applications of virtualization in communication systems
- are able to implement communication data processing applications in a hardware-near domain specific language that can be synthesized to communication hardware platforms

**Contents**

Hardware Architectures and abstractions for the hardware-acceleration of protocol-based communication systems, interfaces, hardware-near domain specific language (e.g. p4), Offloading
applications to the data plane, kernel-bypass, virtualization of communication systems, Verification
approaches to hardware programs for communication systems.

**Special features**

none

**Literature**

Toke Høiland-Jørgensen, Jesper Dangaard Brouer, Daniel Borkmann, John Fastabend, Tom Herbert, David Ahern, anK29d David Miller. 2018.M25

- The eXpress data path: fast programmable packet processing in the operating system kernel. In Proceedings of the 14th International Conference on emerging Networking. Experiments and Technologies (CoNXT '18). Association for Computing Machinery, New York, NY, USA, 54–66. https://doi.org/10.1145/3281411.3281443

- Marcos A. M. Vieira, Matheus S. Castanho, Racyus D. G. Pacífico, Elerson R. S. Santos, Eduardo P. M.
Câmara Júnior, and Luiz F. M. Vieira. 2020. Fast Packet Processing with eBPF and XDP: Concepts, Code, Challenges, and Applications. ACM Comput. Surv. 53, 1, Article 16 (January 2021), 36 pages. https://doi.org/10.1145/3371038L27

# Modul: Hardware-accelerated Communication Systems

**Module:** Hardware-accelerated Communication Systems

- Pat Bosshart, Dan Daly, Glen Gibb, Martin Izzard, Nick McKeown, Jennifer Rexford, Cole Schlesinger, Dan

Talayco, Amin Vahdat, George Varghese, and David Walker. 2014. P4: programming protocol-independent packet processors. SIGCOMM Comput. Commun. Rev. 44, 3 (July 2014), 87–95. https://doi.org/10.1145/2656877.2656890
- Lecture slides

**Applicability in other degree programs**

# Modul: Hybrid Artificial Intelligence

**Module:** Hybrid Artificial Intelligence

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| SoSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Project-oriented form of examination | 5 | | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 28 h |
| **Self-study time** | 122 h |
| **Module coordinator** | Dr. Daniel Kudenko |
| **Lecturer** | Dr. Daniel Kudenko |
| **Institute** | L3S Research Center |
| **Faculty** | Forschungszentrum |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Hybrid Artificial Intelligence - Seminar | 2 | Project-oriented form of examination |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Artificial Intelligence I & II |

**Qualification goals**

1. Basic understanding of hybrid AI and neuro-symbolic approaches
2. Overview of the state-of-the-art in Hybrid AI.

**Contents**

In the first decades of AI research, the focus was on symbolic, knowledge-based reasoning, e.g. logic-based representations and inferences, rule-based systems. The advantage of such approaches are that the AI behaviour is for the most part transparent and provable. However, the computational complexity of these approaches did prevent AI from being applied to many real-world applications. With the success of deep neural networks this has changed, and AI systems are increasingly permeating modern technology. However, this comes at the cost of transparency and safety guarantees. As a result, a new field of AI research is emerging that attempts to combine the classic symbolic approaches and more recently LLM reasoning with the modern sub-symbolic (i.e. neural) technologies. In this seminar students will explore this new research area and gain a fundamental understanding of the directions taken. Presentation papers can be picked, amongst others, from the following topics: 1. Neuro-Symbolic Computing 2. Approaches based on ”Thinking Fast and Slow” 3. Hybrid Reinforcement Learning, specifically LLM-supported RL

**Special features**

Project-oriented form of examination. The examination must be registered in QIS in the first registration period of a semester.

**Literature**

Research articles are provided.

**Applicability in other degree programs**

# Modul: Image Analysis I

**Module:** Image Analysis I

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| SoSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Oral exam | 4 | 15 min | graded |
| SL | Academic achievement | 1 | 3 Draftings with Jupyter Notebooks | ungraded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | apl. Prof. Dr. techn. Franz Rottensteiner |
| **Lecturer** | M. Sc. Hubert Kanyamahanga |
| **Institute** | Institut für Photogrammetrie und Geoinformation |
| **Faculty** | Fakultät für Bauingenieurwesen und Geodäsie |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Image Analysis I - Vorlesung | 3 | Oral exam |
| Image Analysis I - Übung | 1 | Academic achievement |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Photogrammetric Computer Vision |

**Qualification goals**

This module provides fundamental knowledge about image analysis strategies based on machine learning. After successfully completing the module, students will be able to

- understand and explain the essential steps of image analysis from image acquisition to image interpretation,
- understand and explain the basics of probabilistic classifiers and modern deep learning methods based on neural networks,
- analyse and evaluate the advantages and disadvantages of statistical image analysis methods,
- evaluate the results of image analysis methods using reference data,
- evaluate and define the necessary requirements for the development of an image analysis method with regard to the sensor data,
- develop, implement and test their own machine learning methods for specific tasks within the scope of the module content.

**Contents**

- Image acquisition and image pre-processing
- Evaluation of results
- Features from images and point clouds
- Overview of machine learning methods
- Probabilistic classification methods: Bayesian classification, logistic regression
- Neural Networks
- Convolutional Neural Networks, Deep Learning, Transformers
- Applications of deep learning
- Domain adaptation, learning with noisy training labels.

The lab includes programming tasks in Python in combination with Jupyter notebooks, in which the contents of the lecture are supplemented by their practical application.

# Modul: Image Analysis I

**Module:** Image Analysis I

| Special features |
| --- |
| none |
| **Literature** |
| Bishop, C. M., Pattern Recognition and Machine Learning, Springer, NY, 2006. Duda, R. O., Hart, P. E., Stork, D. G.: Pattern Classification. Second edition, Wiley & Sons, New York, USA, 2001. Goodfellow, I., Bengio, Y., Courville, A: Deep Learning. MIT Press, Cambridge, MA, USA, 2016. |
| **Applicability in other degree programs** |
| Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; |

# Modul: Image Analysis II

**Module:** Image Analysis II

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Oral exam | 4 | 15 min | graded |
| SL | Academic achievement | 1 | 3 Draftings with Jupyter Notebooks | ungraded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | apl. Prof. Dr. techn. Franz Rottensteiner |
| **Lecturer** | M. Sc. Hubert Kanyamahanga |
| **Institute** | Institut für Photogrammetrie und Geoinformation |
| **Faculty** | Fakultät für Bauingenieurwesen und Geodäsie |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Image Analysis II - Vorlesung | 3 | Oral exam |
| Image Analysis II - Übung | 1 | Academic achievement |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Image Analys I |

**Qualification goals**

The module provides basic knowledge of image analysis strategies based on machine learning, segmentation methods and the modeling of objects for 3D reconstruction. After successfully completing the module, students will be able to
- understand and explain the basics of non-probabilistic machine learning methods and methods for non-semantic segmentation,
- analyze and evaluate the advantages and disadvantages of methods,
- evaluate the results of image analysis methods using reference data,
- evaluate and define the necessary requirements for the development of an image analysis method with regard to the sensor data,
- develop, implement and test their own machine learning or non-semantic segmentation methods for specific tasks within the scope of the module content.

**Contents**

•Overview of machine learning methods
- Non-probabilistic discriminative classifiers: random forests, boosting, support vector machines
- Graphical models
- Probabilistic models of context: Markov Random Fields, Conditional Random Fields
- Learning with faulty training labels
- The scale space
- Segmentation: Extraction of points and edges
- Segmentation: Extraction of homogeneous regions
- Modeling of 3D objects The exercises include programming tasks in Python in combination with Jupyter notebooks, in which the contents of the lecture are deepened and supplemented by their practical application.

**Special features**

none

**Literature**

Bishop, C. M., Pattern Recognition and Machine Learning, Springer, NY, 2006. Duda, R. O., Hart, P. E., Stork, D. G.: Pattern

# Modul: Image Analysis II

**Module:** Image Analysis II

| |
|---|
| Classification. Second edition, Wiley & Sons, New York, USA, 2001. Forsyth, D.A., Ponce, J., Computer Vision, A Modern Approach, Prentice Hall, 2003. |
| **Applicability in other degree programs** |
| Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; |

# Modul: Image Sequence Analysis

**Module:** Image Sequence Analysis

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Oral exam | 4 | 15 min | graded |
| SL | Academic achievement | 1 | Various home exercises | ungraded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Dr.-Ing. Max Mehltretter |
| **Lecturer** | Dr.-Ing. Max Mehltretter |
| **Institute** | Institut für Photogrammetrie und Geoinformation |
| **Faculty** | Fakultät für Bauingenieurwesen und Geodäsie |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Image Sequence Analysis - Vorlesung | 2 | Oral exam |
| Image Sequence Analysis - Hörsaalübung | 2 | Academic achievement |

| Requirements for participation: | Recommended for participation: |
|---|---|
| keine | Photogrammetric Computer Vision . Prior knowledge on image processing |

**Qualification goals**

At the end of the course, students have a good insight into the goals, tasks and methods of image sequence analysis. They are able to evaluate monoscopic and stereoscopic image sequences with regard to 3D geometry and content and know the limits of the automatic methods used for this purpose: foreground/background separation, optical flow , object tracking etc. They are also able to integrate motion models into the evaluation, for example on the basis of Kalman filter, EKF; particle filters are also known in principle. In individual areas, the students have exemplary detailed knowledge, e.g. in the area of tracking-by-detection and data association. As a basis for further Master's studies, the students should develop their analytical and transfer skills through exercises, also from current research projects.

**Contents**

- Introduction to the field of image sequence analysis (incl. sensors and general considerations)
- Background subtraction
- Motion of pixels / points: Optical flow and Scene flow
- Object detection and tracking (incl. motion models and filtering approaches)
- Re-Identification
- Body pose estimation
- Action Detection

**Special features**

To achieve the 5 ETCS, the lab must be successfully completed. The course is taught in English

**Literature**

- David A. Forsyth and Jean Ponce (2003): Computer Vision, A Modern Approach.
- Richard Hartley and Andrew Zisserman (2003): Multiple View Geometry in Computer Vision.
- Wolfgang Förstner and Bernhard P. Wrobel (2016): Photogrammetric Computer Vision.
- Ian Goodfellow, Yoshua Bengio and Aaron Courville (2016): Deep Learning.
- Christopher M. Bishop (2006): Pattern Recognition and Machine Learning.

# Modul: Image Sequence Analysis

**Module:** Image Sequence Analysis

| Applicability in other degree programs |
| --- |
| Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Optical Technologies M.Sc.; Optische Technologien M.Sc.; |

# Modul: International Sustainable Product Development Project (ISPDP)

**Module:** International Sustainable Product Development Project (ISPDP)

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| SoSe/WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Projektorientierte Prüfungsform | 5 | Abschlussbericht (20 Seiten) und Projektpräsentation (15 min) | benotet |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 70 h |
| **Self-study time** | 80 h |
| **Module coordinator** | Prof. Dr.-Ing. Roland Lachmayer |
| **Lecturer** | M. Sc. Timo Stauß |
| **Institute** | Institut für Produktentwicklung und Gerätebau |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| International Sustainable Product Development Project (ISPDP) - Vorlesung | 2 | Projektorientierte Prüfungsform |
| International Sustainable Product Development Project (ISPDP) - Hörsaalübung | 3 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| keine | keine |

**Qualification goals**

Nach erfolgreichem Abschluss des Moduls sind die Studierenden in der Lage,

- Nachhaltigkeitskompetenz: Die Studierenden sind in der Lage, die 17 Sustainable Development Goals (insbesondere SDG 12) entlang des gesamten Produktlebenszyklus einzuordnen, zu bewerten und für die Entwicklung nachhaltiger(er) Produkte anzuwenden.
- Systemisches und zirkuläres Denken: Sie verfügen über ein ganzheitliches, kreislaufwirtschaftlich geprägtes Nachhaltigkeitsverständnis für die Entwicklung innovativer Produkte im internationalen Kontext.
- Projektmanagement in hybriden und interkulturellen Teams: Die Studierenden können Projektpläne erstellen, hybride Projekte koordinieren und effektiv in interdisziplinären und interkulturellen Teams arbeiten.
- Globale und kulturelle Reflexionsfähigkeit: Sie erkennen die Relevanz kultureller und paradigmatischer Unterschiede für globale Zusammenarbeit, reflektieren die Auswirkungen ihres Handelns im internationalen Kontext und entwickeln ein tieferes Verständnis gesellschaftlicher Werte.
- Kreativität und Kommunikationsfähigkeit: Die Studierenden können Produktideen visuell skizzieren und in Präsentationen fachgerecht erläutern sowie durch Perspektivenwechsel zu innovativen Lösungen beitragen.
- Berufsorientierung und Zukunftsperspektiven: Sie erhalten Einblicke in internationale Karrierewege in Wissenschaft und Industrie und sind motiviert, sich langfristig an der Lösung globaler Herausforderungen zu beteiligen.

**Contents**

Das International Sustainable Product Development Project bietet, Studierenden aus Deutschland und den USA eine Plattform für gemeinsame, praxisnahe Projektarbeit im Bereich nachhaltiger Produktentwicklung. Im Mittelpunkt steht dabei der interkulturelle Austausch, der nicht nur die Zusammenarbeit in gemischten Teams fördert, sondern auch ein besseres Verständnis für unterschiedliche Herangehensweisen an Nachhaltigkeit schafft.

Der Austausch erfolgt in Zusammenarbeit mit der Pennsylvania State University sowie der Jönköping University und umfasst sowohl virtuelle als auch Präsenzphasen. Geplant ist jeweils eine gemeinsame Projektwoche vor Ort in Pennsylvania sowie eine Woche in Hannover, in der die amerikanischen und schwedischen Studierenden zu Gast in Deutschland sind. Ergänzt wird das Programm durch regelmäßige Online-Termine, die sich über das gesamte Semester

# Modul: International Sustainable Product Development Project (ISPDP)

**Module:** International Sustainable Product Development Project (ISPDP)

erstrecken und somit eine kontinuierliche Zusammenarbeit und Vorbereitung ermöglichen.
Die Veranstaltung ist mit 5 ECTS-Punkten anerkannt und schließt mit einem benoteten Projektbericht im Paper-Charakter von ca. 20 Seiten sowie einer abschließenden Präsentation (ca. 15 Minuten) der erarbeiteten Ergebnisse ab.

**Special features**

ANMELDUNG IM SEPTEMBER! Infos unter :https://www.ipeg.uni-hannover.de/de/studium/lehrveranstaltungen-mit-praxisbezug

Dies ist ein Hybridkurs. Der Austausch erfolgt in Zusammenarbeit mit der Pennsylvania State University sowie Jönköping University und umfasst sowohl virtuelle als auch Präsenzphasen. Geplant sind jeweils eine gemeinsame Projektwoche vor Ort in Pennsylvania sowie eine Woche in Hannover, in der die amerikanischen sowie schwedischen Studierenden zu Gast in Deutschland sind. Ergänzt wird das Programm durch regelmäßige Online-Termine, die sich über das gesamte Semester erstrecken und somit eine kontinuierliche Zusammenarbeit und Vorbereitung ermöglichen.

Das Modula kann in allen Bachelor Studiengängen der Fakultät Maschinenbau im Studium Generale oder als Tutoirum angerechnet werden.

Das Modul findet in englischer Sprache statt.

**Literature**

Entwicklungsmethodik nachhaltiger Produkte (2025): Prof. R. Lachmayer, Johanna Wurst, Jorin Thelemann, Springer Vieweg
Methodology for the Development of Sustainable Products (2026): Prof. R. Lachmayer, Johanna Wurst, Jorin Thelemann, Springer Nature

**Applicability in other degree programs**

Biomedizintechnik M.Sc.; Maschinenbau B.Sc.; Maschinenbau M.Sc.; Nachhaltige Ingenieurwissenschaft B.Sc.; Nachhaltige Ingenieurwissenschaft M.Sc.; Produktion und Logistik B.Sc.; Produktion und Logistik M.Sc.; Wirtschaftsingenieur M.Sc.;

# Modul: Interpretable Machine Learning

**Module:** Interpretable Machine Learning

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Oral exam | 5 | | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Prof. Dr. rer. nat. Marius Lindauer |
| **Lecturer** | Prof. Dr. rer. nat. Marius Lindauer |
| **Institute** | Institut für Künstliche Intelligenz |
| **Faculty** | Fakultät für Elektrotechnik |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Interpretable Machine Learning - Vorlesung | 2 | Oral exam |
| Interpretable Machine Learning - Übung | 2 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Basic knowledge in the areas of: AI, machine learning, deep learning. |

**Qualification goals**

Students have knowledge of the theoretical and practical fundamentals of interpretable machine learning (iML). They understand the mathematical foundations and can implement, execute and evaluate iML approaches. In a final project, students will have learned how to independently apply the concepts they have learned in the lecture to a new problem.

**Contents**

1. Introduction
2. GAMs and Rule-based Approaches
3. Feature Effects
4. Local Explanations
5. Shapley Values for Explainability
6. Instance-wise Feature Selection
7.+8. Gradient-based Feature Attribution
9. Actionable Explanation and Resources
10. Evaluating Interpretability and Utility
11. Conclusion

**Special features**

none

**Literature**

Interpretable ML Book by Molnar: https://christophm.github.io/interpretable-ml-book/.
Samek, W., Montavon, G., Vedaldi, A., Hansen, L. K., & Müller, K. R. (Eds.). (2019). Explainable AI: interpreting, explaining and visualizing deep learning (Vol. 11700). Springer Nature., ISO 690, https://www.springer.com/de/book/9783030289539

# Modul: Interpretable Machine Learning

**Module:** Interpretable Machine Learning

| Applicability in other degree programs |
| --- |
| Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; |

# Modul: Introduction to Natural Language Processing

**Module:** Introduction to Natural Language Processing

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| SoSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam | 5 | 90 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Prof. Dr. Henning Wachsmuth |
| **Lecturer** | Prof. Dr. Henning Wachsmuth |
| **Institute** | Institut für Künstliche Intelligenz |
| **Faculty** | Fakultät für Elektrotechnik |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Introduction to Natural Language Processing - Vorlesung | 2 | Written exam |
| Introduction to Natural Language Processing - Übung | 2 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Basics of statistics. Knowledge of programming. |

**Qualification goals**

The students have basic skills needed to tackle analysis and generation tasks in natural language processing (NLP) with knowledge-based methods. Starting from fundamentals of linguistics and empirical methods, they have learned rule-based and basic statistical techniques. The application of these techniques they have master for fundamental NLP tasks, including text segmentation, syntactic parsing, and entity recognition. Students learn to design, implement, and evaluate respective NLP methods, both theoretically and in practical assignments. Besides the topical content, the students have learned how to conduct data-driven scientific experiments.

**Contents**

Overview of Natural Language Processing.
Basics of Linguistics.
NLP using Rules.
NLP using Lexicons.
Basics of Empirical Methods.
NLP using Regular Expressions.
NLP using Context-Free Grammars.
NLP using Language Models.
Practical Issues.

**Special features**

The home assignments will include both programming and pencil-and-paper tasks.

**Literature**

Daniel Jurafsky and James H. Martin. 2009. Speech and Language Processing: An Introduction to Natural Language Processing, Speech Recognition, and Computational Linguistics. Prentice-Hall, 2nd edition. Free draft of third edition:

# Modul: Introduction to Natural Language Processing

**Module:** Introduction to Natural Language Processing

| |
|---|
| https://web.stanford.edu/~jurafsky/slp3/ |
| **Applicability in other degree programs** |

# Modul: Laser Scanning - Modelling and Interpretation

**Module:** Laser Scanning - Modelling and Interpretation

| Type of module | | | Area of competence | | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Oral exam | 3 | 15 mim | graded |
| SL | Academic achievement | 2 | Exercise | ungraded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 42 h |
| **Self-study time** | 108 h |
| **Module coordinator** | apl. Prof. Dr.-Ing. Claus Brenner |
| **Lecturer** | Tim Schimansky |
| **Institute** | Institut für Kartographie und Geoinformatik |
| **Faculty** | Fakultät für Bauingenieurwesen und Geodäsie |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Laser Scanning - Modelling and Interpretation - Vorlesung | 2 | Oral exam |
| Laser Scanning - Modelling and Interpretation - Hörsaalübung | 1 | Academic achievement |

| Requirements for participation: | Recommended for participation: |
|---|---|
| keine | Programming Skills |

**Qualification goals**

This lecture imparts the basic principles about laser scanning and its respective application areas. After successful completion of the lecture, students are able to explain and apply selected techniques and algorithms for the low-, intermediate- and high-lever processing of laser scanning data

**Contents**

Airborne, terrestrial and mobile mapping laser scanning: scan geometry and technical characteristics. Low-, intermediate and high-level tasks. Representation of 3D rotations: matrix, angles, axis and angle, quaternions. Estimation of similarity transforms and the iterative closest point algorithm. Estimation and segmentation of lines and planes. Region growing, RANSAC and MSAC, Hough transform. Robust estimation. Mapping (integration of scans). Point cloud classification: decision trees and random forests.Markov chains and Markov chain Monte Carlo methods and their use for high-level interpretation. Deep learning for point clouds. In the exercises, selected algorithms will be programmed.

**Special features**

Lecture is given in English

**Literature**

Skript

**Applicability in other degree programs**

Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Optical Technologies M.Sc.; Optische Technologien B.Sc.; Optische Technologien M.Sc.;

# Modul: Model Predictive Control

**Module:** Model Predictive Control

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| SoSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | wirtten exam | 4 | 90 min Programming exercise | graded |
| SL | Academic achievement | 1 | | ungraded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 42 h |
| **Self-study time** | 108 h |
| **Module coordinator** | Prof. Dr.-Ing. Matthias Müller |
| **Lecturer** | Prof. Dr.-Ing. Matthias Müller |
| **Institute** | Institut für Regelungstechnik |
| **Faculty** | Fakultät für Elektrotechnik und Informatik |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Model Predictive Control - Vorlesung | 2 | Oral exam |
| Model Predictive Control - Hörsaalübung | 1 | Academic achievement |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Regelungstechnik I und II |

**Qualification goals**

The students analyze and synthesize various types of model predictive controllers for different system classes and implement them in Matlab. They are able to derive systems-theoretic guarantees of MPC controllers, including closed-loop stability and robustness, and can assess the different properties, advantages, and disadvantages of different MPC schemes. The students have insight into current research topics in the field of model predictive control, which enables them to do their own first research projects in this area.

**Contents**

This lecture deals with Model Predictive Control (MPC), a modern optimization-based control technique which has been actively researched and widely applied in industry within the last years. After an introduction to the basic ideas and stability concepts of MPC, more recent and current advances in research, like tube-based MPC considering robustness issues, economic MPC, distributed MPC, and stochastic MPC are discussed.

# Modul: Model Predictive Control

**Module:** Model Predictive Control

| Special features |
| --- |
| Eine Studienleistung muss in der Form einer Programmierübung erbracht werden. |
| **Literature** |
| keine |
| **Applicability in other degree programs** |
| Maschinenbau M.Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Wirtschaftsingenieur M.Sc.; |

# Modul: MOOC Aircraft Engines

**Module:** MOOC Aircraft Engines

| Type of module | | | Area of competence | | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe/SoSe | 1 Semester | Englisch | 3 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam | 3 | 60 min | graded |

| | |
|---|---|
| **Workload** | 90 h |
| **Attendance study period** | 28 h |
| **Self-study time** | 62 h |
| **Module coordinator** | Dr. Yavuz Gündogdu |
| **Lecturer** | Marcel Oettinger |
| **Institute** | Institut für Turbomaschinen und Fluid-Dynamik |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| MOOC Aircraft Engines - Vorlesung | 2 | Written exam |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Strömungsmechanik II, Strömungsmaschinen I, Thermodynamik |

**Qualification goals**

The module introduces basic engineering and physical understanding of the requirements, components and preliminary design of simple aircraft jet engines

After successful completion of the course, the students have knowledge of the thermodynamic changes of state taking place in the individual components of aircraft jet engines and are able to apply this knowledge to the calculation of the engine efficiency, the optimisation of the thermodynamic cycle and also stage theory and straight cascades. Moreover, the students are able to determine and evaluate the losses, dimensionless quantities, and characteristic maps of aircraft jet engines and their individual components.

**Contents**

Furthermore, the students gain insight into phenomena such as rotating stall, surging, and engine aeroacoustics as well as the dynamic behaviour of jet engines and their control systems.

**Special features**

Sprache: Englisch Die Veranstaltung findet als Online-Vorlesung statt und ist ein Betandteil der "Flugtriebwerke"-Vorlesung. Studierende müssen daher bei Bedarf zwischen MOOC und Flugtriebwerke wählen.

**Literature**

Bräunling: Flugzeugtriebwerke: Grundlagen, Aero-Thermodynamik, ideale und reale Kreisprozesse, thermische Turbomaschinen, Komponenten, Emissionen und Systeme. 3. Aufl., Berlin [u.a.] : Springer, 2009. Farokhi, S.: Aircraft Propulsion. 2. Aufl., Chichester: Wiley, 2014. Cumpsty, N., Heyes, A.: Jet Propulsion, Cambridge University Press, 2015.

**Applicability in other degree programs**

Maschinenbau M.Sc.;

# Modul: Multi-Agent Interactions and Games

**Module:** Multi-Agent Interactions and Games

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Klausur | 5 | 90 min | benotet |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Dr. Daniel Kudenko |
| **Lecturer** | Dr. Daniel Kudenko |
| **Institute** | L3S Research Center |
| **Faculty** | Forschungszentrum |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Multi-Agent Interactions and Games - Vorlesung | 2 | Klausur |
| Multi-Agent Interactions and Games - Übung | 2 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| keine | KI 1 und KI 2 |

**Qualification goals**

1. The students master the mathematical foundations of multi-agent interactions using games as a formal model. 2. They know algorithms for distributed problem solving. 3. They have developed an understanding of the complexities of coordination and competition.

**Contents**

1. Game Theory (Mathematical definition of games and rational behaviour, games under uncertainty, repeated games. 2. Algorithms to compute optimal behaviour (Alpha-Beta and extenstions, Monte Carlo Tree Search). 3. Modes of Interaction (Communication, Negotiation and Bargaining, Argumentation). 4. Mechanism Design. 5. Multi-agent Learning

**Special features**

none

**Literature**

1. Yoav Shoham, Kevin Leyton-Brown: "Multiagent Systems Algorithmic, Game-Theoretic, and Logical Foundations", Cambridge University Press, 2009. 2. Gerhard Weiss (ed.): "Multi-Agent Systems (2nd Ed.)", MIT Press, 2013.

**Applicability in other degree programs**

# Modul: Optical Measurement Technology

**Module:** Optical Measurement Technology

| Type of module | | | Area of competence | | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam / Oral exam | 5 | 90 min/20 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 42 h |
| **Self-study time** | 108 h |
| **Module coordinator** | Dr.-Ing. Christian Pape |
| **Lecturer** | Dr.-Ing. Christian Pape |
| **Institute** | Institut für Mess- und Regelungstechnik |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Optical Measurement Technology - Vorlesung | 2 | Written exam / Oral exam |
| Optical Measurement Technology - Hörsaalübung | 1 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Measurement Technology I |

**Qualification goals**

The module gives an overview on theory, methods and devices in optical metrology.

After successful completion of the module, students are able

- to explain and apply basic concepts of optical metrology,
- to apply the basics of geometrical optics and wave optic,
- to compare different light sources and sensors and assign them to the measurement task,
- to explain fibre optic systems,
- to compare methods from the fields of surface metrology and geometric metrology and evaluate them for the application case.

**Contents**

At the beginning, fundamentals of optics and photonics such as ray and wave optics are revised, which are essential for the understanding of concepts in optical metrology. Focusing on metrology in research and industrial applications, the lecture covers optical methods for measurement of topography, distance, and deformation as well as fiber optical sensors, which include concepts such as interferometry, holography and confocal microscopy. In addition, semi-optical methods such as atomic force microscopy and near field microscopy are addressed and compared to non-optical methods, e.g., scanning electron microscopy. To gain an in-depth understanding of the concepts involved in optical metrology, all devices and optical setups are explained in detail including light sources, cameras, and optical elements.

**Special features**

Examination depending on the number of participants: Individual examination 20 minutes orally or 90 minutes in writing.

**Literature**

Born, Wolf. Principles of Optics: Electromagnetic Theory of Propagation, Interference and Diffraction of Light; Demtröder: Experimentalphysik; Saleh, Teich: Grundlagen der Photonik; Lauterborn, Kurz: Coherent Optics; Goodman: Introduction to Fourier Optics; Hugenschmidt: Lasermesstechnik; These and other sources are available as free download from www.springer.com in German and English.

# Modul: Optical Measurement Technology

**Module:** Optical Measurement Technology

| Applicability in other degree programs |
| --- |
| Biomedizintechnik M.Sc.; Maschinenbau M.Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Medizintechnik B.Sc.; Nanotechnologie M.Sc.; Optical Technologies M.Sc.; Optische Technologien M.Sc.; |

# Modul: Photogrammetric Computer Vision

**Module:** Photogrammetric Computer Vision

| Type of module | | | Area of competence | | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Oral exam | 3 | 15 min | graded |
| SL | Academic achievement | 2 | Various home exercises | ungraded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 42 h |
| **Self-study time** | 108 h |
| **Module coordinator** | Prof. Dr.-Ing. habil. Christian Heipke |
| **Lecturer** | Prof. Dr.-Ing. habil. Christian Heipke |
| **Institute** | Institut für Photogrammetrie und Geoinformation |
| **Faculty** | Fakultät für Bauingenieurwesen und Geodäsie |

| Structure of the module | | |
|---|---|---|
| **Title and form of the course** | **Semester hours** | **Ep / Aa** |
| Photogrammetric Computer Vision - Vorlesung | 2 | Oral exam |
| Photogrammetric Computer Vision - Übung | 1 | Academic achievement |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Bachelorabschluss in einem Ingenieurfach empfohlen. |

**Qualification goals**

After studying the module the students have a good overview and detailed knowledge of some exemplary methods of 3D reconstruction from images and image sequences (structure from motion, sfm). They understand the geometric transformations between image and object space, the usual procedures for pose estimation of moving sensors and basics of signal theory as applied to image matching. Students can thus evaluate pros and cons of sfm. In the lab part, carried out in small groups, image sequences are captured using flying robots; these image sequences are being exploited using available software. In this way the students come to gain practical experience of digital image capture and geometric 3D reconstruction and can evaluate the obtained results.

**Contents**

Short introduction into aims, commonalities and differences of photogrammetry and computer vision, 3D image processing, projective geometry: transformation between image and object space, in linear models. Robust estimation (RANSAC). Different methods to represent 3D rotations (Euler angles axis-angle representation, quaternions). Structure from motion (sfm) from stereoscopic images and image sequences: interest operators (SIFT, SURF), sliding pose estimation, dense image matching, determination of object geometries. Methods for evaluation of results of image based approaches.

**Special features**

No information

**Literature**

David A. Forsyth and Jean Ponce (2003). Computer Vision, A Modern Approach. Prentice Hall. Richard Hartley and Andrew Zisserman (2003).

**Applicability in other degree programs**

Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Optical Technologies M.Sc.; Optische Technologien M.Sc.;

# Modul: Power Electronics

**Module:** Power Electronics

| Type of module | | Area of competence | | | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Oral exam | 5 | | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Prof. Dr.-Ing. Axel Mertens |
| **Lecturer** | Prof. Dr.-Ing. Axel Mertens |
| **Institute** | Institut für Antriebssysteme und Leistungselektronik |
| **Faculty** | Fakultät für Elektrotechnik und Informatik |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Power Electronics - Vorlesung | 2 | Oral exam |
| Power Electronics - Übung | 1 | |
| Power Electronics - Labor | 1 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | none |

**Qualification goals**

The lecture gives an introduction into the general topics of modern power electronics with a strong focus on the operation principle of power electronic circuits and their components. After participation the students will be able to explain the basic characteristics of power semiconductors, design passive components for typical applications and calculate and simulate converter stages. They will also be able to understand and characterize the interaction between one or multiple converters and the grid.

**Contents**

Power Electronics for high efficient energy conversion
Applications
Components
Line-commutated converter, dc/dc-Converter, dc/ac-Converter

**Special features**

none

**Literature**

Mohan, Undeland, Robbins: Power Electronics: Converters, Applications, and Design
Lutz, Schlangenotto, Scheuermann, De Donker: Semiconductor Power Devices
Van den Bossche, Valchev: Inductors and Transformers for Power Electronics

**Applicability in other degree programs**

# Modul: Project: Machine Learning

**Module:** Project: Machine Learning

| Type of module | | | Area of competence | | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| SoSe/WiSe | 1 Semester | Englisch | 6 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| SL | Academic achievement | 6 | Final presentation, report | ungraded |

| | |
|---|---|
| **Workload** | 180 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 124 h |
| **Module coordinator** | Prof. Dr. rer. nat. Marius Lindauer |
| **Lecturer** | Prof. Dr. rer. nat. Marius Lindauer |
| **Institute** | Institut für Künstliche Intelligenz |
| **Faculty** | Fakultät für Elektrotechnik |

| Structure of the module | | |
|---|---|---|
| **Title and form of the course** | **Semester hours** | **Ep / Aa** |
| Project: Machine Learning - Labor | 4 | Academic achievement |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | It is strongly recommended to have successfully completed courses on Machine Learning (Bodo Rosenhahn) and courses in the field of ML (AutoML, RL, iML) beforehand. |

**Qualification goals**

Students are able to transfer their theoretical knowledge of machine learning in all its facets (ML, DL, iML, RL, AutoML) to a practical application with a related research question. They have thus strengthened their skills in both knowledge transfer and implementation. Furthermore, they have acquired all the necessary skills (presentations, reports, proper scientific work) to prepare a Master's thesis in the field of ML.

**Contents**

After an introduction to the specific question (which is determined individually for each student or group) about the scientific research, the practical objectives are defined and the first practical approaches for given benchmarks are implemented and systematically evaluated. At the end, a final presentation is given and a corresponding report with all approaches and results is submitted.

**Special features**

Participation limit: 20.

**Literature**

Automated Machine Learning: Methods, Systems, Challenges by Frank Hutter, Lars Kotthoff, Joaquin Vanschoren

**Applicability in other degree programs**

# Modul: Recursive State Estimation for dynamic Systems

**Module:** Recursive State Estimation for dynamic Systems

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| SoSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Oral exam | 4 | 15 min | graded |
| SL | Academic achievement | 1 | Exercise | ungraded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | PD Dr.-Ing. Hamza Alkhatib |
| **Lecturer** | PD Dr.-Ing. Hamza Alkhatib |
| **Institute** | Geodätisches Institut Hannover |
| **Faculty** | Fakultät für Bauingenieurwesen und Geodäsie |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Recursive State Estimation for dynamic Systems - Vorlesung | 2 | Oral exam |
| Recursive State Estimation for dynamic Systems - Hörsaalübung | 2 | Academic achievement |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Basic engineering mathematics and applied statistics, basic Matlab programming skills |

**Qualification goals**

To present mathematical approaches to the best possible way of estimating the state of a general nonlinear dynamic system recursively, and to provide the implementation towards discrete-time systems in software based on typical applications in the field of object tracking and robotics After successful completion of this module, the students are able to give an overview of typical filtering approaches in a general discrete-time system; explain the principles of different Gaussian, Bayesian and particle filters; apply different filter approaches to data sets in the field of object tracking and robotic; analyse application problems with regard to adequate system and observation models; correctly interpret predicted and filtered states obtained from the aforementioned filters.

**Contents**

optimal recursive state estimation in discrete-time systems (Kalman filter)
- Gaussian filters (extended Kalman filter, unscented Kalman filter and ensamble Kalman Filter) for nonlinear systems
- introduction into Bayesian inference
- the Bayes filter
- introduction into Monte Carlo techniques
- the particle filter
- applications to a tracking problems (e.g., regarding the motion of robots)

**Special features**

none

**Literature**

Hastie, Trevor J.; Friedman, Jerome H.; Tibshirani, Robert (2017): The elements of statistical learning. Data mining, inference, and prediction. 2. ed.. New York: Springer. Brunton, Steven L.; Kutz, Jose Nathan (2019): Data-driven science and engineering. Machine learning, dynamical systems, and control. Cambridge, United Kingdom, New York, NY: Cambridge University Press.

**Applicability in other degree programs**

Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017;

# Modul: Scientific Machine learning

**Module:** Scientific Machine learning

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 2 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Oral exam | 1 | 20 min | graded |
| SL | Academic achievement | 1 | Semester Project | ungraded |

| | |
|---|---|
| **Workload** | 60 h |
| **Attendance study period** | 28 h |
| **Self-study time** | 32 h |
| **Module coordinator** | Prof. Xiaoying Zhuang |
| **Lecturer** | Prof. Xiaoying Zhuang |
| **Institute** | Hannoversches Zentrum für Optische Technologien |
| **Faculty** | Fakultät für Maschinenbau |

| Structure of the module | | |
|---|---|---|
| **Title and form of the course** | **Semester hours** | **Ep / Aa** |
| Scientific Machine learning - Vorlesung | 2 | Oral exam<br>Academic achievement |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | Probability, Matrix theory (linear algebra) |

**Qualification goals**

Nowadays machine learning (ML) has revolutionized numerous scientific fields, as data-mining and learning has became a state-of-the-art technique. The aggravating complexity as well as the demands of data quality and quantity generated in contemporary scientific problems have drivens the need of employing ML techniques in scientific modeling. These machine learning-assisted techniques is able to accelerate, automate, and even improve the traditional workflows. Emerging at the forefront of this trend is a novel field called scientific machine learning (SciML). The central goal of SciML is to introduce existing scientific understanding into ML, producing powerful and generalized ML-informed to the prior knowledge. A plethora of approaches have been proposed for embedding scientific principles into ML and SciML has been successfully applied in a various research fields and is now expected to address some of the biggest challenges in science. Understanding the fundamentals and mathematics toward different machine learning tasks using the classical and state-of-the-art SciML methods for various applications are the goals of this course. The knowledge obtained from this course consitute an important qualification for students in physics, material science, chemistry and mechanical engineering. The course is of high relevance and importance in many applications, including materials processing, optical technology, machinary, biotechnology engineering, civil engineering, electric engineering, to name but a few. In these areas, SciML will assist scientists and engineers to build more generalized and robust machine learning predictive models from complex real-world raw data, to utilize various hetergeneous data sources, different data types and even discover new principles from all those data. In this course, the students will be introduced to the fundamental concepts, theories, computations as well as applications of SciML, starting from fundamental introduction of machine learning algorithms oriented to different learning tasks including regressions and classifications. The understanding of basic machine learning technique will be then applied to scientific computing where physical descriptions are made to be awared by the neural network. Variety of demonstrations of SciML in different engineering fields will be expounded for students from different backgrounds. Furthermore, the common computing platform that can be used for SciML and their limiations will also be shown and discussed. At the end of this course, students should be familiar with the classical machine learning models and able to setup their own models from open-source libraries. Furthermore, the students are expected to be able to utilize the prior knowledge in their own research filed in building the SciML models and understand the validity and limits of their results. They shall be experienced on understanding and discussing the state of the art literature in the scientific machine learning and on the defense of their findings by an oral presentation of a selected problem.

# Modul: Scientific Machine learning

**Module:** Scientific Machine learning

| Contents |
| --- |
| Part I Basics of Artificial Intelligence and Machine Learning<br>1. Introduciton 1: Review of the history of artificial intelligence and machine learning and state of the art applications<br>2. Introduction 2: Basic concepts and limitations of AI<br>3. Setup of the neural network architecture (including basic concepts and ingredients of a neural network, training process)<br>4. Commonly used types of network architecture e.g. ANN, CNN, RNN, including introduction to some open source tools<br>5. Regression, classification, optimization and parameters<br>Part II Applications to Sciences and Engineering Problems<br>6. Machine learning for image processing and identification<br>7. Physics informed machine learning: collocation approach<br>8. Deep energy method: energy and potential based approach (nonlinear materials, transfer learning)<br>9. Machine learning for waveguide<br>10. Machine learning for materials design and engineering<br>11. Machine learning for classification and mining<br>Students are also guided by practical exercises in the computer lab, assigning also specific projects to be solved through the implementation of codes. The codes will be written in Python language based on scikit-learn and pytorch libraries. A introduction and examples to using scientific machine learning for solving partial differential equations will be demonstrated. |
| **Special features** |
| Examination: Semester project and oral presentation |
| **Literature** |
| none |
| **Applicability in other degree programs** |
| Optische Technologien M.Sc.; |

# Modul: Sensors and Nanosensors - Measuring non-electrical quantities

**Module:** Sensors and Nanosensors - Measuring non-electrical quantities

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam / Oral exam | 5 | 60 min/ 20 min | graded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Prof. Dr.-Ing. Stefan Zimmermann |
| **Lecturer** | Prof. Dr.-Ing. Stefan Zimmermann |
| **Institute** | Institut für Grundlagen der Elektrotechnik und Messtechnik |
| **Faculty** | Fakultät für Elektrotechnik und Informatik |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Sensors and Nanosensors - Measuring non-electrical quantities - Vorlesung | 2 | Written exam / Oral exam |
| Sensors and Nanosensors - Measuring non-electrical quantities - Übung | 2 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| none | A good understanding of physics is helpful |

**Qualification goals**

Students will gain a broad overview of the various sensor principles and measurement methods for measuring non-electrical quantities. In particular, common physical, optical, chemical and biochemical sensors, including semiconductor sensors, and measurement methods as well as nanosensors, which offer completely new possibilities in sensor technology, will be discussed. The sensor principles will be explained in detail using the underlying fundamental physical and chemical effects. The objective is to gain scientific understanding of the sensor principles including limitations and cross-sensitivities. After completing the module, students will be able to explain the underlying measuring principle of various sensors in detail and evaluate the measuring principles (general advantages and disadvantages, selectivity, sensitivity, areas of application, random and systematic measuring errors, etc.) with respect to specific applications. Furthermore, the students will be able to select between different measuring principles and sensors for a specific measuring task, evaluate the sensor signals, and design and calculate basic measuring circuits.

**Contents**

Physical and chemical effects of sensor principles including typical applications of various sensors (physical, semiconducting, optical, chemical and biochemical) and measurement methods for measuring non-electrical quantities: Temperature, geometric quantities (distance, position, angle, level, …), mechanical quantities (force, pressure, mass, torque, …), kinematic quantities (turning rate, rpm, acceleration, velocity, …), fluidic quantities (volume flow rate, mass flow rate), magnetic field, optical and acoustic quantities, chemical and biochemical quantities (humidity, pH, concentration, …).

**Special features**

none

**Literature**

A corresponding literature list will be provided at the beginning of the lecture

**Applicability in other degree programs**

# Modul: Sustainable Combustion

**Module:** Sustainable Combustion

| Type of module | | | | Area of competence | | | |
|---|---|---|---|---|---|---|---|
| Wahl | | | | AI-Driven Mechatronics and Robotics (Englischsprachige Variante) | | | |
| **Offer in** | **Duration** | **Language** | **ECTS** | **Recommended from** | | | |
| WiSe | 1 Semester | Englisch | 5 | **Admission WiSe:** | 1/2. Semester | **Admission SoSe:** | 1/2. Semester |

| Examination performance (Ep) / Academic achievement (Aa) | | | | |
|---|---|---|---|---|
| **Kind** | | **ECTS** | **Duration / Scope** | **Grading scale** |
| PL | Written exam / Oral exam | 4 | 90 min/20 min | graded |
| SL | Academic achievement | 1 | Laboratory | ungraded |

| | |
|---|---|
| **Workload** | 150 h |
| **Attendance study period** | 56 h |
| **Self-study time** | 94 h |
| **Module coordinator** | Prof. Dr. Friedrich Dinkelacker |
| **Lecturer** | Prof. Dr. Friedrich Dinkelacker |
| **Institute** | Institut für Technische Verbrennung |
| **Faculty** | Fakultät für Maschinenbau |

**Structure of the module**

| Title and form of the course | Semester hours | Ep / Aa |
|---|---|---|
| Sustainable Combustion - Vorlesung | 2 | Written exam / Oral exam |
| Sustainable Combustion - Hörsaalübung | 1 | Academic achievement |
| Sustainable Combustion - Labor | 1 | |

| Requirements for participation: | Recommended for participation: |
|---|---|
| keine | Thermodynamics I |

**Qualification goals**

The modul teaches the fundamentals of combustion together with its implication to the questions of environmental impact and the challenges in this respect.

After successfully completing the course, students will be able to
- know about the challenges of combustion with respect to environmental topics,
- differentiate between types of combustion and describe different types in detail,
- make up the balance for combustion processes,
- explain typical examples of applications for various types of combustion,
- identify potentials for reducing emissions and to evaluate them,
- be able to discuss the potentials and challenges of sustainable fuels with respect to the environmental impact for different application fields.

**Contents**

- Importance and problems of combustion - also for sustainable energy
- Fundamentals, types and spread of flames
- Balance of amount of substance, mass and energy
- Chemical kinetics and ignition processes
- Laminar and turbulent combustion
- Liquid and solid fuels - Sustainable fuels
- Emissions
- Technical applications
- Sustainable combustion approaches

**Special features**

The course contains a laboratory experiment. The content of the lecture is rather similar to the German lecture Nachhaltige Verbrennungstechnik. Only one of them can be selected.

# Modul: Sustainable Combustion

**Module:** Sustainable Combustion

| Literature |
| --- |
| Turns: An Introduction to Combustion: Concepts and Application - Warnatz, Maas, Dibble: Combustion |
| **Applicability in other degree programs** |
| Energietechnik M.Sc.; Maschinenbau B.Sc.; Maschinenbau M.Sc.; Nachhaltige Ingenieurwissenschaft B.Sc.; Nachhaltige Ingenieurwissenschaft M.Sc.; Wirtschaftsingenieur M.Sc.; |