

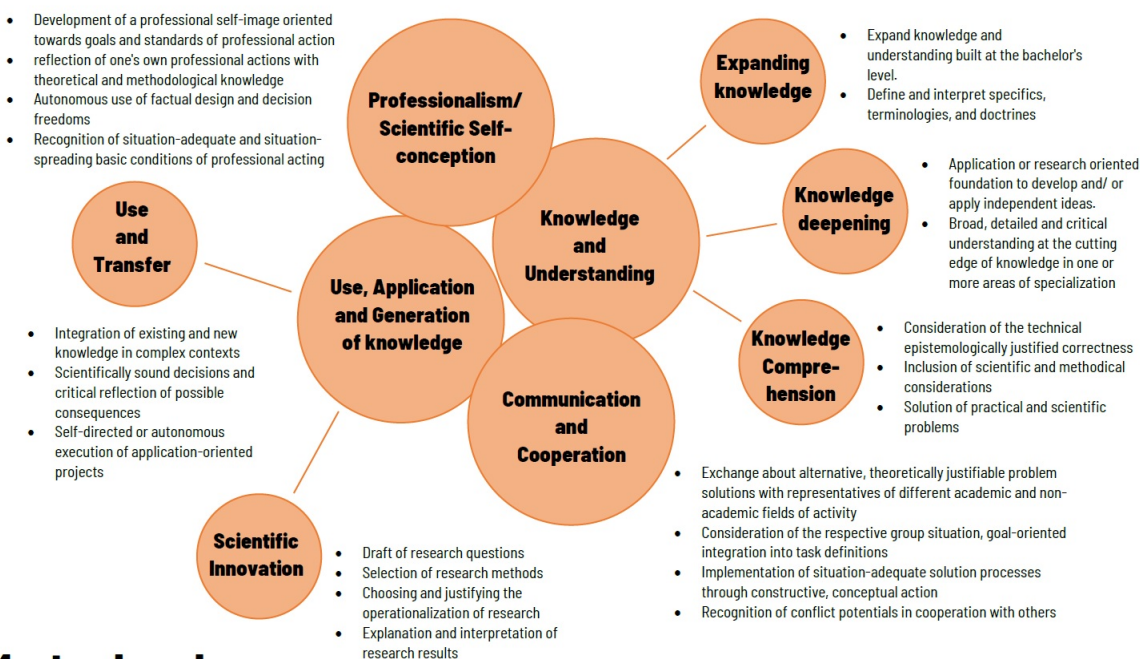
Module Manual Mechatronics (Master)

When designing a study program, in addition to study and examination regulations, a module handbook is created that contains a description of the content of the modules and the competencies to be acquired. Modules can be compulsory or part of the elective range. Each module is concluded with a final module examination and is assigned a certain number of credit points. Study programs and thus also modules are consistently designed from the qualification goals (learning outcomes) to be achieved. In the fields of

- Knowledge and Understanding,
- Use, application and generation of knowledge,
- Scientific self-conception/professionalism and
- Communication and Cooperation

competencies are acquired during the course of study in the respective subject-specific context. Not all competencies or their characteristics are acquired in every module; what is relevant is that at the end of the program students have acquired all competencies.

The basis for this is the Qualifications Framework for German Higher Education Qualifications (Qualifikationsrahmen für Deutsche Hochschulabschlüsse, HQR) and the model legal regulation in accordance with Article 4 Paragraphs 1 - 4 of the State Treaty on Study Accreditation of the Conference of Ministers of Education and Cultural Affairs.



Master-Level

Program Objectives

The integration of as many nations as possible of students with different technical fields of origin requires the positioning as a non-consecutive study program in English. The content of the program should enable students, after successful completion of their studies, to become qualified. After successful completion of their studies, the students should be able to act as qualified interdisciplinary dialogue partners in practice. The professional level should be high in order to be able to face the competition in the university landscape. The intercultural teams of the students in project work enable them to contribute their specialist knowledge and to design interdisciplinary systems, as is required in the disciplines of method review and model building. The level should enable the students to pursue a further scientific path (e.g. doctorate). In the area of social skills, students should have acquired systematic thinking, the ability to think abstractly and the ability to communicate in order to be able to take on leadership tasks, for example.

Content Modules

Master studies

| |
|--|
| Embedded Computing |
| Advanced Mathematics |
| Electrical Drives |
| Power Electronics |
| Engineering Design and Materials |
| Engineering Mechanics |
| Integration of Mechatronic Systems |
| Process Interface Equipment |
| Simulation of Mechatronic Systems |
| Scientific Project |
| Advanced Control Systems |
| Automation |
| Special Module |
| Optional Module |
| Master-Thesis |
| Robotics |
| Systems Analysis and Simulation with LabView |

Module: Embedded Computing

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|----------------------------------|---|
| Course of study: | Mechatronics (Master) |
| Degree: | Master of Engineering (M.Eng.) |
| Module number: | EMM10 |
| Module title: | Embedded Computing |
| Module responsible: | Prof. Dr. rer. nat. Markus Pfeil |
| Typ of module: | Mandatory module |
| Module Content: | <ul style="list-style-type: none"> - Embedded Systems in motor management, ABS, medical devices and its increasing programming needs. - Modeling of embedded systems (Cyber-Physical Systems) - Functions of 32-bit micro controllers (ARM), interface functions, its programming under Linux - Implementation of operating systems on microcontrollers |
| Courses: | Embedded Computing Embedded Computing Lab Embedded Project |
| Teaching and learning forms: | Lecture and Laboratory / practical course and Project Lecture with integrated applications, development and programming of functions for embedded systems, project management (project idea, realization, presentation) |
| Prerequisites for participation: | Bachelor knowledge |
| Applicability of the module: | Electrical Engineering and Embedded Systems |
| Prerequisites allocation ECTS: | PF |
| ECTS credits: | 10 |
| Grading: | benotet |
| Workload: | 10 ECTS Embedded Computing 150 h (60 h Lecture, 90 h Homework) Embedded Computing Lab 60 h (30 h Lecture, 30 h Homework) Embedded Project 90 h (30 Lecture, 60 h Homework) |
| Duration of the module: | two semester |
| Frequency of offering: | Every semester |
| Literature: | B. P. Douglas; "Real-Time UML", Second Edition. Addison Wesley Longman, Inc., 2000. P. Marwedel; "Embedded System Design", Springer Verlag, 2006. D. Abbott; "Linux for Embedded and Real-time Applications", Elsevier Science, 2003 |
| Compulsory attendance: | no |

Competence dimensions

Knowledge and understanding

The graduates have broadened their knowledge in the following fields and are capable of reproducing this knowledge:

- Mechatronic and electrical engineering
- Model and simulate mechatronic systems
- Construct electrical and IT components

Focus:

Knowledge Comprehension

Use, application and generation of knowledge/art

Focus:

Communication and cooperation

With the contents for the module, sustainable work, design and economics will be taught. It will be improved to a level, that it fits to the needs of companies. The intercultural competence of the graduates will be developed by

- international tandem teams
- mixed teams in the labs
- mixed teams for projects and seminars

Scientific / artistic self-image and professionalism

In the course of their study, the graduates have already reached a level of knowledge and understanding that enables them to analyze not only simple but also complex interactions. On this basis, they are capable of independently identifying scientific or practice-related issues in the following fields:

- mechatronic questions
- model and simulate mechatronic systems
- construct electrical and IT components
- present mechatronic projects

Module: Advanced Mathematics

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|----------------------------------|--|
| Course of study: | Mechatronics (Master) |
| Degree: | Master of Engineering (M.Eng.) |
| Module number: | MM01 |
| Module title: | Advanced Mathematics |
| Module responsible: | Prof. Dr. rer. nat. Wolfgang Ertel |
| Typ of module: | Mandatory module |
| Module Content: | <p>1 Linear Algebra (Repetition)</p> <ul style="list-style-type: none"> - Video Lectures (Gilbert Strang) <p>2 Computer Algebra</p> <ul style="list-style-type: none"> - Gnuplot, a professional Plotting Software - Short Introduction to GNU Octave / MATLAB, Python <p>3 Calculus - Selected Topics (Repetition)</p> <ul style="list-style-type: none"> - Sequences and Convergence; - Series; - Continuity - Taylor Series - Differential Calculus in many Variables <p>4 Statistics and Probability (Repetition)</p> <ul style="list-style-type: none"> - Statistical Parameters - Probability Theory - Distributions - Random Numbers - Principal Component Analysis - Estimators <p>5 Numerical Mathematics Fundamentals</p> <ul style="list-style-type: none"> - Arithmetics on the Computer - Numerics of Linear Systems of Equations - Roots of Nonlinear Equations <p>6 Function Approximation</p> <ul style="list-style-type: none"> - Polynomial Interpolation - Spline interpolation - Method of Least Squares and Pseudoinverse - Singular Value Decomposition (SVD) <p>7 Numerical Integration and Solution of Ordinary Differential Equations</p> <ul style="list-style-type: none"> - Numerical Integration - Numerical Solution of Ordinary Differential Equations - Linear Differential Equations with Constant Coefficients |
| Courses: | Advanced Mathematics for Engineers Advanced Mathematics for Engineers - Lab |
| Teaching and learning forms: | Lecture/Practical training |
| Prerequisites for participation: | Undergraduate Mathematics, e.g. Calculus (multidimensional), Linear Algebra, Statistics, Programming |
| Applicability of the module: | Mechatronics Electrical Engineering and Embedded Systems Informatik |
| Prerequisites allocation ECTS: | Portfolio with 80% weight of the written examination (K90) and 20% weight of the laboratory results (P). |
| ECTS credits: | 10 |
| Grading: | benotet |
| Workload: | 30h / 1 ECTS |
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |

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|------------------------|---|
| Literature: | J W. Cheney and D. Kincaid. Numerical mathematics and computing. Thomson Brooks/Cole, 2007. J. Nocedal and S.J. Wright. Numerical optimization. Springer Verlag, 1999. S.M. Ross. Introduction to probability and statistics for engineers and scientists. Academic Press, 2009. G. Strang. Introduction to linear algebra. Wellesley Cambridge Press, 3rd edition, 2003. H. Schwarz: Numerische Mathematik, Teubner Verlag. M. Brill.: Mathematik für Informatiker. Hanser Verlag, 2001. W. Nehrlich: Diskrete Mathematik, Fachbuchverlag Leipzig. |
| Compulsory attendance: | no |

Competence dimensions

Knowledge and understanding

After successfully attending this course the graduates is able to solve mathematical problems arising in typical engineering tasks. Primary focus is on numerically solving on linear problems and on the statistical interpretation of results from measurements. In numerical mathematics, the focus is put on methods for function approximation from data, solution of equations, integration and solution of differential equations. Generation and test of random numbers are essential foundations of simulation and cryptography.

Focus:

Deepening of individual components of knowledge

Use, application and generation of knowledge/art

The graduates have broadened their knowledge in the following fields and are capable of reproducing this knowledge: High level programming languages with built in mathematical functions like Octave or Python will be used for the practical assignments (e.g. programming of algorithms).

Focus:

Use and transfer

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Electrical Drives

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|----------------------------------|---|
| Course of study: | Mechatronics (Master) |
| Degree: | Master of Engineering (M.Eng.) |
| Module number: | MM02 |
| Module title: | Electrical Drives |
| Module responsible: | Prof. Dr.-Ing. László Farkas |
| Typ of module: | Mandatory module |
| Module Content: | <p>Introduction -Fundamental equations; -energies, forces, powers DC machine -mechanics, equivalent circuit, main equations; - types of machines, variable supply voltage; -application in drives, operating range, risks AC machine -Fundamentals of transformer: equations for AC machine; -Electrical machine: equivalence to rotating transformer; -torque, power; -operating range, fundamental understanding Induction machine -mechanics, equivalent circuit; -(rotor) resistance, inductances; -heyland circle, Kloss formula; -operation modes, controlling; -application in drives, risks, construction Synchronous machine -mechanics, equivalent circuit, phasor diagram; -field oriented control, analogon to dc machine Permanent Magnet Synchronous Machine (PMSM) -mechanics, equations, phasordiagram; -effect of reluctance; -mechanical specialities; -rotor design Brushless DC-Motor (BLDC) -application in drives; -advantages/disadvantages in relation to normal synchronous machine Field of application -powertrain in hybrids and e-drives; -application for full drives or auxiliary drives; -costs versus necessity; -comparison of force densities</p> |
| Courses: | Electrical Drives |
| Teaching and learning forms: | Lecture |
| Prerequisites for participation: | Principles of electrical engineering |
| Applicability of the module: | Mechatronics Electrical Engineering and Embedded Systems |
| Prerequisites allocation ECTS: | Written examination, 90 minutes. |
| ECTS credits: | 5 |
| Grading: | benotet |
| Workload: | 30h / 1 ECTS |
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |
| Literature: | <p>J. Pollefliet: Electronic power control - vol.2: Electronic motor control, Academia press K. Hofer; Elektrische Antriebe in Fahrzeugen W. Leonhard: Control of Electrical Drives, Springer 1997 (dt.: Regelung elektrischer Antriebe, Springer 2000) H. Schäfer, Praxis der elektrischen Antriebe für Hybrid- und Elektrofahrzeuge</p> |
| Compulsory attendance: | no |

Competence dimensions

Knowledge and understanding

The lecture gives an overview together with formulas of the most important electrical machines in the application for drives. The graduates are able to describe the function of these most used electrical machines and drives together with the necessary control in the drive and give application-hints and examples.

Focus:

Broadening of prior knowledge

Use, application and generation of knowledge/art

Focus:

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Power Electronics

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|----------------------------------|--|
| Course of study: | Mechatronics (Master) |
| Degree: | Master of Engineering (M.Eng.) |
| Module number: | MM03 |
| Module title: | Power Electronics |
| Module responsible: | Prof. Dr.-Ing. László Farkas |
| Typ of module: | Mandatory module |
| Module Content: | Based on a modern Power Electronics device for electrical drives the main structure and the most important components will be discussed. Especially an introduction to the power semiconductors with their characteristic curves will be given. In the next step the classical circuits are discussed with their main application including the (dis-)advantages: without commutation, commutation by circuit / by network, self commutation. Also an introduction to the possible operation quadrants, their triggering and the harmonics in general is given. Especially the modern vector control (voltage space-vector) will be discussed in detail for the example of the synchronous machine. Finally, a prospect will be given to the most important electrical machines for e-drives with the focus to the used power electronics. |
| Courses: | Power Electronics |
| Teaching and learning forms: | V |
| Prerequisites for participation: | Principles of electrical engineering |
| Applicability of the module: | Mechatronics |
| Prerequisites allocation ECTS: | K90 |
| ECTS credits: | 5 |
| Grading: | benotet |
| Workload: | 30h / 1 ECTS |
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |
| Literature: | N. Mohan, T.M. Undeland, W.P. Robbins: Power Electronics - Converters, Applications and Design; Wiley 2003 W. Leonhard: Control of Electrical Drives ; Springer 1997 (dt.: Regelung elektrischer Antriebe, Springer 2000) K. Heumann: Grundlagen der Leistungselektronik, Teubner 2001 |
| Compulsory attendance: | no |

Competence dimensions

Knowledge and understanding

The students have deepened their existing knowledge in the following areas and are capable of not only reproducing the corresponding contents but also of explaining them. They understand the underlying principles, the whys and wherefores:

- valuation of structure of modern power electronics and the interaction of most important components,
- analyze of the used components,
- comparison of concepts.

Focus:

Deepening of individual components of knowledge

Use, application and generation of knowledge/art

Focus:

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Engineering Design and Materials

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|----------------------------------|---|
| Course of study: | Mechatronics (Master) |
| Degree: | Master of Engineering (M.Eng.) |
| Module number: | MM04 |
| Module title: | Engineering Design and Materials |
| Module responsible: | Prof. Dr.-Ing. Michael Niedermeier |
| Typ of module: | Mandatory module |
| Module Content: | <ul style="list-style-type: none"> – product design: mechatronics – selection of materials: steel, light-metals, plastics, ceramics, composites – smart materials and lightweight structures – corrosion – joining technologies – selected machine elements |
| Courses: | Engineering Design and Materials |
| Teaching and learning forms: | Lecture/Exercise/Term Paper/Presentations |
| Prerequisites for participation: | |
| Applicability of the module: | Mechatronics Electrical Engineering and Embedded Systems Technik-Management & Optimierung |
| Prerequisites allocation ECTS: | Written examination, 90 minutes. |
| ECTS credits: | 6 |
| Grading: | benotet |
| Workload: | 30h / 1 ECTS |
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |
| Literature: | H. Roloff, W. Mattek, Maschinenelemente, Vieweg Verlag Braunschweig, Michael Ashby, Materials Selection in Mechanical Design, Elsevier |
| Compulsory attendance: | no |

Competence dimensions

Knowledge and understanding

Focus:

Use, application and generation of knowledge/art

The most important materials can be selected and used to design a mechatronical product. The graduates are able to calculate and design the mechanical parts of a mechatronical product. To gain a practice related understanding on the subject of corrosion, tribology and surface technology together with user related know how on important types of metals.

Focus:

Use and transfer

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Engineering Mechanics

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|----------------------------------|---|
| Course of study: | Mechatronics (Master) |
| Degree: | Master of Engineering (M.Eng.) |
| Module number: | MM05 |
| Module title: | Engineering Mechanics |
| Module responsible: | Prof. Dr.-Ing. Ralf Stetter |
| Typ of module: | Mandatory module |
| Module Content: | This lecture consolidates highly specialized knowledge of engineering mechanics as basis for theoretical and applied research. Special chapters from the areas statics, kinematics, kinetics, and dynamics are presented in the lecture and are consolidated by means of tutorials in form of team practice. Through this specialized problem solving qualifications for the development of new calculation methods are acquired. The subject matter taught additionally serves as a basis for the application of the finite element method. The students should be able, on the one hand, to calculate the rigidity and stiffness even of complicated components and to analyze even complex mechanisms dynamically, on the other hand also to play an active role in the advancement of the research field "mechanics". |
| Courses: | Engineering Mechanics |
| Teaching and learning forms: | Lecture |
| Prerequisites for participation: | Knowledge of mathematics and basics of engineering mechanics |
| Applicability of the module: | Mechatronics Electrical Engineering and Embedded Systems |
| Prerequisites allocation ECTS: | Written examination, 90 minutes. |
| ECTS credits: | 6 |
| Grading: | benotet |
| Workload: | 180h |
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |
| Literature: | -Dankert&Dankert: Technische Mechanik: Statik, Festigkeitslehre, Kinematik/Kinetik. Vieweg Teubner Verlag; 2013. -Hibbeler: Statics&Dynamics. MACMILLAN. - Gross, D.; Hauger, W.; Schröder, J.; Wall, W.A.; Rajapakse, N.: Engineering Mechanics 1 – Statics; Springer; 2013. - Gross, D.; Hauger, W.; Schröder, J.; Wall, W.A.; Bonet, J.: Engineering Mechanics 2 – Mechanics of Materials; Springer; 2011. - Gross, D.; Ehlers, W.; Wriggers, P.; Schröder, J.; Müller, R.: Statics – Formulas and Problems. Springer; 2017. - Gross, D.; Ehlers, W.; Wriggers, P.; Schröder, J.; Müller, R.: Mechanics of Materials – Formulas and Problems. Springer; 2017. |
| Compulsory attendance: | no |

Competence dimensions

Knowledge and understanding

This lecture consolidates highly specialized knowledge of engineering mechanics as basis for theoretical and applied research. Special chapters from the areas statics, kinematics, kinetics, and dynamics are presented in the lecture and are consolidated by means of tutorials in form of team practice. Through this specialized problem solving qualifications for the development of new calculation methods are acquired. The subject matter taught additionally serves as a basis for the application of the finite element method.

Focus:

Deepening of individual components of knowledge

Use, application and generation of knowledge/art

Focus:

Communication and cooperation

Scientific / artistic self-image and professionalism

After finishing the lecture, the graduates are able, on the one hand, to calculate the rigidity and stiffness even of complicated components and to analyze even complex mechanisms dynamically, on the other hand also to play an active role in the advancement of the research field "mechanics".

Module: Integration of Mechatronic Systems

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|----------------------------------|--|
| Course of study: | Mechatronics (Master) |
| Degree: | Master of Engineering (M.Eng.) |
| Module number: | MM06 |
| Module title: | Integration of Mechatronic Systems |
| Module responsible: | Prof. Dr.-Ing. Raphael Ruf |
| Typ of module: | Mandatory module |
| Module Content: | <p>This module deals with concepts and methods from the area of statistical experimental planning and the modeling of mechatronic systems: Integration of mechatronic systems: A) Theoretical part: Introduction and overview; Structure of mechatronic systems; Description and modeling of mechatronic systems; Sensors; Actuators; Concepts and methods from the field of modeling mechatronic systems B) Practical part: Automation determines our world. In this laboratory, the students can gain hands-on practical experience with actuators, sensors and controls. Depending on the student's background, the complexity of the task can be adapted accordingly. Beginners learn, for example, simple pneumatic circuits, experiment with different sensors and simulate / control small automation solutions. Experienced students can deepen their knowledge in a complex system with a superior Windows interface and seven Siemens S7 controllers. In the so-called Festo-Lab we use various didactic systems for Mechatronic (manufacturer: Festo didactics):</p> <ul style="list-style-type: none"> - Pneumatics (actuators, valves, sensors) - various sensors - Simulation software for electronics, pneumatics and mechatronic - small mechatronic solutions for material handling - the large, interlinked playmobil consisting of seven independent modules and a superior control system - Kuka robot with attached image processing |
| Courses: | Integration of Mechatronic Systems |
| Teaching and learning forms: | Lecture |
| Prerequisites for participation: | Mathematics Basic of control theory |
| Applicability of the module: | Mechatronics |
| Prerequisites allocation ECTS: | Written examination, 90 minutes. |
| ECTS credits: | 5 |
| Grading: | benotet |
| Workload: | 30h / 1 ECTS |
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |
| Literature: | |
| Compulsory attendance: | no |

Competence dimensions

Knowledge and understanding

The graduates will be able to explain the essential elements of mechatronics.

Focus:

Knowledge Comprehension

Use, application and generation of knowledge/art

Graduates can design, build and bring into service a simple mechatronic system. At the end of the semester, each graduate can be proficient at least with MecLab and fluid sim simulation.

Focus:

Use and transfer

Communication and cooperation

Depending on the background of the student we will discuss at the beginning of the semester which stations are to be run individually. Each student should work independently on his / her stations to gain practical experience. Through the modular, individually customizable concept, each student can solve his / her tasks or be supported accordingly. At the end of the semester, each student should be proficient at least with MecLab and fluid sim simulation.

Scientific / artistic self-image and professionalism

Module: Process Interface Equipment

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|----------------------------------|---|
| Course of study: | Mechatronics (Master) |
| Degree: | Master of Engineering (M.Eng.) |
| Module number: | MM07 |
| Module title: | Process Interface Equipment |
| Module responsible: | Prof. Dr.-Ing. Raphael Ruf |
| Typ of module: | Mandatory module |
| Module Content: | <ul style="list-style-type: none"> - Introduction and overview of industrial automation systems - System interfaces to field elements (binary, digital, analog and signal adaption) - Sensor principles and example devices - Actuators - Operational amplifiers - ADC- and DAC converters - Linearisation <p>Lab tests:</p> <ul style="list-style-type: none"> - Intelligent contactor turning on / off Ohmic inductive load (Identification of R, L, and C of load, non-linear behaviour of L, over Voltage protection) - Temperature measurement by TC, RTD and and pyroelectric sensor (Identify type of sensor, Parameter Identification of dynamic model Pt1-Tt, Limits of linear behaviour of different type of measurement amplifiers) - Characteristics of intelligent position sensors (Limit switches, inductive sensor, capacitive sensor, 2/3 wire interface, switching distance) - Position control of pneumatic platform (kinematics of platform, acceleration sensor, pwm signal smoothing, behaviour of pneumatic cylinders and valves) - AC drive unit coupled to a PLC (signal adaptation to analogue input:: Resistor, Tacho generator, Current (Hall) sensor, loop powered current level detector, proximity switches for detection of rotation) |
| Courses: | Process Interface Equipment Laboratory on Process Interface Equipment |
| Teaching and learning forms: | Lecture + Practical training |
| Prerequisites for participation: | <ul style="list-style-type: none"> -Basic mathematical knowledge -Basic physical knowledge -Electrical engineering -Electronics -Measurement technology Participation of the lecture is necessary for the attending the lab. |
| Applicability of the module: | Mechatronics Electrical Engineering and Embedded Systems |
| Prerequisites allocation ECTS: | Written examination, 90 minutes. |
| ECTS credits: | 8 |
| Grading: | benotet |
| Workload: | 30h / 1 ECTS |
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |
| Literature: | Gussow, M.: Basic Electricity Schrüfer, E.: Elektrische Messtechnik Alciatore, D.: Introduction to Mechatronics Webster, J.: The Measurement, Instrumentation and Sensors Handbook Fischer, R.: Elektrotechnik für Maschinenbauer |
| Compulsory attendance: | no |

Competence dimensions

Knowledge and understanding

Graduates are able to name components of an automation system which are closely related to the respective technical process. Focus is on sensors as well as actuators and their interfacing to the automation system.

Graduates are capable of designing and simulating measurement amplifiers using operational amplifiers.

Graduates have a solid knowledge of the most common wiring techniques found in automation systems.

Focus:

Deepening of individual components of knowledge

Use, application and generation of knowledge/art

Graduates are capable of applying the knowledge they have acquired in the following fields:

- Wiring of up-to-date process components to the respective automation computer.
- Theoretical and practical experience concerning intelligent sensors and actuators of industrial process interface equipment.
- Designing of measurement amplifiers and signal adaption units.

Focus:

Use and transfer

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Simulation of Mechatronic Systems

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|----------------------------------|---|
| Course of study: | Mechatronics (Master) |
| Degree: | Master of Engineering (M.Eng.) |
| Module number: | MM08 |
| Module title: | Simulation of Mechatronic Systems |
| Module responsible: | Prof. Dr.-Ing. Konrad Wöllhaf |
| Typ of module: | Mandatory module |
| Module Content: | <ul style="list-style-type: none">• Introduction• Model Forms• Simulation Algorithms• Simulation in Practice• Applications• Component Models• HIL / Co-Simulation |
| Courses: | Simulation of Mechatronic Systems |
| Teaching and learning forms: | Lecture |
| Prerequisites for participation: | Mathematics Basic of control theory |
| Applicability of the module: | Mechatronics Informatik |
| Prerequisites allocation ECTS: | Written examination, 90 minutes. |
| ECTS credits: | 5 |
| Grading: | benotet |
| Workload: | 30h / 1 ECTS |
| Duration of the module: | one semester |
| Frequency of offering: | Winter semester only |

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| Literature: | <p>Angermann, A.; Beuschel, M.; Rau, M. & Wohlfarth, U. MATLAB – Simulink – Stateflow De Gruyter Oldenbourg, 2021</p> <p>Angermann, A.; Beuschel, M.; Rau, M. & Wohlfarth, U. (2002), Matlab-Simulink-Stateflow, Oldenbourg.</p> <p>Atkinson, L.V. & Harley, P.J. (1983), An Introduction to Numerical Methods with Pascal, Addison-Wesley.</p> <p>Cellier, F.E. (1992), Continuous system modeling, Springer.</p> <p>Karnopp, D.C.; Margolis, D.L. & Rosenbert, R.C. (2000), System Dynamics, John Wiley & Sons, New York.</p> <p>Lyshevski, S.E. (1999), Electromechanical Systems, Electric Machines, and Applied Mechatronics, CRC Press.</p> <p>Mathews, J.H. (1992), Numerical Methods, Prentice-Hall.</p> <p>Tiller, M. (2001), Introduction to Physical Modeling with Modelica, Kluwer Academic Publishers Group.</p> <p>Eine Sammlung von links auf der Homepage von Prof. Wöllhaf: www.hs-weingarten.de/~woellhaf Links zum Thema Simulation</p> <ul style="list-style-type: none"> - MATLAB Simulink Programming Free Tutorials - A Partial List of On-Line Matlab Tutorials and Matlab Books - Online Hilfe zu Matlab ... - Eine freundlichen Einführung in Matlab ... - MATLAB/SIMULINK Resources... - An Introduction to Matlab ... - Matlab Quick Reference... - David Gilliam, Matlab (engl.)... - Matlab, Free Clones... - A Collection of Modelling and Simulation Resources on the Internet... - ODE++ , a class library for ordinary differential equations ... - Numerische Methoden für Differentialgleichungen... - A Ressource for 3D Programmers |
| Compulsory attendance: | no |

Competence dimensions

Knowledge and understanding

Absolventinnen und Absolventen haben ihr Wissen auf folgenden Gebieten erweitert und können dieses Wissen auch wiedergeben:

- die Herausforderungen in einem Simulationsprojekt
- verschiedene Simulationsmethoden
- die Herausforderungen bei HIL-Simulationen

Focus:

Broadening of prior knowledge

Use, application and generation of knowledge/art

Absolventinnen und Absolventen können das Wissen aus folgenden Themenbereichen praktisch anwenden:

- ein Simulationsprojekt organisieren
- geeignete Simulationsmethoden und Algorithmen auswählen und verwenden
- dynamische Systeme modellieren und diese in expliziten Differentialgleichungen erster Ordnung umwandeln
- Matlab zur Lösung alltäglicher Rechenaufgaben aus der Ingenieurpraxis einsetzen
- ODE-Systeme mit Matlab und Simulink umsetzen und simulieren.

The students should be able, on the one hand, to calculate the rigidity and stiffness even of complicated components and to analyze even complex mechanisms dynamically, on the other hand also to play an active role in the advancement of the research field.

Focus:

Use and transfer

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Scientific Project

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|----------------------------------|--|
| Course of study: | Mechatronics (Master) |
| Degree: | Master of Engineering (M.Eng.) |
| Module number: | MM09 |
| Module title: | Scientific Project |
| Module responsible: | Prof. Dr.-Ing. Raphael Ruf |
| Typ of module: | Mandatory module |
| Module Content: | <p>Project of relevance for Mechatronics to be performed at the RWU.</p> <ul style="list-style-type: none"> - Providing the essential tools necessary to understand different cultures - Training participants' usage of the given tools in various cross cultural scenarios and teams - Finding a common understanding of what a team comprises of, which is shared by all participants - Being aware of communication und language problems within the participants - Clarifying the goals and rules of the project teams for effective co-operation - Finding constructive and neutral ways of dealing with conflict - Understanding functions, targets, roles and expectations of each team member - Integrating a permanent intercultural learning process for the future |
| Courses: | <p>Working in international scientific project teams seminar</p> <p>Scientific project</p> |
| Teaching and learning forms: | Project |
| Prerequisites for participation: | |
| Applicability of the module: | Mechatronics |
| Prerequisites allocation ECTS: | seminar paper + presentation |
| ECTS credits: | 6 |
| Grading: | graded |
| Workload: | 30h per 1 ECTS |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | Depends on the chosen project. |
| Compulsory attendance: | no |

Competence dimensions

Knowledge and understanding

Focus:

Use, application and generation of knowledge/art

In the course of their study, the graduates have already reached a level of knowledge and understanding that enables them to analyze not only simple but also complex interactions. On this basis, they are capable of independently identifying scientific or practice-related issues. They can also develop solutions to problems for the following complex issues and thus make a contribution to the further development of science/society/practice: Independent working on the field of mechatronics.

Focus:

Scientific innovation

Communication and cooperation

The graduates are capable of communicating effectively. By attending the module, they have improved their communicative skills in the following fields (technical/general/foreign language): To develop a process of learning that encourages intercultural understanding and tolerance amongst the participants. To effectively work in teams by enhancing each team member's contribution in successfully completing a scientific project.

Scientific / artistic self-image and professionalism

Module: Advanced Control Systems

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|----------------------------------|--|
| Course of study: | Mechatronics (Master) |
| Degree: | Master of Engineering (M.Eng.) |
| Module number: | MM10 |
| Module title: | Advanced Control Systems |
| Module responsible: | Prof. Dr.-Ing. Lothar Berger |
| Typ of module: | Mandatory module |
| Module Content: | Attendees are first given an introduction to analysis and modeling of dynamic systems - electrical, mechanical, and thermal. Then, design and optimization of single and multiple stage digital PID control is presented, as well as single-input and multi-input state control - without and with observer, optimal control, and model-predictive control. Finally, adaptive control methods are illustrated; based upon recursive parameter estimation, and neural nets. Within the complementary lab, attendees are educated to choose and implement suitable digital control methods for given dynamic systems - like mixer tank setup and balanced beam setup - utilizing computer-based tools like MATLAB/Simulink; as C programmed algorithms. |
| Courses: | Digital Control Digital Control Lab |
| Teaching and learning forms: | Lecture; Lab - or - E-Learning: Lessons, Exercises; Homework: Practical work |
| Prerequisites for participation: | Advanced Mathematics |
| Applicability of the module: | Simulation of Mechatronic Systems, Integration of Mechatronic Systems, Robotics, Embedded Control, Scientific Project, Master Thesis |
| Prerequisites allocation ECTS: | K60: Written examination; 60 minutes |
| ECTS credits: | 5 |
| Grading: | benotet |
| Workload: | Presence: 60h, Self-study: 90h - or - Online: 36h, Self-study: 90h, Homework: 24h |
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |
| Literature: | Script - or - lessons, exercises, and sample solutions; and complementary: Burns, R.S., Advanced Control Engineering, Butterworth-Heinemann Macia, N. F., Thaler, G. J.: Modeling and Control of Dynamic Systems, Cengage Learning Moudgalya, K. M.: Digital Control, Wiley Press, W. H., Teukolsky, S. A., Numerical Recipes in C, Cambridge |
| Compulsory attendance: | no |

Competence dimensions

Knowledge and understanding

Attendees learned about models of dynamic systems - electrical, mechanical, and thermal - and both classical control methods, like digital PID control, and advanced control methods, like state control without/with observer, model-predictive control, and adaptive control.

Focus:

Deepening of individual components of knowledge

Use, application and generation of knowledge/art

Attendees learned to characterize, model, and simulate dynamic systems - electrical, mechanical, and thermal - and choose and implement suitable digital control methods, from both established methods, like digital PID control, and advanced methods, like state control without/with observer, optimal control, model-predictive control, and adaptive control. Attendees learned to assess these digital control methods, regarding effort, safety, and cost-effectiveness; and how to implement these, utilizing computer-based tools like MATLAB/Simulink; as C programmed algorithms. Through the complementary lab, attendees learned to choose and implement suitable digital control methods for given dynamical systems; like mixer tank setup and balanced beam setup.

Focus:

Scientific innovation

Communication and cooperation

Attendees learned about presenting and applying advanced digital control methods as a systems science; aimed at interdisciplinary projects; operated within a team of scientists, engineers, designers, and economists.

Scientific / artistic self-image and professionalism

Attendees learned about economical and ecological considerations in choosing, implementing, and optimizing advanced digital control methods for industrial processes.

Module: Automation

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|----------------------------------|---|
| Course of study: | Mechatronics (Master) |
| Degree: | Master of Engineering (M.Eng.) |
| Module number: | MM11 |
| Module title: | Automation |
| Module responsible: | Prof. Dr.-Ing. Raphael Ruf |
| Typ of module: | Mandatory module |
| Module Content: | <ul style="list-style-type: none"> - Fields of automation - Microcontroller characteristics - ARM Cortex M4 architecture by example of STM32 devices - Basic programming of STM32 MCUs - Software patterns for programming embedded systems |
| Courses: | Automation |
| Teaching and learning forms: | Lecture with programming exercises. Every participant receives his own evaluation board and extension board for the duration of the lecture. |
| Prerequisites for participation: | Knowledge in basic electrical engineering |
| Applicability of the module: | |
| Prerequisites allocation ECTS: | Klausur 90 Minuten |
| ECTS credits: | 5 |
| Grading: | graded |
| Workload: | 30h per 1 ECTS |
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |
| Literature: | Noviello, C.: Mastering STM32 Mazidi, M.: STM32 Arm Programming for Embedded Systems Amos, B.: Hands-on RTOS with Microcontrollers Yiu, J.: The Definite Guide to Cortex M3 and M4 Processors Gannsele, J.: The Art of Designing Embedded Systems Pont, M.: Patterns for Time-Triggered Embedded Systems Prinz, P.: C in a Nutshell |
| Compulsory attendance: | no |

Competence dimensions

Knowledge and understanding

Graduates can give an overview over the different fields of automation and are able to judge, which automation computer is suitable respectively. They have knowledge about the most important microcontroller characteristics and a solid up-to-date market overview.

Graduates have a solid understanding of the ARM Cortex M4 architecture and further microcontroller peripheral features using the example of STM microcontrollers.

Graduates know about fundamental software patterns used in product automation.

Focus:

Broadening of prior knowledge

Use, application and generation of knowledge/art

Due to up-to-date market overview obtained from attending the module, graduates can choose the most appropriate microcontroller for their actual task at hand. This serves economic as well as ecological (reduced energy consumption and or battery operation) purposes.

With the software patterns learned in this module, graduates may lay the successful foundation of developing electronic embedded products. Thanks to using proven patterns, chances of entering a dead-end in the developing cycle are reduced to a minimum.

Focus:

Use and transfer

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Special Module

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|----------------------------------|--------------------------------|
| Course of study: | Mechatronics (Master) |
| Degree: | Master of Engineering (M.Eng.) |
| Module number: | MM13 |
| Module title: | Special Module |
| Module responsible: | Prof. Dr.-Ing. Raphael Ruf |
| Typ of module: | Compulsory elective module |
| Module Content: | |
| Courses: | §29 SPO Tab. 2 |
| Teaching and learning forms: | |
| Prerequisites for participation: | |
| Applicability of the module: | |
| Prerequisites allocation ECTS: | |
| ECTS credits: | 8 |
| Grading: | |
| Workload: | |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | |
| Compulsory attendance: | no |

Competence dimensions

Knowledge and understanding

Focus:

Use, application and generation of knowledge/art

Focus:

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Optional Module

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|----------------------------------|--------------------------------|
| Course of study: | Mechatronics (Master) |
| Degree: | Master of Engineering (M.Eng.) |
| Module number: | MM14 |
| Module title: | Optional Module |
| Module responsible: | Prof. Dr.-Ing. Raphael Ruf |
| Typ of module: | Elective module |
| Module Content: | |
| Courses: | §29 SPO Tab. 3 |
| Teaching and learning forms: | |
| Prerequisites for participation: | |
| Applicability of the module: | |
| Prerequisites allocation ECTS: | |
| ECTS credits: | |
| Grading: | |
| Workload: | |
| Duration of the module: | one semester |
| Frequency of offering: | |
| Literature: | |
| Compulsory attendance: | no |

Competence dimensions

Knowledge and understanding

Focus:

Use, application and generation of knowledge/art

Focus:

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Master-Thesis

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|----------------------------------|---|
| Course of study: | Mechatronics (Master) |
| Degree: | Master of Engineering (M.Eng.) |
| Module number: | MM15 |
| Module title: | Master-Thesis |
| Module responsible: | Prof. Dr.-Ing. Raphael Ruf |
| Typ of module: | Mandatory module |
| Module Content: | The Master thesis is to be written in English language. If the thesis work is performed at one of the partner universities, tutoring and marking are performed by one professor from RWU and one professor from the partner university. After completion, the results of the Master Thesis are to be presented in a public presentation at the RWU. |
| Courses: | |
| Teaching and learning forms: | Project |
| Prerequisites for participation: | In order to be entitled to begin the Master thesis, candidates need to have gained at least 55 ECTS from the modules of semesters MM1 and MM2. |
| Applicability of the module: | |
| Prerequisites allocation ECTS: | Master-Thesis and colloquium |
| ECTS credits: | 25 |
| Grading: | graded |
| Workload: | 30h per 1 ECTS |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | |
| Compulsory attendance: | no |

Competence dimensions

Knowledge and understanding

Focus:

Use, application and generation of knowledge/art

Focus:

Communication and cooperation

Scientific / artistic self-image and professionalism

The Master-Thesis is an accredited examination which shall prove the candidates ability to solve problems and work on a topic from the subject-matter of his major field of study within a specified period of time using adequate methods.

Module: Robotics

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|----------------------------------|---|
| Course of study: | Mechatronics (Master) |
| Degree: | Master of Engineering (M.Eng.) |
| Module number: | MM16 |
| Module title: | Robotics |
| Module responsible: | Prof. Dr.-Ing. Konrad Wöllhaf |
| Typ of module: | Mandatory module |
| Module Content: | <p>The module Robotics will give interested students an introduction to the state of the art in robotics. This includes mobile systems as well as manipulators for indoor and outdoor use.</p> <p>Manipulators:</p> <ul style="list-style-type: none"> • History, Types of Robots, Applications, Social Impact • Kinematic: Homogeneous Transformation, Euler-Angles, Quaternions, DH-Parameter, Forward-Backward Kinematic • Robot-Movements: Trajectories, Collision Detection • Dynamics: Principle-Virtual Work, Iterative Newton-Euler, Luh-Walker-Paul • Position Control • Programming: Languages, Online/Offline, Control-Panel <p>Mobile Robotics:</p> <p>In this lecture the basics for the definition and handling of mobile robotics will be explained. This includes AUVs, UUVs and UGVs with a focus on UGVs. Beside real world examples the general technologies for the development of mobile systems will be introduced and explained. Therefore the following topics are handled during the lecture:</p> <ul style="list-style-type: none"> • description of platforms of mobile robots (kinematic and dynamic models) • possible sensors for mobile systems • communication for mobile systems (inter robot communication, local on board communication and communication with the control station) • self localization • automatic generation of maps based on sensor data • algorithms for collision avoidance • algorithms for path planning |
| Courses: | Robotics Lab on Robotics |
| Teaching and learning forms: | Lecture / practical training (laboratory) |
| Prerequisites for participation: | MOBILE ROBOTICS: - knowledge about geometry and matrix operations - basics in physics - control theory basics Robotics Lab: Basics in programming, robotics lecture or adequate previous knowledge. |
| Applicability of the module: | Mechatronics Electrical Engineering and Embedded Systems Informatik |
| Prerequisites allocation ECTS: | Written examination, 90 minutes |
| ECTS credits: | 8 |
| Grading: | benotet |
| Workload: | 30h / 1 ECTS |
| Duration of the module: | one semester |
| Frequency of offering: | Summer semester only |

| | |
|------------------------|---|
| Literature: | <p>MANIPULATORS: - R. Isermann, Mechatronic Systems, Springer 1999 - Schilling, Fundamentals of Robotics, Prentice Hall - Craig, Robotics, Addison Wesley</p> <p>MOBILE ROBOTICS: - Howie Choset, Kevin M. Lynch., Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia E. Kavraki, Sebastian Thrun; Principles of Robot Motion – Theory, Algorithms, and Implementation; MIT Press; 2005 - Sebastian Thrun, Wolfram Burgard, Dieter Fox; Probabilistic Robotics; MIT Press; 2006 - Saeed B. Niku; Introduction to Robotics – Analysis, Systems, Applications; Prentice Hall; 2001</p> <p>Weber, W. Industrieroboter Hanser-Verlag, 2019</p> <p>Behrens, R. Biomechanische Grenzwerte für die sichere Mensch-Roboter-Kollaboration Springer Vieweg, 2018</p> <p>Hesse, S., Greifer-Praxis: Greifer in der Handhabungstechnik Vogel, 1991 DIN EN ISO 10218-2 Industrieroboter - Sicherheitsanforderungen - Teil 2: Robotersysteme und Integration (ISO 10218-2:2011) Beuth Verlag, Berlin, 2012</p> <p>Hesse, S. & Malisa, V. (Eds.) Taschenbuch Robotik - Montage - Handhabung Carl Hanser Verlag GmbH & Co. KG, 2016</p> <p>Buxbaum, H.-J. (Ed.) Mensch-Roboter-Kollaboration Springer-Verlag, 2020</p> |
| Compulsory attendance: | no |

Competence dimensions

Knowledge and understanding

Absolventinnen und Absolventen haben ihr Wissen auf folgenden Gebieten erweitert und können dieses Wissen auch wiedergeben:

- die Einsatzgebiete
- Herausforderungen beim Einsatz von Robotern
- Verschiedene Möglichkeiten der Bahnplanung
- Aufbau von Robotersystemen
- Wie ein Roboter dynamisch simuliert werden kann
- Kuka-Roboter in unterschiedlichen Arten bewegen
- Koordinatensysteme einrichten
- Kuka-Roboter programmieren
- Simulation einer Roboterzelle mit Kuka-SimPro
- Automatisierungsaufgaben mit Hilfe von Industrierobotern lösen
- Einen einfachen mobilen Roboter programmieren

Focus:

Broadening of prior knowledge

Use, application and generation of knowledge/art

Absolventinnen und Absolventen können das Wissen aus folgenden Themenbereichen praktisch anwenden:

- Das inverse Problem für 6-achs-Roboter lösen.
- Mit homogenen Transformationsmatrizen 3D Systeme beschreiben.
- Einfache Automatisierungsaufgaben mit Hilfe eines Roboters lösen.

Focus:

Use and transfer

Communication and cooperation

Scientific / artistic self-image and professionalism

Module: Systems Analysis and Simulation with LabView

| | |
|----------------------------------|---|
| Course of study: | Mechatronics (Master) |
| Degree: | Master of Engineering (M.Eng.) |
| Module number: | MM20 |
| Module title: | Systems Analysis and Simulation with LabView |
| Module responsible: | Prof. Dr.-Ing. Raphael Ruf |
| Typ of module: | Elective module |
| Module Content: | <p>LabVIEW is a data driven oriented programming language for measurement acquirement and processing including the visualisation of measuring devices.</p> <p>The course concentrates on basics of LabVIEW and its applications concerning data acquirement and communications by USB (NI DAQ 6251), RIO-Systems with FPGA, CAN-Bus and Ethernet (Internet communication). The actual version is LabVIEW 2012</p> |
| Courses: | |
| Teaching and learning forms: | Lecture/Practical training |
| Prerequisites for participation: | Knowledge of programming languages like C |
| Applicability of the module: | |
| Prerequisites allocation ECTS: | Portfolio |
| ECTS credits: | 5 |
| Grading: | benotet |
| Workload: | 30h / 1 ECTS |
| Duration of the module: | one semester |
| Frequency of offering: | Every semester |
| Literature: | |
| Compulsory attendance: | no |

Competence dimensions

Knowledge and understanding

Focus:

Use, application and generation of knowledge/art

After successful participation the students should be able to write simple LabVIEW programs for measurement data acquirement, processing and visualization. They should furthermore be able to pass the (optional) CLAD test, arranged by the company National Instruments on Internet (http://www.ni.com/training/labview_exam.htm). This is a prerequisite for becoming a CLAD (Certified LabVIEW Associate Developer), which can be accomplished in a separated examination.

Focus:

Use and transfer

Communication and cooperation

Scientific / artistic self-image and professionalism

Valid from: WiSe21/22

SPO: Deadline: 18.06.2021

Print date: 20.10.2021