## Module: Automatic Control Systems

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| **Level** | Master | **Short Name** | ACS |
| **Responsible Lecturers** | Hahn, Martin, Prof. Dr.-Ing. | | |
| **Department, Facility** | Mechanical Engineering and Business Administration | | |
| **Course of Studies** | Mechanical Engineering, Bachelor | | |
| **Compulsory/elective** | Compulsory | **ECTS Credit Points** | 4 |
| **Semester of Studies** | 5 | **Semester Hours per Week** | 4 |
| **Length (semesters)** | 1 | **Workload (hours)** | 120 |
| **Frequency** | WiSe | **Presence Hours** | 60 |
| **Teaching Language** | English | **Self-Study Hours** | 60 |
| The following section is filled only if there is **exactly one** module-concluding exam. | | | |
| **Exam Type** | Written Exam | **Exam Language** | English |
| **Exam Length (minutes)** | 120 | **Exam Grading System** | One-third Grades |
| **Learning Outcomes** | The students can apply the methods for modelling, analysis and controller synthesis of modern mechanical engineering systems (see teaching contents). | | |
| **Participation Prerequisites** | Recommended are:<br>• Mathematics (ODEs, Laplace Transformation)<br>• Basics of kinematics and dynamics as well as mechatronic systems | | |
| The previous section is filled only if there is **exactly one** module-concluding exam. | | | |
| **Consideration of Gender and Diversity Issues** | ✔ Use of gender-neutral language (THL standard)<br>✘ Target group specific adjustment of didactic methods<br>✘ Making subject diversity visible (female researchers, cultures etc.) | | |
| **Applicability** | | | |
| **Remarks** | | | |

## Module Course: Automatic Control Systems (Lecture)

(of Module: Automatic Control Systems)

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| **Course Type** | Lecture | **Form of Learning** | Presence |
| **Mandatory Attendance** | no | **ECTS Credit Points** | 2 |
| **Participation Limit** | | **Semester Hours per Week** | 3 |
| **Group Size** | | **Workload (hours)** | 60 |
| **Teaching Language** | English | **Presence Hours** | 45 |
| **Study Achievements ("Studienleistung", SL)** | | **Self-Study Hours** | 15 |
| **SL Length (minutes)** | | **SL Grading System** | |
| The following section is filled only if there is a course-specific exam. | | | |
| **Exam Type** | | **Exam Language** | |
| **Exam Length (minutes)** | | **Exam Grading System** | |
| **Learning Outcomes** | | | |
| **Participation Prerequisites** | | | |
| The previous section is filled only if there is a course-specific exam. | | | |
| **Contents** | **Introduction**<br><br>Model-based controller design (methods and development tools), Application of the feedback principle, terms and standards, development related to the VDI 2206 standard, block diagrams, examples (fresh water supply of a rainwater system, Control functions of modern heating systems, controlled hardware-in-the-loop test bench, active suspension vehicle systems), exercises on the basic concepts of control engineering (water level control, gas tanks).<br><br>**Modelling of Control Engineering Systems**<br><br>Modelling of mechanic systems, actuators, sensors and information processing systems, simplified physical models, mathematical models, 1st and 2nd order systems, step-response, impulse response.<br><br>Exercises for modelling a maglev train (modelling the mechanical subsystem, the electrical and magnetic circuit of the supporting magnet, calculation of the operating point, linearization around one operating point).<br><br>**Systems Analysis**<br><br>Laplace transformation (definition and calculation rules, inverse Laplace transformation, use of correspondence tables, frequently used excitation functions, limit theorems, existence of limit values), solution of differential | | |

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| | equations using Laplace transformation, partial fraction decomposition, transfer functions, characteristic equation, poles and zeros.<br><br>1st and 2nd order systems (calculation of eigenfrequencies and damping parameters from measured variables, poles and transient response, step response), calculation using the example of the mathematical model of a maglev train.<br><br>Stability (basic stability criterion, necessary and sufficient condition for stability, Hurwitz criterion).<br><br>Analysis methods in the frequency domain, especially for 2nd order systems (frequency response, bottom diagram, root locus curve), transfer behavior of systems, transfer functions and block diagrams, examples (radar antenna and servo valve).<br><br>Exercise Laplace transformation, transfer function and frequency response for a DC motor, calculation with transfer functions, relationship between transfer function and frequency response, transformation of block diagrams.<br><br>**Controller Design**<br><br>Fundamentals of linear control theory, design criteria (system structure, system parameters, parameter sensitivity/robustness, command and disturbance behaviour), requirements for the dynamic behaviour of the controlled system and calculation, basic types of controllers (P, I, D and combinations) and their behaviour, control and regulation using the example of position control of a radar antenna.<br><br>Controller, system, command and disturbance transfer functions using the example of the course control of a ship, stationary errors (position and speed), control quality, influence of disturbances on position controls.<br><br>Position control with P, PI, PD and PID controller, permanent control difference, pole specification, frequency characteristic curve method, case studies (e.g. controller design for a DC motor, feedforward control). |
| **Literature** | Dorf & Bishop, Modern Control Systems, Pearson International, 2017.<br><br>Franklin, Powell, Emami-Naeini, Feedback Control of Dynamic Systems, Pearson International, 2018. |
| **Remarks** | |

TECHNISCHE HOCHSCHULE LÜBECK

**Module Course: Automatic Control Systems (Practical Training)**

(of Module: Automatic Control Systems)

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| **Course Type** | Practical Training | **Form of Learning** | Presence |
| **Mandatory Attendance** | yes | **ECTS Credit Points** | 2 |
| **Participation Limit** | | **Semester Hours per Week** | 1 |
| **Group Size** | 12 | **Workload (hours)** | 60 |
| **Teaching Language** | English | **Presence Hours** | 15 |
| **Study Achievements ("Studienleistung", SL)** | Practical Training | **Self-Study Hours** | 45 |
| **SL Length (minutes)** | | **SL Grading System** | Pass |

The following section is filled only if there is a course-specific exam.

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| **Exam Type** | | **Exam Language** | |
| **Exam Length (minutes)** | | **Exam Grading System** | |
| **Learning Outcomes** | | | |
| **Participation Prerequisites** | | | |

The previous section is filled only if there is a course-specific exam.

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| **Contents** | The practical training is carried out on a changing selection from the following tests: Speed control for a motor, position control for a pendulum, stabilization of an inverted rotary pendulum. All experiments are performed in a CAMeL-View TestRig based environment and allow to learn a model-driven design of control systems in the model, testbed and prototype phases.<br><br>Objectives are:<br>• Reliable use of development tools for modelling, analysis and synthesis of closed-loop control systems<br>• Design of a controller and its test on a simulation model as well as on real hardware in the laboratory |
| **Literature** | Dorf & Bishop, Modern Control Systems, Pearson International, 2017.<br><br>Franklin, Powell, Emami-Naeini, Feedback Control of Dynamic Systems, Pearson International, 2018. |
| **Remarks** | The prerequisite for successful participation is the completion of laboratory experiments and the preparation of suitable reports. |