Module: Modeling and Numerical Analysis

Level	Bachelor	**Short Name**	MNA
Responsible Lecturers	Kral, Roland, 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	6	**Semester Hours per Week**	4
Length (semesters)	1	**Workload (hours)**	120
Frequency	SuSe	**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	Students • know how to derive the differential equations which describe the dynamics of the by using the underlying physical laws • have learned to implement the mathematical models on a computer and how hardware can be embedded • know about the important properties of nonlinear and linear dynamic systems.
Participation Prerequisites	Recommended are: • Mathematics I, II, and III • Courses on the fundamentals of engineering (electric circuits, etc.)

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) ✔ Target group specific adjustment of didactic methods ✔ Making subject diversity visible (female researchers, cultures etc.)
Applicability	Automatic Control Systems
Remarks	A practical training in the computer room is part of the course. For the numerical simulation the MATLAB/SIMULINK campus license will be used.

TECHNISCHE HOCHSCHULE LÜBECK

Module Course: Modeling and Numerical Analysis (lecture)

(of Module: Modeling and Numerical Analysis)

Course Type	Lecture	**Form of Learning**	Presence
Mandatory Attendance	no	**ECTS Credit Points**	4
Participation Limit		**Semester Hours per Week**	4
Group Size		**Workload (hours)**	120
Teaching Language	English	**Presence Hours**	60
Study Achievements ("Studienleistung", SL)		**Self-Study Hours**	60
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

Mathematical description of dynamic systems

- Nonlinear and linear systems of differential equations, simple technical examples, behavior of the solution, controlled and observed systems, equilibrium points and linearization

Simulation of dynamic systems

- One step methods, discretization error and convergence, implementation with MATLAB, simulation with SIMULINK block diagrams, hardware in the loop

Methods to derive a mathematical model

- Mechanical systems: Bilances of forces and torques, equations of Euler-Lagrange – Examples: Spring-mass-damper system, pendulum, crane positioning system, anti blocking system
- Thermal systems: Heat flow bilances – Examples: Heating of a DC motor, heat exchanger, heating of a thin rod
- Fluid systems: Mass flow bilances – Examples: Pressure container, three-tank-system, hydraulic cylinder
- Electric systems: Voltage and current bilances – Examples: RLC circuit, RLC circuit with a non-linear resistor
- Electromechanical system: DC motor
- SIMULINK models for a selection of theses examples

General properties of nonlinear systems

	• Stability of nonlinear systems, Lyapunov functions, stability of linear systems, Lyapunov's indirect method, phase portraits, periodic solutions, limit cycles **General properties of linear systems** • Solution formula, step response, frequency response, transfer functions, MATLAB tools • Case study: Rotational pendulum (with laboratory experiment) • Equations of motion, linearization, transfer functions, SIMULINK block diagram, set-up of the experiment, comparison of simulated and measured results.
Literature	• Handouts to lecture, to exercises and to labs • Additional literature according to the list given out in class
Remarks	