Module: Simulation and Control

Level	Master	**Short Name**	SiCo
Responsible Lecturers	Hahn, Martin, Prof. Dr.-Ing.		
Department, Facility	Mechanical Engineering and Business Administration		
Course of Studies	Mechanical Engineering, Master		
Compulsory/elective	Compulsory	**ECTS Credit Points**	5
Semester of Studies	2	**Semester Hours per Week**	4
Length (semesters)	1	**Workload (hours)**	150
Frequency	WiSe	**Presence Hours**	60
Teaching Language	English	**Self-Study Hours**	90
The following section is filled only if there is **exactly one** module-concluding exam.			
Exam Type	Written Exam	**Exam Language**	English
Exam Length (minutes)	90	**Exam Grading System**	One-third Grades
Learning Outcomes	The student shall learn to build up a simulation model for a dynamical technical system. The emphasis is laid on mechanic or mechatronic systems. This will be done in two steps: In the first step, the equations of motions are derived and in a second step, these equations are implemented on a computer. Using some laboratory experiments, the students have the possibility to compare simulated and measured result and they are asked to compare the real behavior with the expected behavior of the system. They learn also how to design advanced controllers (linear and nonlinear).		
Participation Prerequisites	Advanced Topics in Engineering Mathematics, Control 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) ✘ Target group specific adjustment of didactic methods ✘ Making subject diversity visible (female researchers, cultures etc.)		
Applicability			
Remarks			

Module Course: Simulation and Control (Lecture)

(of Module: Simulation and Control)

Course Type	Lecture	**Form of Learning**	Presence
Mandatory Attendance	no	**ECTS Credit Points**	4
Participation Limit		**Semester Hours per Week**	3
Group Size		**Workload (hours)**	120
Teaching Language	English	**Presence Hours**	45
Study Achievements ("Studienleistung", SL)		**Self-Study Hours**	75
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	For the design and the construction of a complicated technical system it becomes more and more important to derive a mathematical simulation model which puts the engineer in a position to show that his design is feasible, to estimate the performance of the system and to optimize parameters. One reason for the fact that simulation models become very popular in an early stage of the system design is that since some years there exist very powerful SW tools which help the engineer to build up the model and to run it with efficient algorithms. Despite of this, the derivation of the model and the correct interpretation of the simulation results or the measurements require a profound knowledge of the underlying theory. Additionally, since automatization plays an increasing role, the knowledge how to design a controller is of great importance. **Introduction** Simulation and the evolution of learning, innovation drivers for mechanical engineering products, methods of function development and mechatronic system design, methods of control engineering, development environments, hardware-in-the-loop testbed applications, position and velocity control revisited, examples. **Mechatronic systems and their components** Components of mechatronic systems, actuators, sensors, information processing, electronic control units, AD and DA converters, use of FPGAs for high-speed control applications,		

	Modelling of Mechatronic Systems Base principles of mechanic system modelling, modelling of multibody systems, modelling of the mechanic and electrical subsystems of a maglev-system, standard representation of mechanical systems, linear and nonlinear state space repre-sentation, transformation of 2nd order systems to state space representation, modelling of hydraulic subsystems, modelling multidomain models. **Simulation and Computation of Mechatronic Systems** Simulation, linearization, eigenvalue and eigenvector calculation, frequency response, FFT, realtime-requirements to use models in testbed applications, algorithms for the solution of systems in state space representation (ode-solvers), mathe-matics of single-step and multistep-solvers (esp. Euler, Heun and Runge-Kutta-algorithms, stepsize and order control, nu-merical stability), **Analysis of Mechatronic Systems** Laplace transformation, partial fraction decomposition, basic rules, transformation of unsteady periodic excitation signals, system stability analysis (linear and nonlinear), block diagram conversion rules, analysis of systems in linear and nonline-ar state space representation, solution in Laplace s-domain, transfer-matrix, eigenvalues, hydraulic servo system example and a maglev system **Synthesis and Control** Overview of linear and nonlinear control theory, basic controller types, classic and modern control approaches, frequency response design methods for controllers, Bode diagram, control settling time, influence of disturbances and nonlinearities, closed loop in state space representation, parameter sensitivity.
Literature	A list of suitable textbooks is provided at the beginning of the lecture.
Remarks	

Module Course: Simulation and Control (Practical Training)

(of Module: Simulation and Control)

Course Type	Practical Training	**Form of Learning**	Presence
Mandatory Attendance	yes	**ECTS Credit Points**	1
Participation Limit		**Semester Hours per Week**	1
Group Size	12	**Workload (hours)**	30
Teaching Language	English	**Presence Hours**	15
Study Achievements ("Studienleistung", SL)	Practical Training	**Self-Study Hours**	15
SL Length (minutes)		**SL Grading System**	Pass
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	**Simulation and laboratory experiments** Introduction into the use blockdiagram based development environments, nonlinear state space representation of 1st and 2nd order system examples, numerics and stability of a rotary manipulator simulation model, symbolic solution and exact numerical errors for a nonlinear system, frequency response methods		
Literature	A list of suitable textbooks is provided at the beginning of the lecture.		
Remarks			