| Studiengang: *Program:* | **Master of Science Maschinenbau** *Bachelor of Science in Mechanical Engineering* | | | FACH HOCHSCHULE LÜBECK University of Applied Sciences |
|---|---|---|---|---|
| 1 Modul: *Module:* | **Simulation and Control** *Simulation und Steuerung/Regelung* | | | **English** *Englisch* |
| | **Semester** *Semester* | **Dauer** *Duration* | **Status** *Status* | **Turnus** *Regular cycle* |
| | 2. Semester | 1 Semester | compulsory | annual |
| | **Kreditpunkte** *Credits* | **Aufwand** *Workload* | **Kontaktzeit** *Contact-hours* | **Selbststudium** *Student's efforts* |
| | 5 ECTS | 150h | 3hrs/week = 45hrs Lecture<br>1h/week = 15hrs Laboratory | 30hrs Preparation and post processing<br>60hrs Self-study |

## 2 Beschreibung
*Description*

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.

## 3 Lernziele
*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).

## 4 Schlüsselqualifikationen
*Key qualifications*

| Sozialkompetenz | Methodenkompetenz | Selbstkompetenz / Personenkompetenz | Interkulturelle Kompetenz | Medienkompetenz |
|---|---|---|---|---|
| | X | X | | |

## 5 Lehrveranstaltung/ -methoden
*Course type and methods*

**Lecture**
- Seminar-like teaching
- Exercises and examples (case studies)

**Laboratory exercises**

## 6 Vorbedingungen / Vorkenntnisse
*Prerequisites*

- Advanced Topics in Engineering Mathematics, Control Systems

## 7 Arbeitsmittel / Literatur
*Required material / Literature*

Chapters of suitable selected textbooks, list provided in the beginning of the class

## Detailinformationen

### 8 Inhalte

*Course topics*

**Building a model for mechanical systems**
Equations of motion for a rigid body, Euler angles, Longitudinal dynamics of an aircraft, linearization, analysis of the linearized dynamics, Lateral motion of a car, the corresponding transfer functions, stability analysis
Systems with elastic behavior, Rotating systems connected by a spring, rotating systems connected by a belt, vibrating beam, rotational motion of the elastic Hubble space telescope, design of a PID controller for the space telescope
Dynamics of robotic systems, underactuated systems, crane positioning system
**Case study with laboratory experiment: Position control for a robot arm with an elastic joint**
Mathematical model, SIMULINK implementation, dynamics added by the elasticity, transfer functions,
measurement of the high-frequency dynamics: step and frequency response, design of a controller for the rigid arm, analysis of the closed-loop system in the presence of elasticity, redesign of the controller for the arm with elasticity
**Mechatronic systems and their components**
Actuators, sensors, microprocessors, AD and DA converters, robotic manipulators, trajectory planning
**General properties of nonlinear systems**
Lyapunov stability, Lyapunov functions, stability of linear systems, Lyapunovs indirect method, limit cycles, LaSalles invariance principle, passivity
**Controller design linear multivariable systems**
Controllability, observability, state feedback, pole placement, LQ controllers, Luenberger observers
Case study (simulation): control of a continuously stirred tank with a chemical reaction, SIMULINK model of the nonlinear plant dynamics, controller design by pole placement, observer design, simulation of the
closed-loop system
**Controller design for nonlinear systems**
Sliding mode control, backstepping, feedback linearization, passivity based control, control of robotic
manipulators
**Case study with laboratory experiment: Swing-up controller for the acrobot**
SIMULINK model, transfer functions for the upward position of the acrobot, stabilization for this position, performance limitations caused by unmodelled actuator and sensor dynamics, limit cycles, design of a swing-up controller

### 9 Prüfungsform

*Assessment*

Written examination at the end of the term: 2 hours.

### 10 Voraussetzung für die Vergabe von Kreditpunkten

*Requirements for granting of credits*

- Successful passing of exam

### 11 Weiterführende Veranstaltungen

*Related courses*

- none

### 12 Zuordnung

*Classification*

| Mathematik & Naturwissenschaft | Ingenieur-wissenschaften | Ingenieur-anwendungen | Entwicklung & Konstruktion | Werkstoffe | Wirschaft, Management, Sprachen | Anderes |
|---|---|---|---|---|---|---|
| | X | X | | | | |

### 13 Modulbeauftragter / Lehrpersonen

*Responsible person / Lecturers*

Prof. Dr. U. Mackenroth/ Prof. Dr. U. Mackenroth