# Appendix A: Course Schedule

**for the study programme Optimisation and Simulation M.Sc.**

Please note: The German version of this document is the legally binding version. The English translation provided here is for information purposes only.

| **Winter semester** | | | L | ST | E | P/S | SSS | CP |
|---|---|---|---|---|---|---|---|---|
| Module number | Module title | Module ID | | | | | | |
| 2015 | Bionic Methods of Optimisation | BMO | 2 | 0 | 2 | 0 | 0 | 6 |
| 2017 | Project | PRO | 0 | 0 | 0 | 2 | 0 | 6 |
| 2039 | Risk Management | RIM | 0 | 4 | 0 | 0 | 0 | 6 |
| 9023 | Elective Module: Optimisation and Simulation | WM | | | | 0 | | 6 |
| 9023 | Elective Module: Optimisation and Simulation | WM | | | | 0 | | 6 |
| | | | | | | | Total CP: | 30 |
| **Summer semester** | | | L | ST | E | P/S | SSS | CP |
| Module number | Module title | Module ID | | | | | | |
| 2035 | Discrete Optimisation | DOPT | 2 | 2 | 0 | 0 | 0 | 6 |
| 2006 | Management Skills | MMK | 2 | 2 | 0 | 0 | 0 | 6 |
| 2013 | Seminar | SE | 0 | 0 | 0 | 4 | 0 | 6 |
| 9023 | Elective Module: Optimisation and Simulation | WM | | | | 0 | | 6 |
| 9023 | Elective Module: Optimisation and Simulation | WM | | | | 0 | | 6 |
| | | | | | | | Total CP: | 30 |
| **Third semester** | | | L | ST | E | P/S | SSS | CP |
| Module number | Module title | Module ID | | | | | | |
| 2033 | Colloquium | MKO | 0 | 0 | 0 | 0 | 0 | 6 |
| 2034 | Master Thesis | MA | 0 | 0 | 0 | 0 | 0 | 24 |
| | | | | | | | Total CP: | 30 |

Abbreviations of the teaching forms: L = lecture, ST = tuition in seminars, E = exercise, S = seminar, P = practical, SSS = supervised self-study (all data in semester credit hours); CP = credit points
W/S = winter/summer semester

| **Simulation** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Module number | Module title | Module ID | W/S | L | ST | E | P/S | SSS | CP |
| 2014 | Mechatronic Systems | MS | S | 2 | 2 | 0 | 0 | 0 | 6 |
| 2011 | Multi-Body Simulation | MKS | S | 2 | 0 | 1 | 1 | 0 | 6 |
| 2010 | Model-Based System Development | MSE | W | 2 | 2 | 0 | 0 | 0 | 6 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2012 | Multidisciplinary Modelling With Modelica | MMM | S | 2 | 0 | 2 | 0 | 0 | 6 |
| 2047 | Multiphysics Simulation | MPH | W | 2 | 0 | 2 | 0 | 0 | 6 |
| 2016 | Simulation of Optical Systems | SOS | S | 2 | 0 | 2 | 0 | 0 | 6 |
| 2009 | System Simulation | SYS | S | 2 | 2 | 0 | 0 | 0 | 6 |

# Appendix B: Module catalogue

for the study programme Optimisation and Simulation M.Sc.



Please note: The German version of this document is the legally binding version. The English translation provided here is for information purposes only.

| Bionic Methods of Optimisation | | | | | BMO |
|---|---|---|---|---|---|
| Identification number: | Workload: | Credits: | Study semester: | Frequency of the offer | Duration: |
| 2015 | 180 h | 6 | 1st or 2nd semester | Annual (Winter) | 1 semester |

| 1 | Course: | Planned group sizes | Scope | | Actual contact time / classroom teaching | | Self-study | |
|---|---|---|---|---|---|---|---|---|
| | Lecture | 60 students | 2 | SCH | 30 | h | 60 | h |
| | Tuition in seminars | 30 students | 0 | SCH | 0 | h | 0 | h |
| | Exercise | 20 students | 2 | SCH | 30 | h | 60 | h |
| | Practical or seminar | 15 students | 0 | SCH | 0 | h | 0 | h |
| | Supervised self-study | 60 students | 0 | SCH | 0 | h | 0 | h |

**2 Learning outcomes/competences:**

The students know the concept of bionics as well as types and procedures of bionic optimisation algorithms. The students are able to assess for which problems bionic algorithms, especially genetic algorithms, are suitable, as well as evaluate the quality of the optimisation results. They can structure and model given problems in such a way that bionic algorithms become applicable. They are able to use neural networks for modelling and increasing efficiency.

**3 Contents:**

Classification of optimisation algorithms (heuristic, combinatorial, analytical, bionic). Types of heuristic procedures: Random walk, hill climbing, simulated annealing, genetic algorithms, other stochastic methods.

On genetic algorithms: Biological model, mathematical operators (selection, mutation, etc.), theoretical background (schema theorem, building block hypothesis, speed of convergence).

Evolutionary strategies, differential evolution, particle swarming, ant algorithms, bee swarming algorithms. Case studies, classic test functions (Rosenbrock saddle, Travelling Salesperson, etc.).

Implementation of a programming project.

Basics of artificial neural networks, the most important models, areas of application, especially in optimisation tasks.

**4 Forms of teaching:**

Seminar-based teaching with project work

**5 Participation requirements:**

| Formal: | None |
|---|---|
| Content: | None |

**6 Forms of assessment:**

Project work

**7 Prerequisite for the award of credit points:**

Module examination pass

**8 Application of the module (in the following study programmes)**

BioMechatronics M.Sc. and Optimisation and Simulation M.Sc.

**9 Importance of the grade for the final grade:**

according to MRPO

**10 Module Officer:**

Prof. Dr. math. Friedrich Biegler-König

**11 Other information:**

Literature will be announced at the beginning of the course.

| | |
|---|---|
| | - Gerdes et. al, Evolutionäre Algorithmen<br>- Script Neural Networks |
| 12 | Language:<br>German |

| Discrete Optimisation | | | | | DOPT |
|---|---|---|---|---|---|
| Identification number: | Workload: | Credits: | Study semester: | Frequency of the offer | Duration: |
| 2035 | 180 h | 6 | 1st or 2nd sem. | Annual (Summer) | 1 semester |

| 1 | Course: | Planned group sizes | Scope | | Actual contact time / classroom teaching | | Self-study | |
|---|---|---|---|---|---|---|---|---|
| | Lecture | 60 students | 2 | SCH | 30 | h | 60 | h |
| | Tuition in seminars | 30 students | 2 | SCH | 30 | h | 60 | h |
| | Exercise | 20 students | 0 | SCH | 0 | h | 0 | h |
| | Practical or seminar | 15 students | 0 | SCH | 0 | h | 0 | h |
| | Supervised self-study | 60 students | 0 | SCH | 0 | h | 0 | h |

**2 Learning outcomes/competences:**

The students are familiar with different problem characteristics and the corresponding solution methods of integer and combinatorial optimisation problems and are able to solve relevant real-world problems with the help of suitable models and methods of discrete optimisation.

**3 Contents:**

- Integer linear optimisation problems
- Knapsack problems
- Assignment and matching problems
- Travelling Salesperson and Chinese Postman problems
- Scheduling problems (machine allocation, flow production)
- Cutting-stock & bin-packing problems
- Facility & hub location problems

**4 Forms of teaching:**

Seminar-based teaching with accompanying exercise

**5 Participation requirements:**

| | |
|---|---|
| Formal: | None |
| Content: | Basic knowledge of linear optimisation |

**6 Forms of assessment:**

Term paper, written examination, combination examination, performance examination, project work, oral examination or examination during the course

**7 Prerequisite for the award of credit points:**

Module examination pass

**8 Application of the module (in the following study programmes)**

Optimisation and Simulation M.Sc.

**9 Importance of the grade for the final grade:**

according to MRPO

**10 Module Officer:**

Prof. Dr. rer. nat. Jonas Ide

**11 Other information:**

Literature will be announced at the beginning of the course.
The course material is summarised in a script that accompanies the lecture.

**12 Language:**

German

| Colloquium | | | | | MKO |
|---|---|---|---|---|---|
| Identification number: | Workload: | Credits: | Study semester: | Frequency of the offer | Duration: |
| 2033 | 180 h | 6 | 3rd semester | each semester | |

| 1 | Course: | Planned group sizes | Scope | | Actual contact time / classroom teaching | | Self-study | |
|---|---|---|---|---|---|---|---|---|
| | Lecture | 60 students | 0 | SCH | 0 | h | 180 | h |
| | Tuition in seminars | 30 students | 0 | SCH | 0 | h | 0 | h |
| | Exercise | 20 students | 0 | SCH | 0 | h | 0 | h |
| | Practical or seminar | 15 students | 0 | SCH | 0 | h | 0 | h |
| | Supervised self-study | 60 students | 0 | SCH | 0 | h | 0 | h |

**2 Learning outcomes/competences:**

The colloquium complements the master thesis and is to be assessed independently. It serves to determine whether the candidate is capable of orally presenting and independently justifying the scientific topic of the master thesis, its subject-related foundations, its interdisciplinary connections and its non-subject-related references, as well as assessing its significance for practice.

**3 Contents:**

- Content of the thesis according to the topic
- Disputation on the procedure in the preparation of the thesis and the questions that arose in the context of the thesis

**4 Forms of teaching:**

Oral examination for the master thesis

**5 Participation requirements:**

| | |
|---|---|
| Formal: | None |
| Content: | Treatment of the master thesis |

**6 Forms of assessment:**

Oral examination

**7 Prerequisite for the award of credit points:**

**8 Application of the module (in the following study programmes)**

Electrical Engineering M.Eng., Mechanical Engineering M.Sc. and Optimisation and Simulation M.Sc.

**9 Importance of the grade for the final grade:**

according to MRPO

**10 Module Officer:**

Prof. Dr.-Ing. Jens Haubrock

**11 Other information:**

Literature will be announced at the beginning of the course.

**12 Language:**

German

| Management Skills | | | | | MMK |
|---|---|---|---|---|---|
| Identification number: | Workload: | Credits: | Study semester: | Frequency of the offer | Duration: |
| 2006 | 180 h | 6 | 1st or 2nd semester | Annual<br>Summer | 1 sem. |

| 1 | Course: | Planned group sizes | Scope | | Actual contact time / classroom teaching | | Self-study | |
|---|---|---|---|---|---|---|---|---|
| | Lecture | 60 students | 2 | SCH | 30 | h | 60 | h |
| | Tuition in seminars | 30 students | 2 | SCH | 30 | h | 60 | h |
| | Exercise | 20 students | 0 | SCH | 0 | h | 0 | h |
| | Practical or seminar | 15 students | 0 | SCH | 0 | h | 0 | h |
| | Supervised self-study | 60 students | 0 | SCH | 0 | h | 0 | h |

| | |
|---|---|
| 2 | Learning outcomes/competences:<br>Students know and understand different management methods and can apply them to specific cases. They understand the connection between corporate goals, leadership culture and social mission. They have learned to analyse entrepreneurial measures from different perspectives. They can evaluate their own behaviour/perception more realistically. They can use methods to motivate employees and themselves, to work successfully in a team and to react sensibly in case of conflict or crisis. They can apply methods to deal sensibly with high task loads. |
| 3 | Contents:<br>Strategic corporate planning, motivational theories, leadership methods, values in management, social, professional and methodological competence, general legal issues, occupational safety, environmental protection, energy and resource efficiency, sustainable economic activities, code of German references, intercultural management, global development and production strategies, project management, self-management, target tracking and controlling, balanced score card, technology excellence level, change management, conflict management, stress and time management, communication in the event of a crisis. |
| 4 | Forms of teaching:<br>Lectures, case studies, exercises |
| 5 | Participation requirements:<br>Formal: None<br>Content: None |
| 6 | Forms of assessment:<br>Written examination, combination examination or oral examination |
| 7 | Prerequisite for the award of credit points:<br>Module examination pass |
| 8 | Application of the module (in the following study programmes)<br>Electrical Engineering M.Eng., Mechanical Engineering M.Sc. and Optimisation and Simulation M.Sc. |
| 9 | Importance of the grade for the final grade:<br>according to MRPO |
| 10 | Module Officer:<br>Prof. Dr.-Ing. Bruno Hüsgen |
| 11 | Other information:<br>Literature will be announced at the beginning of the course. |
| 12 | Language:<br>German |

| Master Thesis | | | | | M.A. |
|---|---|---|---|---|---|
| Identification number: | Workload: | Credits: | Study semester: | Frequency of the offer | Duration: |
| 2034 | 720 h | 24 | 3rd semester | each semester | 20 weeks |

| 1 | Course: | Planned group sizes | Scope | | Actual contact time / classroom teaching | | Self-study | |
|---|---|---|---|---|---|---|---|---|
| | Lecture | 60 students | 0 | SCH | 0 | h | 720 | h |
| | Tuition in seminars | 30 students | 0 | SCH | 0 | h | 0 | h |
| | Exercise | 20 students | 0 | SCH | 0 | h | 0 | h |
| | Practical or seminar | 15 students | 0 | SCH | 0 | h | 0 | h |
| | Supervised self-study | 60 students | 0 | SCH | 0 | h | 0 | h |

| | | |
|---|---|---|
| 2 | Learning outcomes/competences: | |
| | With the master thesis, each candidate demonstrates that he/she is able to complete a practice-oriented task from his/her subject area within a specified period of time, both in its subject-specific details and in the interdisciplinary contexts, working independently and according to scientific methods. | |
| 3 | Contents: | |
| | The master thesis is an independent scientific work from the subject area of the respective study programme with a description and explanation of its solution. It can also be determined by an empirical investigation or by conceptual or design tasks or by an evaluation of existing sources. A combination of these forms is possible. | |
| 4 | Forms of teaching: | |
| | Written composition with faculty tutoring | |
| 5 | Participation requirements: | |
| | Formal: | None |
| | Content: | Coordinated topic from the student's special subject area |
| 6 | Forms of assessment: | |
| 7 | Prerequisite for the award of credit points: | |
| 8 | Application of the module (in the following study programmes) | |
| | Electrical Engineering M.Eng., Mechanical Engineering M.Sc. and Optimisation and Simulation M.Sc. | |
| 9 | Importance of the grade for the final grade: | |
| | according to MRPO | |
| 10 | Module Officer: | |
| | Prof. Dr.-Ing. Jens Haubrock | |
| 11 | Other information: | |
| | Literature will be announced at the beginning of the course. | |
| 12 | Language: | |
| | German | |

| Mechatronic Systems | | | | | MS |
|---|---|---|---|---|---|
| Identification number: | Workload: | Credits: | Study semester: | Frequency of the offer | Duration: |
| 2014 | 180 h | 6 | 1st or 2nd semester | Annual (Summer) | 1 semester |

| 1 | Course: | Planned group sizes | Scope | | Actual contact time /classroom teaching | | Self-study | |
|---|---|---|---|---|---|---|---|---|
| | Lecture | 60 students | 2 | SCH | 30 | h | 60 | h |
| | Tuition in seminars | 30 students | 2 | SCH | 30 | h | 60 | h |
| | Exercise | 20 students | 0 | SCH | 0 | h | 0 | h |
| | Practical or seminar | 15 students | 0 | SCH | 0 | h | 0 | h |
| | Supervised self-study | 60 students | 0 | SCH | 0 | h | 0 | h |

**2 Learning outcomes/competences:**

Students can apply standardised methods to describe the kinematics and dynamics of technical systems.

**3 Contents:**

Basic kinematic principles:
Kinematics of the point, the rigid and the solid body, the systems of rigid bodies in spatial motion
- Movement models of mechanisms, cardan joint, planetary gear, gyroscope

Synthetic mechanics:
Axioms of Newton and Euler (impulse theorem, twist theorem)
- Planetary motion, gyroscopic motion, stability of motion, force effect of unbalanced rotors, dynamics of machine foundations, e.g. tower generators, model demonstrations

Kinematics in the relative system:
- Proof of the earth's rotation with Foucault pendulum, free fall on rotating earth

Analytical mechanics, differential and integral principles:
Principle of virtual work, d'Alembert's principle, Lagrange's liberation principle
- Equilibrium, stability, equations of motion of mechanisms and elastic bodies

Hamilton's principle, Lagrange's equations:
- Calculus of variations, Lagrange multipliers, crank drive, torsional vibrations in shaft lines, beam, string and diaphragm vibrations

**4 Forms of teaching:**

Lecture, seminar-based teaching

**5 Participation requirements:**

| Formal: | None |
|---|---|
| Content: | None |

**6 Forms of assessment:**

Written examination or oral examination

**7 Prerequisite for the award of credit points:**

Module examination pass

**8 Application of the module (in the following study programmes)**

| | |
|---|---|
| | BioMechatronics M.Sc. and Optimisation and Simulation M.Sc. |
| 9 | Importance of the grade for the final grade:<br>according to MRPO |
| 10 | Module Officer:<br>Prof. Dr.-Ing. Heinrich Kühlert |
| 11 | Other information:<br>Literature will be announced at the beginning of the course. |
| 12 | Language:<br>German |

| Multi-Body Simulation | | | | | MKS |
|---|---|---|---|---|---|
| Identification number: | Workload: | Credits: | Study semester: | Frequency of the offer | Duration: |
| 2011 | 180 h | 6 | 1st or 2nd semester | Annual (Summer) | 1 semester |

| 1 | Course: | Planned group sizes | Scope | | Actual contact time /classroom teaching | | Self-study | |
|---|---|---|---|---|---|---|---|---|
| | Lecture | 60 students | 2 | SCH | 30 | h | 60 | h |
| | Tuition in seminars | 30 students | 0 | SCH | 0 | h | 0 | h |
| | Exercise | 20 students | 1 | SCH | 15 | h | 30 | h |
| | Practical or seminar | 15 students | 1 | SCH | 15 | h | 30 | h |
| | Supervised self-study | 60 students | 0 | SCH | 0 | h | 0 | h |

**2 Learning outcomes/competences:**

Students will be able to apply standardised methods for describing the kinematics and dynamics of mechanical and mechatronic systems, analyse the kinematics and dynamics of mechanisms with an MBS program system, interpret simulation results and compare them with the results of MBS simulation programmes.

**3 Contents:**

- Mechanisms (definition, examples)
- Concepts in plane kinematics
- Coordinate systems, generalised coordinates
- Coercive conditions
- Examples for the standardised description of mechanisms
- Numerical solution of the kinematics
- Equations of motion of dynamics under constraints
- Lagrange multipliers
- Force and control elements
- Spatial systems
- Euler parameters
- Examples for the standardised description of spatial systems

**4 Forms of teaching:**

Seminar-based teaching with exercises and practical training on the computer

**5 Participation requirements:**

| | |
|---|---|
| Formal: | None |
| Content: | None |

**6 Forms of assessment:**

Written examination, combination examination, performance examination or oral examination

**7 Prerequisite for the award of credit points:**

Module examination pass

**8 Application of the module (in the following study programmes)**

BioMechatronics M.Sc., Mechanical Engineering M.Sc. and Optimisation and Simulation M.Sc.

**9 Importance of the grade for the final grade:**

according to MRPO

**10 Module Officer:**

Prof. Dr.-Ing. Rolf Naumann

**11 Other information:**

Literature will be announced at the beginning of the course. Literature:
Rill, G.: Schaeffer, T.: Grundlagen und Methodik der Mehrkörpersimulation, Vieweg +Teubner Verlag, ISBN 978-3-8348-0888-2,2010.

| | |
|---|---|
| | Haug, E.J.H: Computer-Aided Kinematics and Dynamics of Mechanical Systems, Volume 1. Basic Methods, Allyn And Bacon, ISBN 0-205-11669-8 (v.1) 1989. |
| 12 | Language:<br>German |

| Model-Based System Development | | | | | MSE |
|---|---|---|---|---|---|
| Identification number: | Workload: | Credits: | Study semester: | Frequency of the offer | Duration: |
| 2010 | 180 h | 6 | 1st or 2nd semester | Annual (Winter) | 1 semester |

| 1 | Course: | Planned group sizes | Scope | | Actual contact time / classroom teaching | | Self-study | |
|---|---|---|---|---|---|---|---|---|
| | Lecture | 60 students | 2 | SCH | 30 | h | 60 | h |
| | Tuition in seminars | 30 students | 2 | SCH | 30 | h | 60 | h |
| | Exercise | 20 students | 0 | SCH | 0 | h | 0 | h |
| | Practical or seminar | 15 students | 0 | SCH | 0 | h | 0 | h |
| | Supervised self-study | 60 students | 0 | SCH | 0 | h | 0 | h |

2 Learning outcomes/competences:

The students use targeted methodical procedures (modelling and simulation methods) for the development of system solutions for signal processing in complex mechatronic systems. They confidently apply the basic signal and system theory methods and means of description in context, use fundamental signal processing methods and independently design signal processing systems. The students apply the essential steps of model-based development from the idea to the design and prototypical testing to the realisation (usually in the form of an embedded system) and testing of the system in the respective development phases. They will use the MATLAB®/Simulink® tool chain for model-based development and be able to use the most important extensions and tools for coupling.

3 Contents:

Model-based system design:
Development procedure models, development methodology

Signal and systems theory supplements:
Elementary signals, system properties, time domain and frequency domain methods, system description methods, continuous-time view/discrete-time view, z-transformation, stability

Systems and methods of signal processing: Signal processing chain, signal processing systems,
Filters, filter design, bilinear transformation, digital filters (direct constructs/wave digital filters), special methods

Aspects of realisation and implementation: Fixed point arithmetic, scaling Test methods
Architectures
HW/SW implementation Application examples

4 Forms of teaching:

Seminar-based teaching with exercises/practical computer-based training

5 Participation requirements:

| Formal: | None |
|---|---|
| Content: | None |

| | |
|---|---|
| 6 | Forms of assessment:<br>Written examination, combination examination, performance examination or oral examination |
| 7 | Prerequisite for the award of credit points:<br>Module examination pass |
| 8 | Application of the module (in the following study programmes)<br>BioMechatronics M.Sc. and Optimisation and Simulation M.Sc. |
| 9 | Importance of the grade for the final grade:<br>according to MRPO |
| 10 | Module Officer:<br>Prof. Dr.-Ing. Joachim Waßmuth |
| 11 | Other information:<br>Literature will be announced at the beginning of the course. |
| 12 | Language:<br>German |

| Multidisciplinary Modelling With Modelica | | | | | MMM |
|---|---|---|---|---|---|
| Identification number: | Workload: | Credits: | Study semester: | Frequency of the offer | Duration: |
| 2012 | 180 h | 6 | 1st or 2nd semester | Annual (Summer) | 1 semester |

| 1 | Course: | Planned group sizes | Scope | | Actual contact time / classroom teaching | | Self-study | |
|---|---|---|---|---|---|---|---|---|
| | Lecture | 60 students | 2 | SCH | 30 | h | 60 | h |
| | Tuition in seminars | 30 students | 0 | SCH | 0 | h | 0 | h |
| | Exercise | 20 students | 2 | SCH | 30 | h | 60 | h |
| | Practical or seminar | 15 students | 0 | SCH | 0 | h | 0 | h |
| | Supervised self-study | 60 students | 0 | SCH | 0 | h | 0 | h |

| | |
|---|---|
| 2 | Learning outcomes/competences:<br>Students understand the basic characteristics of object-oriented multidisciplinary modelling and simulation. In particular, they are able to develop and simulate their own physical models on the basis of the modelling language Modelica. |
| 3 | Contents:<br>- Continuous systems<br>- Signal and energy flow<br>- Object diagrams as generalisation of block diagrams<br>- Differential Algebraic Equations (DAE)<br>- Code generation for DAEs<br>- Discontinuous and structurally variable systems<br>- Time and state events<br>- Efficient handling of many switching elements<br>- Synchronisation of events<br>- Physical applications. |
| 4 | Forms of teaching:<br>Seminar-based teaching with exercises and practicals |
| 5 | Participation requirements:<br>Formal: None<br>Content: None |
| 6 | Forms of assessment:<br>Term paper, written examination, combination examination, performance examination, project work, oral examination or examination during the course |
| 7 | Prerequisite for the award of credit points:<br>Module examination pass |
| 8 | Application of the module (in the following study programmes)<br>BioMechatronics M.Sc. and Optimisation and Simulation M.Sc. |
| 9 | Importance of the grade for the final grade:<br>according to MRPO |
| 10 | Module Officer:<br>Prof. Dr. phil. Bernhard Bachmann |
| 11 | Other information:<br>Literature will be announced at the beginning of the course. |
| 12 | Language:<br>German |

| Multiphysics Simulation | | | | | MPH |
|---|---|---|---|---|---|
| Identification number: | Workload: | Credits: | Study semester: | Frequency of the offer | Duration: |
| 2047 | 180 h | 6 | 1st or 2nd semester | Annual (Winter) | 1 semester |

| 1 | Course: | Planned group sizes | Scope | | Actual contact time / classroom teaching | | Self-study | |
|---|---|---|---|---|---|---|---|---|
| | Lecture | 60 students | 2 | SCH | 30 | h | 60 | h |
| | Tuition in seminars | 30 students | 0 | SCH | 0 | h | 0 | h |
| | Exercise | 20 students | 2 | SCH | 30 | h | 60 | h |
| | Practical or seminar | 15 students | 0 | SCH | 0 | h | 0 | h |
| | Supervised self-study | 60 students | 0 | SCH | 0 | h | 0 | h |

| | |
|---|---|
| 2 | Learning outcomes/competences:<br>The students can describe various physical phenomena (e.g. from the fields of structural mechanics, heat transfer, electrodynamics, acoustics, ...) with the help of partial differential equations and identify the coupling terms in multi-physics problems. They know the methodological procedure for the modelling and numerical simulation of coupled partial differential equations and can use free and commercial simulation software to solve multiphysics problems in a target-oriented manner. |
| 3 | Contents:<br>- Definition of multiphysics via coupled partial differential equations<br>- Treatment of typical couplings (e.g. electro-thermal WW, fluid-thermal WW, fluid-structure interaction, etc.) and their applications in practice<br>- Numerical solution methods (especially FEM)<br>- Best practice in modelling (CAD for simulation, appropriate discretisation, domain and boundary conditions, development of solution strategies, etc.)<br>- Modelling and simulation using free and commercial simulation software<br>- Application examples |
| 4 | Forms of teaching:<br>Lecture, seminar-style teaching with exercises on the computer |
| 5 | Participation requirements:<br>Formal: None<br>Content: None |
| 6 | Forms of assessment:<br>Project work |
| 7 | Prerequisite for the award of credit points:<br>Module examination pass |
| 8 | Application of the module (in the following study programmes)<br>Mechanical Engineering M.Sc. and Optimisation and Simulation M.Sc. |
| 9 | Importance of the grade for the final grade:<br>according to MRPO |
| 10 | Module Officer:<br>Prof. Dr. rer. nat. Lars Fromme |
| 11 | Other information:<br>Literature will be announced at the beginning of the course. |
| 12 | Language:<br>German |

| Project | | | | | PRO |
|---|---|---|---|---|---|
| Identification number: | Workload: | Credits: | Study semester: | Frequency of the offer | Duration: |
| 2017 | 180 h | 6 | 1st or 2nd semester | Annual (Winter) | 1 semester |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | Course: | Planned group sizes | Scope | | Actual contact time / classroom teaching | | Self-study | |
| | Lecture | 60 students | 0 | SCH | 0 | h | 0 | h |
| | Tuition in seminars | 30 students | 0 | SCH | 0 | h | 0 | h |
| | Exercise | 20 students | 0 | SCH | 0 | h | 0 | h |
| | Practical or seminar | 15 students | 2 | SCH | 30 | h | 150 | h |
| | Supervised self-study | 60 students | 0 | SCH | 0 | h | 0 | h |

| | | |
|---|---|---|
| 2 | Learning outcomes/competences: | |
| | Methods and tools for the creation of a scientifically interesting and comprehensive product through independent planning and implementation. | |
| 3 | Contents: | |
| | - Work processes and time/project plans<br>- Apply problem-finding and problem-solving strategies<br>- Documentation and presentation of the project | |
| 4 | Forms of teaching: | |
| | Project in small groups | |
| 5 | Participation requirements: | |
| | Formal: | None |
| | Content: | None |
| 6 | Forms of assessment: | |
| | Written examination, combination examination, performance examination or oral examination | |
| 7 | Prerequisite for the award of credit points: | |
| | Module examination pass | |
| 8 | Application of the module (in the following study programmes) | |
| | Optimisation and Simulation M.Sc. | |
| 9 | Importance of the grade for the final grade: | |
| | according to MRPO | |
| 10 | Module Officer: | |
| | Prof. Dr.-Ing. Rolf Naumann | |
| 11 | Other information: | |
| | Literature will be announced at the beginning of the course. | |
| 12 | Language: | |
| | German | |

| Risk Management | | | | | RIM |
|---|---|---|---|---|---|
| Identification number: | Workload: | Credits: | Study semester: | Frequency of the offer | Duration: |
| 2039 | 180 h | 6 | 1st or 2nd semester | Annual (Winter) | 1 semester |

| 1 | Course: | Planned group sizes | Scope | | Actual contact time / classroom teaching | | Self-study | |
|---|---|---|---|---|---|---|---|---|
| | Lecture | 60 students | 0 | SCH | 0 | h | 0 | h |
| | Tuition in seminars | 30 students | 4 | SCH | 60 | h | 120 | h |
| | Exercise | 20 students | 0 | SCH | 0 | h | 0 | h |
| | Practical or seminar | 15 students | 0 | SCH | 0 | h | 0 | h |
| | Supervised self-study | 60 students | 0 | SCH | 0 | h | 0 | h |

**2 Learning outcomes/competences:**

The students know basic approaches for (especially financial) risk management in companies and have the ability to apply it in practice

**3 Contents:**

- Risk concept. History of risk management
- Significance and objectives of risk management
- Legal and institutional framework
- Risk types. Risk classification
- Organisation of risk management. Risk management as a process
- Techniques for risk identification
- Mathematical modelling of risks
- Risk aggregation and assessment
- Risk management strategies and techniques
- IT support for risk management. esp. simulation of operational processes
- Risk management as a building block for optimising the value chain in companies
- Individual issues of risk management (e.g. sector-specific structuring) and case studies

**4 Forms of teaching:**

Tuition in seminars

**5 Participation requirements:**

| | |
|---|---|
| Formal: | None |
| Content: | None |

**6 Forms of assessment:**

Written examination, oral exam or exam accompanying the course

**7 Prerequisite for the award of credit points:**

Module examination pass

**8 Application of the module (in the following study programmes)**

Optimisation and Simulation M.Sc.

**9 Importance of the grade for the final grade:**

according to MRPO

**10 Module Officer:**

Prof. Dr. rer. nat. Claudia Cottin

**11 Other information:**

Literature will be announced at the beginning of the course. Accompanying material is provided (e.g. short script and current professional articles). Literature source for mathematical aspects of the course in particular: C. Cottin, S. Doehler: Risikoanalyse, 2. Auflage. Springer

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|---|---|
| | Spektrum 2013. |
| 12 | Language:<br>German |

| Seminar | | | | | SE |
|---|---|---|---|---|---|
| Identification number: | Workload: | Credits: | Study semester: | Frequency of the offer | Duration: |
| 2013 | 180 h | 6 | 1st or 2nd semester | each semester | 1 semester |

| | Course: | Planned group sizes | Scope | | Actual contact time / classroom teaching | | Self-study | |
|---|---|---|---|---|---|---|---|---|
| 1 | Lecture | 60 students | 0 | SCH | 0 | h | 0 | h |
| | Tuition in seminars | 30 students | 0 | SCH | 0 | h | 0 | h |
| | Exercise | 20 students | 0 | SCH | 0 | h | 0 | h |
| | Practical or seminar | 15 students | 4 | SCH | 60 | h | 120 | h |
| | Supervised self-study | 60 students | 0 | SCH | 0 | h | 0 | h |

| | | |
|---|---|---|
| 2 | Learning outcomes/competences: | |
| | Students have developed their skills in written and oral presentation of technical topics by working on a given topic from the field of optimization and simulation, summarising it in writing, and presenting it in an approx. one-hour lecture | |
| 3 | Contents: | |
| | Selected topics on optimisation and simulation (partly in English) | |
| 4 | Forms of teaching: | |
| | Independent elaboration and presentation of a given topic | |
| 5 | Participation requirements: | |
| | Formal: | None |
| | Content: | None |
| 6 | Forms of assessment: | |
| | In-class examination | |
| 7 | Prerequisite for the award of credit points: | |
| | Module examination pass | |
| 8 | Application of the module (in the following study programmes) | |
| | Optimisation and Simulation M.Sc. | |
| 9 | Importance of the grade for the final grade: | |
| | according to MRPO | |
| 10 | Module Officer: | |
| | Prof. Dr. phil. Bernhard Bachmann | |
| 11 | Other information: | |
| | Literature will be announced at the beginning of the course. | |
| 12 | Language: | |
| | German | |

| Simulation of Optical Systems | | | | | SOS |
|---|---|---|---|---|---|
| Identification number: | Workload: | Credits: | Study semester: | Frequency of the offer | Duration: |
| 2016 | 180 h | 6 | 1st or 2nd semester | Annual (Summer) | 1 semester |

| 1 | Course: | Planned group sizes | Scope | | Actual contact time / classroom teaching | | Self-study | |
|---|---|---|---|---|---|---|---|---|
| | Lecture | 60 students | 2 | SCH | 30 | h | 60 | h |
| | Tuition in seminars | 30 students | 0 | SCH | 0 | h | 0 | h |
| | Exercise | 20 students | 2 | SCH | 30 | h | 60 | h |
| | Practical or seminar | 15 students | 0 | SCH | 0 | h | 0 | h |
| | Supervised self-study | 60 students | 0 | SCH | 0 | h | 0 | h |

| | |
|---|---|
| 2 | Learning outcomes/competences:<br>Recognise the basic concepts of optical systems for use in an industrial environment. Select suitable systems for different questions. Evaluate the operational capability in the respective environment. Solve selected problems from the field of optical systems. Design optical systems. Select suitable components. Exemplary implementation of selected tasks for optical systems. Develop application programmes for optical systems. Apply typical optics and image processing libraries. Name, interpret and design interacting light-generating and light-directing components. Enable students to develop their own solutions in application areas of optical systems. |
| 3 | Contents:<br>Selected areas of geometrical optics and wave optics. Overview of optical systems, Typical structure of selected optical systems, Industrial use of optical systems. Camera concepts: Interfaces, sensor principles, spectral sensitivity, optical sensors and measurement technology, optical device technology, imaging systems of sensor technology, two- and three-dimensional data acquisition, illumination principles, optics design and simulation. |
| 4 | Forms of teaching:<br>Seminar-based teaching with accompanying exercise |
| 5 | Participation requirements:<br>Formal: None<br>Content: None |
| 6 | Forms of assessment:<br>Written examination, combination examination, performance examination or oral examination |
| 7 | Prerequisite for the award of credit points:<br>Module examination pass |
| 8 | Application of the module (in the following study programmes)<br>Optimisation and Simulation M.Sc. |
| 9 | Importance of the grade for the final grade:<br>according to MRPO |
| 10 | Module Officer:<br>Prof. Dr.-Ing. Reinhard Kaschuba |
| 11 | Other information:<br>Literature will be announced at the beginning of the course. |
| 12 | Language:<br>German |

| System Simulation | | | | | SYS |
|---|---|---|---|---|---|
| Identification number: | Workload: | Credits: | Study semester: | Frequency of the offer | Duration: |
| 2009 | 180 h | 6 | 1st or 2nd semester | Annual (Summer) | 1 semester |

| 1 | Course: | Planned group sizes | Scope | | Actual contact time / classroom teaching | | Self-study | |
|---|---|---|---|---|---|---|---|---|
| | Lecture | 60 students | 2 | SCH | 30 | h | 60 | h |
| | Tuition in seminars | 30 students | 2 | SCH | 30 | h | 60 | h |
| | Exercise | 20 students | 0 | SCH | 0 | h | 0 | h |
| | Practical or seminar | 15 students | 0 | SCH | 0 | h | 0 | h |
| | Supervised self-study | 60 students | 0 | SCH | 0 | h | 0 | h |

**2 Learning outcomes/competences:**

The students know the basic methods for modelling (complex) technical systems and can apply these to new problems. They know how to prepare the models created and implement them on common system simulators, such as Matlab/Simulink. They can also plan simulation experiments systematically and carry them out in a targeted manner. Furthermore, they are able to assess the opportunities, limits and problems of a numerical simulation as well as analyse the results professionally.

**3 Contents:**

- Introduction (definitions, types of simulation, process models, goals)
- Modelling methods (balance-space based, formalisms for mech./electri. syst., cross-disciplinary techniques, experimental modelling)
- Model preparation for simulation (transfer to state representation, block diagram, linearisation, treatment of algebraic loops and structural singularities, descriptor form)
- Simulation procedures (classification, selection criteria, num. problems)
- Simulation experiments (planning, implementation and follow-up)
- Application examples

**4 Forms of teaching:**

Lectures and computer seminars

**5 Participation requirements:**

| Formal: | None |
|---|---|
| Content: | None |

**6 Forms of assessment:**

Term paper, written examination, combination examination, performance examination, project work, oral examination or examination during the course

**7 Prerequisite for the award of credit points:**

Module examination pass

**8 Application of the module (in the following study programmes)**

BioMechatronics M.Sc., Mechanical Engineering M.Sc. and Optimisation and Simulation M.Sc.

**9 Importance of the grade for the final grade:**

according to MRPO

**10 Module Officer:**

Prof. Dr.-Ing. Klaus Panreck

**11 Other information:**

Literature will be announced at the beginning of the course.

**12 Language:**

German

| Elective Module: Optimisation and Simulation | | | | | WM |
|---|---|---|---|---|---|
| Identification number: | Workload: | Credits: | Study semester: | Frequency of the offer | Duration: |
| 9023 | 180 h | 6 | 1st or 2nd semester | each semester | 1 semester |

| | Course: | Planned group sizes | Scope | | Actual contact time / classroom teaching | | Self-study | |
|---|---|---|---|---|---|---|---|---|
| 1 | Lecture | 60 students | | SCH | | h | | h |
| | Tuition in seminars | 30 students | | SCH | | h | | h |
| | Exercise | 20 students | | SCH | | h | | h |
| | Practical or seminar | 15 students | 0 | SCH | 0 | h | 0 | h |
| | Supervised self-study | 60 students | | SCH | | h | | h |

| | | |
|---|---|---|
| 2 | Learning outcomes/competences: | |
| 3 | Contents: | |
| 4 | Forms of teaching: | |
| 5 | Participation requirements: | |
| | Formal: | |
| | Content: | |
| 6 | Forms of assessment: | |
| 7 | Prerequisite for the award of credit points: | |
| 8 | Application of the module (in the following study programmes)<br>Optimisation and Simulation M.Sc. | |
| 9 | Importance of the grade for the final grade: | |
| 10 | Module Officer:<br>Prof. Dr.-Ing. Rolf Naumann | |
| 11 | Other information: | |
| 12 | Language:<br>German | |