Fakultät für Maschinenbau

Module Handbook for the Masters Program Systems Engineering for Manufacturing

Modulhandbuch für den Masterstudiengang Systems Engineering for Manufacturing

zur
Studien- und Prüfungsordnung vom 06.02.2020
(Datum des Fakultätsratsbeschlusses)

bis Immatrikulation Wintersemester 2022-23
until enrollment winter semester 2022-23

Version: 08.06.2023

Inhaltsverzeichnis (Table of contents)

1 Einleitung

Dieses Modulhandbuch richtet sich an Studenten des Masterstudienganges "Systems Engineering for Manufacturing" vom 06.02.2020 (Datum des Fakultätsratsbeschlusses).

In diesem Masterstudiengang ist die Lehre fachübergreifend auf die Fachgebiete mit Relevanz für Produktionssysteme fokussiert. Damit werden Fähigkeiten zur standortübergreifenden Entwicklung neuer Produktionssysteme auf Basis der in ihnen zu fertigenden Produkte sowie zur Life Cycle Beherrschung von Produktionssystemen herausgebildet.

Der Studiengang adressiert die methodischen Grundlagen zur Entwicklung von Produktionssystemen nach dem Paradigma der Systems of Systems. Er vermittelt dabei zum einen die fachlichen Grundlagen zum Entwurf und zur Steuerung von Produktionssystemen und ermöglicht zum anderen die Identifikation und bewusste Nutzung der Abhängigkeiten zwischen den einzelnen Teilaspekten eines Produktionssystems.
Zusätzlich werden sprachliche Kenntnisse vermittelt, die eine Anwendung des erlernten Wissens in internationalen Kontexten ermöglicht.

Das Lehrangebot im Studiengang "Systems Engineering for Manufacturing " umfasst neben anderen Umfängen den Pflicht-, den Wahlpflicht- und den E-Learning-Bereich.

Der Pflichtbereich besteht aus Pflichtmodulen. Als Pflichtmodule werden alle Module bezeichnet, die nach Prüfungs- und Studienordnung für den erfolgreichen Abschluss des Studiums zwingend erforderlich sind. Kapitel 2 dieses Modulhandbuchs definiert alle Lehrveranstaltungen, die als Pflichtmodule dem Pflichtbereich des Studienganges zugehörig sind.

Der Wahlpflichtbereich besteht aus Wahlpflichtmodulen. Als Wahlpflichtmodule werden alle Module bezeichnet, die Studierende nach Maßgabe der Prüfungs- und Studienordnung aus dem Wahlpflichtbereich auszuwählen haben.

1 Introduction

This module handbook is intended for the students participating in the masters program "Systems Engineering for Manufacturing" of 06.02.2020 (date of faculty decision).

This master's program provides interdisciplinary education in scientific fields relevant for engineering and use of production systems. It provides knowledge and skills related to the location crossing engineering of new production systems based on the products to be manufactured as well as to life-cycle management of production systems.

The master’s program covers the methodical basis for the engineering of production systems exploiting the paradigm of systems of systems. It provides expertise for the engineering and control of production systems and enables the identification and meaningful application of dependencies between different parts and/or aspects of production systems.
In addition lingual skills are provided enabling the application of the gained knowledge within international contexts.

The curriculum of the masters program “Systems Engineering for Manufacturing” consists (among others) of compulsory, compulsory chosen, and e-learning areas.

The compulsory area consists of compulsory modules. Compulsory modules are modules which are mandatory for the successful finalization of the master’s program following Study and Examination Regulations. Section 2 of this module handbook subsumes all lectures belonging as compulsory modules to the compulsory area.

The compulsory chosen area consists of compulsory chosen modules. The compulsory chosen modules are named compulsory chosen if they are selectable by students out of the compulsory chosen lecture set.

Der Wahlpflichtbereich ist in verschiedene fachspezifische Teilbereiche gegliedert. Die dabei wählbaren Fachbereiche sind die Fachbereiche:

- Mechanik
- Digitale Systeme
- Automation
- Logistik
- Fertigungstechnik
- Informatik
- Wissenschaftliche Grundlagen

Kapitel 3 dieses Modulhandbuchs definiert alle Lehrveranstaltungen, die als Wahlpflichtmodule dem Wahlpflichtbereich des Studienganges zugehörig sind.

Der E-Learning-Bereich besteht aus Modulen, die neue, insbesondere Internet basierte Lehrmedien zur Wissensvermittlung nutzen.

Kapitel 4 dieses Modulhandbuchs spezifiziert alle Lehrveranstaltungen, die dem E -Learning- Bereich zugeordnet werden können.

Kapitel 5 dieses Modulhandbuch spezifiziert alle Anforderungen an das Fachpraktikum.

Kapitel 6 dieses Modulhandbuch spezifiziert alle Anforderungen an die Masterarbeit.

The compulsory chosen modules are arranged in the different scientific areas. The applicable areas are the following:

- Mechanics
- Digital systems
- Automation
- Logistics
- Manufacturing technology
- Information sciences
- Scientific Basics

Section 3 of this module handbook subsumes all lectures belonging as compulsory chosen modules to the compulsory chosen area.

The e-learning area consists of modules covering new, especially Internet based learning media for knowledge acquisition.

Section 4 of this module handbook defines requirements to all lectures possibly being accepted within the e-learning area
.

Section 5 of this module handbook defines requirements to the internship.

Section 6 of this module handbook defines requirements to the master thesis.

2 Pflichtbereich

Der Pflichtbereich besteht aus den nachfolgend genannten Pflichtmodulen.
Entsprechend ist das erfolgreiche Absolvieren gemäß der Studien- und Prüfungsordnung für alle nachfolgend genannten Module für den erfolgreichen Abschluss des Studiums zwingend erforderlich.

2 Compulsory area

The compulsory area consists of the following compulsory modules.
For all modules named in the following it is necessary to successfully pass all modules following the Study and Examination Regulations for the successful finalization of the master's program.

2.1 Mechanics of Materials

Name of Modul German title	Mechanics of Materials Werkstoffmechanik
Teaching aims and content of the module	Teaching aims and competences to be gained: The course is devoted to the basics of material behavior modeling. The starting point is the experiment. In addition, the main features from materials science will be presented. Finally, the experimental observations and the materials science feature will be "translated" into mathematical equations. Contents: Elastic behavior of isotropic and anisotropic materials Inelastic behavior Damage Fracture
Type of lecture	Lectures; Seminars
Literature	J. Rösler, H. Harders, M. Bäker: Mechanical Behaviour of Engineering Materials, Teubner, Springer, 2003 D. Gross, Th. Seelig: Fracture Mechanics, Springer, Berlin, 2011 J. Lemaitre, J.-L. Chaboche: Mechanics of Solid Materials, Cambridge University, Press, Cambridge, 1994
Preconditions for attending	Engineering Mechanics, Materials Science
Usability of module	M-SEM
Prerequisites for the provision of ECTS	Attending of exercises Examination: oral
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	2 hours per week lecture, 2 hours per week exercises
Frequency of provision	SoSe
Duration of module	1 semester
Responsible for the curriculum	Prof. Altenbach, FMB-IFME
Responsible lecturer	Prof. Altenbach, FMB-IFME, apl. Prof. Naumenko, FMB-IFME

2.2 Systems engineering for Manufacturing Systems

Name of module	Systems engineering for Manufacturing Systems
German title	Systementwurf für Produktionssysteme
Teaching aims and content of the module	Teaching aims and competences to be gained: • Methods and processes for engineering and implementation of production systems and control systems embedded within them • Basics for mechatronical engineering of production systems • Basic knowledge and basic skills for application of object oriented methods for production system engineering • Basic knowledge related to description/modelling means for production systems and its application
	Contents: • Basic terms: Engineering problem, structures of production systems, control structures and control layers, design pattern, mechatronical unit • Engineering methodologies: VDI Guideline 2221, AutomationML reference process, VDI Guideline 2206, Munich model • Optimization of engineering processes: Modelling/Analysis of engineering processes, VDI Guideline 3695 • Object orientation and their applicability to mechatronical systems: Basic terms of object orientation, Description of mechatronical units by objects, Advantages and disadvantages of object orientation within the engineering of production systems, • Modelling means: UML, SysML • Data exchange using AutomationML
Type of lecture	Lecture and lecture accompanying exercises Writing and review of a short survey paper
Literature	See first lecture
Preconditions for attending	
Usability of module	M-SEM
Prerequisites for the provision of ECTS	Scientific project consisting of written exam (90 min) and homework
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Presence times: 2 SWS lecture, 1 SWS exercises Self-reliant work: pre- and post-preparation of lectures, study of literature, execution of exercises
Frequency of provision	WiSe
Duration of module	1 Semester
Responsible for the curriculum	Prof. Dr.-Ing. habil. Arndt Lüder, FMB-IAF
Responsible lecturer	Prof. Dr.-Ing. habil. Arndt Lüder, FMB-IAF

2.3 Material Handling Systems

Name of module	Material Handling Systems
German title	Materialhandlingsysteme
Teaching aims and content of the module	Teaching aims and competences to be gained: • Understanding of complex material handling systems and its parts of continuous and non-continuous conveyor units • Ability to calculte working cycles and through put rates for the arbitrary material handling systems • Ability to identify through put bottle necks of material handling systems with different arrival times. • Understanding of prediction possibilities for the availability and reliability of material handling systems
	Contents: • Introduction to the basic elements of material handling systems • Working cycle calculation for non-continuous conveyors • Through put calculation for systems with deterministic and stochastic arrival times • Availability and reliability calculation
Type of lecture	Lectures and tutorials
Literature	See first lecture
Preconditions for attending	Statistics, Physics, Engineering Mechanics
Usability of module	M-SEM
Prerequisites for the provision of ECTS	• Attendance at the lecture and tutorials • proof of achievements • Written exam (90 min)
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Presence times: 2 SWS lecture, 1 SWS exercises Self-reliant work: pre- and post-preparation of lectures, study of literature, execution of exercises
Frequency of provision	WiSe
Duration of module	1 Semester
Responsible for the curriculum	Prof. Katterfeld, FMB-ILM
Responsible lecturer	Prof. Katterfeld, FMB-ILM

2.4 Modelling and Simulation of Mechatronic Systems

Name of module	Modelling and Simulation of Mechatronic Systems
German title	Modellierung und Simulation Mechatronischer Systeme
Teaching aims and content of the module	Teaching aims and competences to be gained: • Programming with MATLAB • Basic of numerical simulation • Basics on modelling of mechatronical systems • Basics on simulation of mechatronical systems • Modelling and simulation with SIMULINK
	Contents: • Introduction to MATLAB programming • Introduction to numeric simulations using MATLAB and SIMULINK • Modelling of mechanical, electrical, and information processing systems using block diagrams • Step by step development of models • Simulation experiments using SIMULINK
Type of lecture	Lectures; Seminars; practicals in small groups
Literature	See LSF
Preconditions for attending	
Usability of module	M-SEM
Prerequisites for the provision of ECTS	Attending of practicals, passing of 3 attestations Written Exam (120 min)
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	1 hour per week lecture, 1 hour per week exercises, 1 hour per week practicals Review lecture notes and development of homework
Frequency of provision	WiSe
Duration of module	1 semester
Responsible for the curriculum	Prof. S. Schmidt, FMB-IMS
Responsible lecturer	Prof. S. Schmidt, FMB-IMS, Dr.-Ing. R. Dariani (Lehrauftrag)

2.5 Material Selection

Name of module	Material Selection
German title	Materialauswahl
Teaching aims and content of the module	Teaching aims and competences to be gained: • Basic knowledge of structures and properties of materials • Basics and advanced knowledge of the data base module CES (Cambridge Engineering Selector) • Fundamental knowledge of the working principles of material selection and material substitution • Advanced knowledge of materials selection for specific applications
	Contents: • Structure of materials • Properties of materials • Basics of material processing • data base content of the CES software package • functions and working principles of the CES software package • practical examples of material selection • practical examples of material substitution
Type of lecture	Lecture and lecture accompanying exercises
Literature	See first lecture
Preconditions for attending	
Usability of module	M-SEM
Prerequisites for the provision of ECTS	written exam (90 min)
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Presence times: 2 SWS lecture, 1 SWS exercises Self-reliant work: pre- and post-preparation of lectures, study of literature, execution of exercises
Frequency of provision	SoSe
Duration of module	1 Semester
Responsible for the curriculum	Prof. Thorsten Halle, FMB-IFW
Responsible lecturer	Prof. Thorsten Halle, FMB-IFW, Prof. Michael Scheffler, FMB-IFW

3 Wahlpflichtbereich

Der Wahlpflichtbereich besteht aus den Fachbereichen

- Mechanik
- Digitale Systeme
- Automation und Ergonomie
- Logistik
- Fertigungstechnik
- Informatik
- Wissenschaftliche Grundlagen

mit den nachfolgend genannten Wahlpflichtmodulen.

Gemäß Studien- und Prüfungsordnung müssen für einen erfolgreichen Studienabschluss aus dem Wahlpflichtbereich aus drei Fachbereichen so viele Wahlpflichtmodule erfolgreich absolviert werden, dass die Summe in den einzelnen Fachbereichen 10 CP ergibt.

Zudem muss gemäß Studien- und Prüfungsordnung für einen erfolgreichen Studienabschluss zwei frei wählbare Module im Umfang von 10 CP erfolgreich absolviert werden.

Als frei wählbares Modul kann jedes an der Otto-von-Guericke Universität gehaltene Modul mit mindestens 5 CP gewählt werden.

3 Compulsory chosen area

The compulsory chosen area consists of the scientific areas

- Mechanics
- Digital systems
- Automation and Ergonomics
- Logistics
- Manufacturing technology
- Information sciences
- Scientific basics

with the following compulsory modules.

Following the Study and Examination Regulations it is mandatory to pass at least as much modules out of three of these areas that the sum of the CPs of the modules successfully passed in each of the selected scientific areas reaches 10 CPs.

Additionally, following the Study and Examination Regulations it is mandatory to pass two free selectable modules with a volume of 10 CP successfully.

As free selectable module any module can be accepted provided at Otto-von-Guericke University in a volume of at least 5 CP.

3.1 Fachbereich Mechanik / Scientific area Mechanics

3.1.1 Simulation methods of dynamical systems

Name of module German title	Simulation methods of dynamical systems
	Simulationsmethoden dynamischer Systeme
Teaching aims and content of the module	Teaching aims and competences to be gained: • Detailed knowledge concerning modelling of dynamic systems • Comprehensive understanding concerning the solution of dynamic problems, time integration, eigenvalue analysis • Understanding of the general spatial description of dynamic systems (rigid and flexible) • Knowledge concerning model reduction • Consideration and assessment of nonlinearities in dynamical systems, understanding of the basic differences of linear and non-linear dynamic system • Ability to evaluate and analyse the results of numerical simulations
	Contents: • Basics of vibration dynamics (oscillator with n degrees of freedom • Time integration methods, eigenvalue calculation methods • Basics of spatial dynamics • Rigid and flexible multibody systems • Linear and non-linear dynamic systems, jump phenomena • Working with different program systems like EMD or SIMPACK
Type of lecture	Lectures, exercises
Literature	See first lecture
Preconditions for attending	Recommended: Knowledge of mechanical vibrations, basics of machine dynamics
Usability of module	M-SEM
Prerequisites for the provision of ECTS	Examination: Written examination (120 min)
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Office hours: 2 SWS lectures, 2 SWS exercises Independent work: follow-up of the lecture, exercise self-employment
Frequency of provision	WiSe
Duration of module	One semester
Responsible for the curriculum	Prof. Woschke, FMB-IFME
Responsible lecturer	Prof. Woschke, FMB-IFME, Dr. Daniel, Dr. Nitzschke, FMB-IFME

3.1.2 Engineering Design

Name of module	Engineering Design
German title	CAx-Grundlagen Industriedesign
Teaching aims and content of the module	Teaching aims and competences to be gained: • Under the umbrella of Engineering Design the development, calculation and design of Engineering Systems will be discussed. At necessary length, some important Machine Elements will be reviewed with relevance to the overall design process. The lectures will be in close relation to the homework and semester project • Knowledge: Students learn to engineer a complete system and understand and appreciate, what disciplines are needed to design an engineering system. The taught approach is independent from certain engineering branches. • Skills: The course provides various engineering design approaches, where all requirements, boundary conditions and expected outcomes are considered and evaluated to find the solution for an engineering task, that best fits the problem definition. • Competence: The students will be able to work in various engineering branches and is prepared to attack and solve an engineering design problem, work in a team of engineers with different, needed special experiences. The course will enable students to take leading functions in a team of engineers.
	Contents: • Introduction • Design problem definition • Fundamentals of creative thinking • Generation of alternative solutions • Fundamentals of technical systems and consequences for the design process • Product planning and clarification of the task • Listing the functional requirements and constraints • Establishing function structures • Methods for searching for solution principles to fulfill the functions • Selecting suitable combinations of solution principles • Evaluating concept variants • Principles of embodiment design • Design guidelines • Size ranges and modular products • Some Machine Elements will be discussed, respectively reviewed, within the outline of the above topics.
Type of lecture	The course will be carried out through lectures and laboratory/seminar sessions. Students will have to work on a defined lecture – accompanying individual semester project and a selected design project. Here students have to present their project at the different stages of their design. This work is usually done in a team of up to five students. Both projects must be presented and submitted in a project report. The team project might have to be presented to class and the presentation will be evaluated.
Literature	"PAHL/BEITZ: Engineering Design", 2nd or 3rd English Edition “Handbook of Mechanical Engineering” both Springer-Verlag (Berlin, Heidelberg, Tokyo, New York)
Preconditions for attending	
Usability of module	M-SEM

Prerequisites for the provision of ECTS	• The defined lecture project counts for 30% of the grade, the selected design project for another 30% and the final exam for 40% (written exam 60 min) of the grade. • Important: The conditions of the design project MUST be met, in order to be admitted to the Final Exam! • All work has to be submitted in English. • Permitted items at the exam: All self written lecture notes, calculator and tables and standards
ECTS and marks	10 CP Marks according to Study and Examination Regulations
Efforts	Attendance times: 2 SWS lecture, 2 SWS exercises (per semester) Self-reliant work: Preparation and wrap-up of lectures, literature studies, projects
Frequency of provision	WiSe, SoSe
Duration of module	2 Semesters
Responsible for the curriculum	Prof. Dr.-Ing. Christiane Beyer
Responsible lecturer	Prof. Dr.-Ing. Christiane Beyer

3.1.3. Mechanics of Lightweight Structures

Name of Modul	Mechanics of Lightweight Structures
German title	Mechanik der Leichtbaustrukturen
Teaching aims and content of the module	Learning objectives and skills acquired: The learning objective is the competence to formulate and use suitable calculation methods for lightweight structures made, for example, of composite materials. The aim is to convey the basics required for practical application in engineering. The focus is on long fiber composites, short fiber reinforced plastics and foams. Starting from the basics of structural mechanics, the influence of inhomogeneity and anisotropy of the used materials will be discussed. The possibilities and limits of numerical simulation are presented.
	Content • Introduction to the theory of elastic plates and shells • Consideration of anisotropies in the elastic material law • Large deformations of plates and shells • Direct variation methods • Fiber types, matrix materials as well as interfaces and coatings • Micromechanics for long fiber composites • Behavior of a single layer • Laminate calculation: Classical layer theory • Higher order laminate theories • Short fiber reinforced plastics • Foams for sandwich structures
Type of lecture	Lectures, exercises on selected issues and lectures on special topics
Literature	Altenbach, H., Altenbach, J., Kissing, W., Mechanics of composite structural elements. Springer, Heidelberg, 2018
Preconditions for attending	Mechanics of Materials or BSc from the Mechanical Engineering Faculty
Usability of the module	according to the module handbook
Prerequisites for the provision of ECTS	Attending of exercises Examination: oral
ECTS and marks	5 CP Grading according to the examination regulation
Effort	2 hours per week lectures, 2 hours per week exercises
Frequency of provision	Summer semester (SoSe)
Duration of module	1 semester
Responsible for the curriculum	apl. Prof. Naumenko, FMB-IFME
Responsible lecture	apl. Prof. Naumenko, FMB-IFME

3.2 Fachbereich Digitale Systeme / Scientific area Digital systems

3.2.1 Finite Element Method

Name of module	Finite Element Method
German title	Finite Elemente Methode
Teaching aims and content of the module	Teaching aims and competences to be gained: The participants will gain experience in the use of the finite element method (FEM) as a computational method for solving complex systems of differential equations, which are essential in engineering problems. FEM is an effective tool for solving problems in structure and solid mechanics. The students will be taught in the proceeding of assembling the structure problem, its discretization and solving within the FEM. The students experience the exposure to finite element software like Ansys.
	Contents: • Fundamentals of the boundary value problem in solid mechanics • Variation calculus and weak form • FE discretization and shape functions • Isoparametric truss elements • Plane finite elements • Volume elements • Extended element technology
Type of lecture	Lectures and exercises
Literature	
Preconditions for attending	Good skills in mechanics and mathematics
Usability of module	M-SEM
Prerequisites for the provision of ECTS	Passing the exam written examination (90 min)
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Time of attendance: • Lecture: 2 SWS • Excercise: 2 SWS Independent work on an individual proof, which is considered in the final grade.
Frequency of provision	WiSe
Duration of module	1 semester
Responsible for the curriculum	Prof. Dr.-Ing. Daniel Juhre
Responsible lecturer	Prof. Dr.-Ing. Daniel Juhre

3.2.2 CAX Basics

Name of module	CAx Basics
German title	CAx-Grundlagen
Teaching aims and content of the module	Teaching aims and competences to be gained: • Basic knowledge of computer-aided tools and systems in product development • Knowledge of product models for developing and modelling products • Learning general procedures for 3D modelling • Competences to familiarise quickly with CAx systems • Knowledge of product development interfaces • Basic knowledge of storage and archiving of product data and documents • Acquiring of basic comprehensions of Product Lifecycle Management (PLM)
	Contents: • Current situation in product development • Product development and computer assistance • Tools and systems of computer support • Components of a CAx system • CAx systems • Auxiliary functions in CAx • Product model definition • Types of product models • Procedures for 3D modelling • Archiving, interfaces, product data management • Product Lifecycle Management (PLM)
Type of lecture	Lectures and CAx exercises accompanying lectures
Literature	See introduction lecture
Preconditions for attending	
Usability of module	M-SEM
Prerequisites for the provision of ECTS	Written exam on the lecture content (120 min), CAD exam (90 min)
ECTS and marks	5 CP Marks according to Study and Examination Regulations
Efforts	Attendance times: 2 SWS lecture, 2 SWS exercises Self-reliant work: Preparation and wrap-up of lectures, literature studies, working on CAD exercises
Frequency of provision	SoSe
Duration of module	1 Semester
Responsible for the curriculum	Prof. Dr.-Ing. Christiane Beyer, FMB-IMK
Responsible lecturer	Dr.-Ing. Dipl.-Math. Michael Schabacker, FMB-IMK

3.2.3 Modeling and Simulation in Logistics Planning

Name of module	Modeling and Simulation in Logistics Planning
German title	Modellierung und Simulation in der Logistikplanung
Teaching aims and content of the module	Teaching aims and competences to be gained: • Provide students with knowledge and skills for applying appropriate simulation concepts and simulation-based optimization to solve planning and decision problems in production and logistics • Identify problems in production and logistics where simulation and simulation-based optimization can be successfully applied • Enable students to apply the role of a competent principal in all phases of simulation studies • Enable students to work with different simulation tools like Plant Simulation, AnyLogic, ExtendSim
	Contents: • Typical problems in production and logistics planning where simulation and simulation-based optimization can be applied • Phases of a simulation study: Goal description, task specification, conceptual modeling, data acquisition, model implementation, validation and verification, experiments • Three simulation paradigms: Discrete-event simulation, discrete-rate simulation, system dynamics simulation • Simulation-based optimization • Further topics: Agent-based simulation, machine learning, visualization, automated model creation, simulation in cyber physical systems in industry 4.0, supply chain simulation
Type of lecture	Lectures and exercises with related scripts and exercise guidelines
Literature	Own script and further reading provided during the semester
Preconditions for attending	Bachelor WLO or WMB or similar
Usability of module	M-SEM
Prerequisites for the provision of ECTS	Participation at lecture and exercises Scientific project (consisting of different assignments)
ECTS and marks	5 CP Marks according to Study and Examination Regulations
Efforts	Attendance times: 2 SWS lecture, 2 SWS exercises Self-reliant work: Wrap-up of lectures, Preparation of exercises and conducting scientific project
Frequency of provision	SoSe
Duration of module	1 Semester
Responsible lecturer	Dr. T. Reggelin, FMB-ILM

3.3 Fachbereich Automation / Scientific area Automation

3.3.1 Advanced Applications of Industry 4.0-Technologies

Name of module	Advanced Applications of Industry 4.0-Technologies
German title	Komplexe Anwendungen von Industrie 4.0-Technologien
Teaching aims and content of the module	Teaching aims and competences to be gained: *Overall goal:* The module introduces students to the application fields of industry 4.0 technologies, namely applications, services in and business models the fields of production, logistics and mobility. By means of several case studies, students develop a clear understanding of complex application fields and the relevant technologies, trends and emerging business models relevant to production companies. After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> • Relevant trends and challenges of production and retail companies • Meaning of industry 4.0-technologies for industrial production and value creation networks • Identification of application fields, evaluation of potentials and risk as well as implementation strategies <u>Abilities / Skills</u> • Phases and management of digitalization projects • Application of frameworks and tools for the analysis, development and optimization of existing business model generation <u>Competencies</u> • Students can evaluate the impact of global trends on the situation of retail, production and logistics companies • Students can explain how industry 4.0-technologies can contribute to make production and logistics processes more efficient
	Content: The term "industry 4.0" has its origin in the fourth industrial revolution and the current trend of automation, data interchange and digitalization in the field of industrial production. The term encompasses the use of Cyber-Physical Systems, the Internet of Things and Cloud Computing. Today, the vision of industry 4.0 goes for beyond production and also incorporates concepts, such as intelligent products, smart mobility solutions, smart logistics and smart buildings. European companies expect productivity gains of up to 30% to balance disadvantages resulting from high wages and high energy cost. In this, industry 4.0 stands This course introduces students to the more complex application fields of industry 4.0-technologies. This includes next to the technical aspects, the evaluation of potentials and risk, project management and change management tasks and the corresponding business models design. Students learn how to evaluate the recent level of digitalization in a company and identify potentials and risk of automation and digitalization. Students get insights into a successful project management for a digitalization project and learn about the importance of change management in this context. One major focus will be given to the development of business models as well as to the adaption of existing research models in the context of industry 4.0.
Type of lecture	Lecture and lecture accompanying group works, case studies and exercises
Literature	See first lecture
Preconditions for attending	Basic understanding of industrial production and digitalization technologies.
Usability of module	M-SEM
Prerequisites for the provision of ECTS	Group case studies Scientific project: Case study - written assignment and group presentation
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Presence times: 2 SWS lecture, 1 SWS exercises Self-reliant work: pre- and post-preparation of lectures, study of literature,

	case study
Frequency of provision	WiSe
Duration of module	1 Semester
Responsible for the curriculum	Prof. Dr.oec. J. Arlinghaus
Responsible lecturer	Prof. Dr.oec. J. Arlinghaus

3.3.2 Factory automation and industrial robotics

Name of module	Factory automation and industrial robotics
German title	Fabrikautomation und Industrieroboter
Teaching aims and content of the module	Teaching aims and competences to be gained: • Provision of knowledge about methods and technologies for engineering and implementation of automated production processes • Provision of knowledge about capabilities and limitations of the application of automation systems • Provision of programming skills for programmable logic controllers • Provision of programming skills for industrial robots
	Contents: • Terms, aims, limitations, and basic structures • Reference process for production system engineering integrating automation system engineering and industrial robots cell engineering • Classification and identification of technical processes • The control loop and its duties • Modelling of technical systems based event-discrete models • Structure and behavior of programmable logic controllers • IEC 61131-3 programming languages for programmable logic controllers • Structure and behavior of industrial robots • Programming technologies for industrial robots
Type of lecture	Lecture and lecture accompanying exercises, Implementation of a control project
Literature	K.H. John, M. Tiegelkamp: IEC 61131-3 - Programming Industrial Automation Systems, Springer, Berlin, 2014 Lunze, J.: Automatisierungstechnik, Oldenbourg Verlag, 2. Auflage, 2008
Preconditions for attending	
Usability of module	M-SEM
Prerequisites for the provision of ECTS	Written exam (90 min) Advanced provisions: Successful development of a PLC control project, Exercise credits
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Presence times: 2 SWS lecture, 1 SWS exercises Self-reliant work: pre- and post-preparation of lectures, study of literature, execution of exercises
Frequency of provision	SoSe
Duration of module	1 Semester
Responsible for the curriculum	Prof. Dr.-Ing. habil. Arndt Lüder, FMB-IAF
Responsible lecturer	Prof. Dr.-Ing. habil. Arndt Lüder, FMB-IAF

3.4 Fachbereich Logistik / Scientific area Logistics

3.4.1 Supply Networks

Name of module German title	Supply Networks
	Logistische Netzwerke
Teaching aims and content of the module	Teaching aims and competences to be gained:: • Requirements in logistics networks • Holistic optimization of logistics networks • Advantages and drawbacks, limits of logistics networks • Data acquisition, SWOT analysis, scenario evaluation • Network planning in theory and practice
	Contents: • Logistics service market • Challenges in supply networks • Supply Chain Design, Planning, Execution, Controlling • Variant and inventory management • Logistics service providers as designers of supply networks • Network planning using the 4flow vista software • Scenario-based optimization of logistics networks • Best practices of industry, trade and logistics service providers
Type of lecture	Lectures and exercises with scripts and exercise guides, seminars and projects.
Literature	Lecture and exercise notes. Baumgarten; Darkow; Zadek (Hrsg.): Supply Chain Steuerung und Services; ISBN 3-540-44308-8
Preconditions for attending	
Usability of module	
Prerequisites for the provision of ECTS	Examinations by writing a term paper (Case study, simulation, presentation etc.) and scientific project
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Lectures / Exercises: 2 SWS Lecture revision, preparing and studying of exercises and writing the term paper
Frequency of provision	SoSe
Duration of module	1 semester, course can be offered en bloc. Module in English.
Responsible for the curriculum	Prof. Zadek FMB-ILM
Responsible lecturer	Prof. Zadek FMB-ILM; Dr. J. Janmontree, FMB-ILM

3.4.2 Collaboration in Supply Networks

Name of module German title	Collaboration in Supply Networks
	Zusammenarbeit in Lieferantennetzwerken
Teaching aims and content of the module	Teaching aims and competences to be gained: • Information deficiencies in logistics networks • Coordination and controlling deficiencies in networks • Technical and power-political roles in networks • Approaches and rules of behavior • Solution-oriented negotiating / Contract negotiations
	Contents: • Challenges in collaborative management • Win-win-partnerships and their benefits • Cost-Benefit-Sharing • Culture of trust and rules • Collaborative IT-Tools for controlling supply networks • Key Performance Indicator System • Interactive role-playing • Best practices of industry, trade and logistics service providers
Type of lecture	Lectures and exercises with appropriate notes and instructions
Literature	Lecture and exercise notes. Baumgarten; Darkow; Zadek (Hrsg.): Supply Chain Steuerung und Services; ISBN 3-540-44308-8
Preconditions for attending	
Usability of module	
Prerequisites for the provision of ECTS	Examinations by writing a term paper (Case study, simulation, presentation etc.) and scientific project
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Lectures / Exercises: 2 SWS Lecture revision, preparing and studying of exercises and writing the term paper
Frequency of provision	SoSe
Duration of module	1 Semester, course can be offered en bloc. Module in English.
Responsible for the curriculum	Prof. Zadek, FMB-ILM
Responsible lecturer	Prof. Zadek, FMB-ILM; Dr. J. Janmontree, FMB-ILM

3.4.3 Handling and Logistics of Bulk Materials

Name of the modulus German title	Handling and Logistics of Bulk Materials Transport und Logistik von Schüttgütern
Teaching aims and content of the module	Teaching aims and competences to be gained: • Understanding of the economic importance of bulk materials as primary resources for manufacturing, chemical and agricultural industry as well as energy production • Understanding of typical supply chains of bulk materials, the technological demands of bulk materials logistics and the complexity of handling plants. • Understanding of the basic physics of bulk materials which made the handling of bulk materials much more difficult in comparison to general cargo. • Ability to identify and understand the function of the most important storage and continuous conveying systems for bulk materials. • Ability to calculate the throughput and power consumption of important continuous conveying systems for bulk materials • Ability to identify critical zones in complex bulk material handling plants regarding throughput bottle necks, blockage, wear and dust with DEM simulations.
	Contents: • Introduction to the bulk material logistics and complex handling plants from an international perspective • Mechanics of bulk materials • Storage of bulk materials • Design, function and calculation of important continuous conveyors • Introduction to the Discrete Element Method (DEM) for the simulation of critical zones in bulk material handling plants
Type of lecture	Lectures and tutorials
Literature	See first lecture
Preconditions for attending	Recommended: Modul Material Handling Systems
Usability of module	according to module handbook
Prerequisites for the provision of ECTS	• Attendance at the lecture and tutorials • proof of achievements • Written exam (90 min)
ECTS and marks	5 CP, Marks following Study and Examination Regulations
Efforts	Presence times: 2 SWS lecture, 1 SWS exercises Self-reliant work: pre- and post-preparation of lectures, study of literature, execution of exercises
Frequency of provision	SoSe
Duration of module	1 Semester
Modulus responsibility	Prof. Katterfeld, FMB-ILM

3.5 Fachbereich Fertigungstechnik / Scientific area Manufacturing technology

3.5.1 Micromanufacturing Technologies

Name of module	Micromanufacturing Technologies
German title	Mikrofertigungstechnik
Teaching aims and content of the module	After successful participation students will be able to: • Classify micro manufacturing technologies within the field of manufacturing technologies and describe special challenges of micro manufacturing • Describe properties, methods and applications of ablating technologies and cutting technologies • Explain and evaluate particularities of machining technologies for micro manufacturing • Describe ablating technologies and cutting technologies applicable in micro manufacturing • Describe particularities of process chain design in micro manufacturing technologies and design process chains exemplary
	Contents: • Introduction in micro manufacturing technologies: classification, process chains, scaling effects • Ablating technologies: classification, electrochemical machining, electrical discharge machining, laser beam machining • Cutting technologies: classification, general basics and basics of micro cutting, cutting with geometrically determined cutting edges, cutting with geometrically undetermined cutting edges
Type of lecture	Lectures and exercises with appropriate notes and instructions
Literature	• Rembold, U.; Fatikow, S.: Microsystem Technology and Microrobotics, Springer Berlin Heidelberg 2010 • Precision Engineering, Journal, Elsevier • Microsystem Technologies, Journal, Springer Nature
Preconditions for attending	Basic knowledge in manufacturing technologies
Usability of module	M-SEM
Prerequisites for the provision of ECTS	Examination as 120 minutes written exam
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Presence times: 2 SWS lecture, 1 SWS exercises Self-reliant work: pre- and post-preparation of lectures, e-learning
Frequency of provision	SoSe
Duration of module	1 Semester
Responsible for the curriculum	Prof. Hackert-Oschätzchen, FMB-IFQ
Responsible lecturer	Prof. Hackert-Oschätzchen, FMB-IFQ

3.5.2 Design and Additive Manufacturing Processes

Name of module	Design and Additive Manufacturing Processes
German title	Design und additive Fertigungsprozesse
Teaching aims and content of the module	Teaching aims and competences to be gained: • Learn the fundamentals of Additive manufacturing of polymers, metals, and ceramics, along with those for emerging materials (e.g., nanocomposites, biomaterials) and complex architectures. • Understand the operating principles, capabilities, and limitations of state-of-the-art AM methods, including Fused Deposition Modeling, Stereolithography, Laser Sintering/Melting, Jetting, Hybrid, a.o. • Become familiar with the complete workflow of AM, including computational design tools, file formats, toolpath generation, scanning, and microstructure characterization. • Understand key design rules for parts made by AM, and compare and contrast AM processes with conventional manufacturing methods such as machining and molding in terms of rate, quality, cost, and flexibility. • Be able to identify unique requirements within the entire design-to-manufacture process and select the best AM technology and optimize its benefits. • Preserve an understanding of current methods of nondestructive inspection/testing (NDI/NDT) and AM-Standards. • Gain hands-on experience with a variety of AM machines; use these machines to fabricate example parts, post-process the parts, and study the results. • Study applications of AM across industries, including aerospace/automotive, biomedical devices, energy, electronics, and consumer products.

	Contents:
	• Introduction and fundamentals of Additive Manufacturing (AM)
	• AM processes & technologies, variability of materials, capabilities & limitations
	• Materials: polymers, fiber-reinforced composites, metals, ceramics, nanocomposites, biomaterials, etc.
	• Design-to-Manufacture processes and capabilities: AM-Prototyping, AM-Tooling, AM-Manufacturing, Pre-/Post-Processing
	• Applications in aerospace, automotive, biomedical, electronics, and consumer products
	• Design for AM and optimization strategies with AM
	• Workflow of pre-processing for AM:
	  ○ 3D CAD software and computational design tools
	  ○ Lattice structure design software
	  ○ Topology optimization software
	  ○ 3D Scanning and Reverse Engineering
	  ○ File formats for AM: STEP, IGES, STL, AMF, etc.
	  ○ G-code/toolpath generation, etc.
	  ○ Microstructure characterization
	• Workflow of post-processing for AM:
	  ○ Part cleaning and surface finish/sanding/waxing
	  ○ Surface coating and painting
	  ○ Preparation for tooling, etc.
	• Nondestructive Inspection/Testing (NDI/NDT) and Standards
	• AM Processes combined with conventional manufacturing methods such as machining, molding, tooling, etc.
	• AM Economics: comparison of AM processes with conventional manufacturing methods in terms of rate, quality, cost, flexibility, etc.
	• Supply Chain Benefits: Reduction of storage space and costs, etc.
	• Future trends

Type of lecture	Lecture and lecture accompanying exercises
Literature	Gibson, Ian; Rosen, David; Stucker, Brent: Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Second Edition. p 1-498, January 1, 2015. Publisher: Springer New York. ISBN-13: 9781493921126; DOI: 10.1007/978-1-4939-2113-3
Preconditions for attending	
Usability of module	M-SEM
Prerequisites for the provision of ECTS	Written exam (120 min) Advanced provisions: Exercise credits
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Presence times: 2 SWS lecture, 1 SWS exercises Self-reliant work: pre- and post-preparation of lectures, study of literature, execution of exercises
Frequency of provision	WiSe
Duration of module	1 Semester
Responsible for the curriculum	Prof. Dr.-Ing. C. Beyer, FMB-IMK
Responsible lecturer	Prof. Dr.-Ing. C. Beyer, FMB-IMK

3.6 Fachbereich Informatik / Scientific area Information schiences

3.6.1 Introduction to Computer Science for Engineers

Name of module German title	Introduction to Computer Science for Engineers
Teaching aims and content of the module	Teaching aims and competences to be gained: • Knowledge and Understanding: ○ Understand the principles of object-oriented programming. ○ Understand and recognize the fundamental data structures such as lists, stacks and queues, trees (binary trees, search-trees and AVL trees), hash tables and graphs. ○ Understand and recognize methods to observe algorithm complexity or performance. ○ Understand and recognize the basic algorithms for sorting and searching. ○ Comprehend the fundamental types of algorithm design paradigm such as Divide-and-Conquer, Greedy, Backtracking and Searching, and Dynamic Programming. • Intellectual and Practical Skills: ○ Distinguish the different types of data structures and algorithm design paradigm evaluate when an algorithmic design situation calls for it. ○ Select appropriate algorithms for basic tasks such as searching and sorting. ○ Design new algorithms or modify existing ones for new application and reason about the efficiency of the result. • Program, test and debug computer programs in Java. • Communication and Interpersonal Skills: ○ Presentation of work and ideas during the tutorials / exercises. ○ Interact with a team and tutors during the tutorials
	Contents: Introduction to • imperative programming paradigm • basic concepts of object-oriented programming • programming in Java • generic programming • fundamental data structures: lists, stacks, queues, trees (binary trees, search-trees and AVL trees), hash tables and graphs • abstract data types • main algorithms for fundamental tasks such as sorting and searching • methods to observe algorithm complexity or performance (Big-O notation) • fundamental types of algorithm design paradigms: Divide-and-Conquer, Greedy, Backtracking and Searching, and Dynamic Programming
Type of lecture	Lectures (2 SWS), Exercises (2 SWS) and Tutorials (1 SWS),
Literature	• Data Structures and Algorithms in Java by Michael T. and Robert Tomassia, John Wiley & Sons, 2005 • Algorithms, 4thEdition by Robert Sedgewick and Kevin Wayne, Addision-Wesley Professional, 2011, ISBN 0-321-57351-X
Preconditions for attending	
Usability of module	M-SEM
Prerequisites for the provision of ECTS	Written examination • Prerequisites for admission: Participation and active involvement in the course, the tutorials and the exercises
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	150 h (70 h contact hours + 80 h complementary reading and realization of

	the exercises)
Frequency of provision	WS
Duration of module	1 Semester
Responsible for the curriculum	Prof. Dr.-Ing. Sanaz Mostaghim, FIN-IKS
Responsible lecturer	Dr. Ch. Braune, FIN-IKS

3.6.2 Evolutionary Multi-Objective Optimization

Name of module	Evolutionary Multi-Objective Optimization
German title	Evolutionary Multi-Objective Optimization
Teaching aims and content of the module	Teaching aims and competences to be gained: • Application of methods of computational intelligence for problem solving in multi-objective optimization • Competence to develop algorithms • Substantiated knowledge in the field of multi-objective optimization
	Contents: In our daily lives we are inevitably involved in optimization. How to get to the university in the least time is a simple optimization problem that we encounter every morning. Just looking around ourselves we can see many examples of optimization problem seven with conflicting objectives and higher complexities. It is natural to want everything to be as good as possible, in other words optimal. The difficulty arises when there are conflicts between different goals and objectives. Indeed, there are many real-world optimization problems with multiple conflicting in science and industry, which are of great complexity. We call them Multi-objective Optimization Problems. Over the past decade, lots of new ideas have been investigated and studied to solve such optimization problems as any new development in optimization which can lead to a better solution of a particular problem is of considerable value to science and industry. Among these methods, evolutionary algorithms are shown to be quite successful and have been applied to many applications. This course addresses the basic and advanced topics in the area of evolutionary multi-objective optimization and contains the following content: • Introduction to single-objective optimization (SO) and multi-objective optimization (MO), classical methods for solving MO, definitions of Pareto-optimality and other theoreticalfoundations for MO • Basics of evolutionary algorithms (algorithms, operators,selection mechanisms, coding and representations) • Evolutionary multi-objective algorithms (NSGA-II, EMOscalarization methods such as MOEA/D) • Large-scale EMO: large scale decision space and many objectiveoptimization (such as NSGA-III) • Constraint handling in SO and MO, robust optimization in EMO, surrogate methods for expensive function evaluations • Dynamic EMO • Evaluation mechanisms (Design of experiments, test problems, metrics, visualization)
Type of lecture	Lecture and lecture accompanying exercises
Literature	• Deb, Kalyanmoy. Multi-Objective Optimization Using Evolutionary Algorithms, Wiley, 2001. • Coello, Carlos A. Coello, Gary B. Lamont, and David A. Van Veldhuizen. Evolutionary algorithms for solving multi-objective problems. Vol. 5. New York: Springer, 2007. • Miettinen, Kaisa. Nonlinear multiobjective optimization. Vol.12. Springer Science & Business Media, 2012. • Ehrgott, Matthias. Multi criteria optimization. Vol. 491. Springer Science & Business Media, 2005. • Kruse, Rudolf, et al. Computational intelligence: a methodological introduction. Springer, 2016.
Preconditions for attending	
Usability of module	M-SEM
Prerequisites for the	Written midterm and final exams (120 min)

provision of ECTS	Advanced provisions: Exercise credits
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Presence times: 2 SWS lecture, 2 SWS exercises Self-reliant work: pre- and post-preparation of lectures, study of literature, execution of exercises
Frequency of provision	WiSe
Duration of module	1 Semester
Responsible for the curriculum	Prof. Dr.-Ing. Sanaz Mostaghim, FIN-IKS
Responsible lecturer	Prof. Dr.-Ing. Sanaz Mostaghim, FIN-IKS

3.6.3 Swarm Intelligence

Name of module	Swarm Intelligence
German title	Swarm Intelligence
Teaching aims and content of the module	Teaching aims and competences to be gained: • Application of methods of swarm intelligence for problem solving (optimization and distributed systems) • Competence for the development of swarm intelligence algorithms
	Contents: • Introduction to swarm intelligence (modelling and definition) • Swarm intelligence in optimization (Modelling, , Ant Colony Optimization, Particle Swarm Optimization, multi-objective Optimization) • Swarm intelligence in dynamic environments • Swarm intelligence for grouping and sorting problems • Swarm robotics
Type of lecture	Lecture and lecture accompanying exercises
Literature	• Eric Bonabeau, Marco Dorigo and Guy Theraulaz, Swarm In-telligence: From Natural to Artificial Systems, Oxford University Press, 1999 • Andries Engelbrecht, Fundamentals of Computational Swarm Intelligence, Wiley 2006 • James Kennedy and Russel Eberhart, Swarm Intelligence, Morgan Kaufmann, 2001 • Zbigniew Michalewicz and David Fogel, How to solve it: Modern Heuristics, Springer, 2001 • Veysel Gazi, Stability Analysis of Swarms, The Ohio State University, 2002 • Marco Dorigo and Thomas Stützle, Ant Colony Optimization, The MIT Press, 2004 • C. Solnon: Ant Colony Optimization and Constraint Programming. Wiley 2010 • Gerhard Weiss, Multiagent Systems: A modern approach to distributed artificial systems, The MIT Press, 2000 • Christian Müller-Schloer, Hartmut Schmeck and Theo Ungerer, Organic Computing –A Paradigm Shift for Complex Systems, Springer, 2011
Preconditions for attending	
Usability of module	M-SEM
Prerequisites for the provision of ECTS	Written midterm and final exams (120 min) Advanced provisions: Exercise credits
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Presence times: 2 SWS lecture, 2 SWS exercises Self-reliant work: pre- and post-preparation of lectures, study of literature, execution of exercises
Frequency of provision	WiSe
Duration of module	1 Semester
Responsible for the curriculum	Prof. Dr.-Ing. Sanaz Mostaghim, FIN-IKS
Responsible lecturer	Prof. Dr.-Ing. Sanaz Mostaghim, FIN-IKS

3.7 Wissenschaftliche Grundlagen / Scientific basics

Für den Fachbereich Wissenschaftliche Grundlagen können je ein Modul der Fachbereiche

- Mechanik
- Digitale Systeme
- Automation und Ergonomie
- Logistik
- Fertigungstechnik

gewählt werden.
Dabei können nur Module eingebracht werden, die noch nicht für einen anderen Fachbereich angerechnet wurden.

Darüber hinaus können die nachfolgenden Module aus dem Modulkatalog für die Masterstudiengänge der Fakultät Maschinenbau eingebracht werden:

- Inelastic Structural Analysis (SoSe)
- Production system planning (SoSe)
- Polymers in Engineering Science – From Polymer Structure to Final Product (WiSe)
- Supply Chain Practice: Enterprise Resource Planning (ERP) Systems (WiSe)

Within the scientific area Scientific Basics two modules of the scientific areas

- Mechanics
- Digital systems
- Automation and Ergonomics
- Logistics
- Manufacturing technology
- Information sciences

can be selected.
Only those modules can be accepts not having been accepted for another scientific area.

In addition, the following modules from the module catalogue for the master's programs of the Faculty Mechanical Engineering can be accepted:

- Inelastic Structural Analysis (Summer)
- Production system planning (Summer)
- Polymers in Engineering Science – From Polymer Structure to Final Product (Winter)
- Supply Chain Practice: Enterprise Resource Planning (ERP) Systems (Winter)

3.8 eLearning lectures

3.8.1 Digitalisation and Automation of Material Handling Systems

Name of module	Digitalisation and Automation of Material Handling Systems
German title	Digitalisierung und Automatisierung von Materialflusstechnik
Teaching aims and content of the module	Teaching aims and competences to be gained: • Use of basic knowledge regarding material handling systems to design and layout complex material handling systems for general cargo • Understanding of automated material handling systems and its parts for diverting and merging of cargo flows • Basics of calculating the power consumption of continuous handling equipment. • Condition Monitoring and digital twin of material handling systems • Introduction automated guided vehicles (AGV) and autonomous mobile robots (AMR)
	Contents: • Introduction to automation and digitalisation of material handling systems • Calculating the power consumption of continuous conveyors • Measurement of technical parameters for condition monitoring of material handling systems • Introduction to automated guided vehicles (AGV) and automated mobile robots (AMR)
Type of lecture	Motivating lectures at semester begin, asynchronous web based learning and group work, mid-term presentation
Literature	See first lecture
Preconditions for attending	Material Handling Systems
Usability of module	M-SEM
Prerequisites for the provision of ECTS	Scientific Project, details will be announced in the first lecture“
ECTS and marks	10 CP Marks following Study and Examination Regulations
Efforts	Presence times: 2 SWS lecture, 1 SWS exercises Self-reliant work: pre- and post-preparation of lectures, study of literature, execution of online exercises, group work
Frequency of provision	WiSe
Duration of module	1 Semester
Responsible lecturer	Prof. Katterfeld, FMB-ILM

3.8.2 Establishing digital engineering chains

Name of module	Establishing digital engineering chains
German title	Erstellung digitaler Entwurfsketten
Teaching aims and content of the module	Teaching aims and competences to be gained: • Provision of knowledge about methods and technologies for implementation of engineering tool chains for the engineering of production systems • Provision of knowledge about capabilities and limitations of engineering data exchange • Provision of design skills for engineering tool interfaces based on common concepts • Provision of AutomationML modelling skills
	Contents: • Motivation and basic structures of engineering tool chains • Problems within engineering data exchange • Views and common concepts on engineering data • Methods for view and common concepts identification • AutomationML basics • Modelling of engineering data views and common concepts with AutomationML • Implementation of engineering chains
Type of lecture	Motivating and summarizing lectures at semester begin and end Web based learning and learning progress control
Literature	
Preconditions for attending	Systems engineering lecture
Usability of module	M-SEM
Prerequisites for the provision of ECTS	Scientific Project, details will be announced in the first lecture“
ECTS and marks	10 CP Marks following Study and Examination Regulations
Efforts	Presence times: 4 lectures with 90 minutes each Self-reliant work online learning and execution of online exercises
Frequency of provision	WS
Duration of module	1 Semester
Responsible for the curriculum	Prof. Dr.-Ing. habil. Arndt Lüder, FMB-IAF
Responsible lecturer	Prof. Dr.-Ing. habil. Arndt Lüder, FMB-IAF

3.8.3 Materials: Requirements, consideration and selection of materials along engineering chains"

Name of Module	Requirements, consideration and selection of materials along engineering chains
German title	Anforderungen, Betrachtung und Auswahl von Materialien entlang von Entwicklungsketten
Teaching aims and content of the module	Teaching aims and competences to be gained: • Knowledge of different materials for special applications – materials selection • Knowledge of the relation between the (micro)structure of materials and the resulting macroscopic material behavior based on fundamental knowledge • Basic knowledge of physical and chemical mechanisms and working principles
	Contents: • Motivation – Materials along the engineering chains • Analyzing the requirements on the materials for their special applications • Consideration of properties for the materials in demand • Analyzing the microstructure of selected materials • Research on the mechanical properties with regard to the microstructure
Type of lecture	Motivating lectures at semester begin, asynchronous webbased learning and group work, mid-term presentation
Literature	
Preconditions for attending	Systems engineering lecture
Usability of module	M-SEM
Prerequisites for the provision of ECTS	Scientific Project, details will be announced in the first lecture“
ECTS and marks	10 CP Marks following Study and Examination Regulations
Efforts	Presence times: 4 lectures with 90 minutes each Self-reliant work online learning and execution of online exercises
Frequency of provision	WiSe
Duration of module	1 Semester
Responsible lecturer	Prof. Manja Krüger, FMB-IWF

4 Internship

Name of module	Internship
German title	Fachpraktikum
Teaching aims and content of the module	Teaching aims and competences to be gained: The internship aims at providing students with knowledge about the practical specialties of systems engineering as well as organizational and social knowledge of the work within practical engineering networks. In addition it shall support the perception of the theoretical concepts provided in the study program.
	Contents: • The contents shall be related to the usual working habit of a systems engineer. • It shall be related to the design/development of product / production systems and/or their components.
Type of lecture	Internship within a company Alternatively the internship can be executed within a research organization or an organization of higher education if the work is related to a research project
Preconditions for attending	Certification of at least 50 CP from compulsory, compulsory chosen, and free elective areas
Usability of module	M-SEM
Prerequisites for the provision of ECTS	Internship documentation providing a closed documentation of the content of the internship with its relation to the study program
ECTS and marks	15 CP Marks following Study and Examination Regulations
Efforts	Independent internship execution
Frequency of provision	Semester independent
Duration of module	Execution time of usually 3 month
Responsible lecturer	Lecturer from Faculty of Mechanical Engineering

5 Master Thesis

Name of module German title	Master Thesis Masterarbeit
Teaching aims and content of the module	Subjects from all parts of the Faculty of Mechanical Engineering usually with an orientation towards scientific relevance The master thesis shall prove the capabilities of the student to independently deal with a scientific subject within a predefined period of time applying scientific methodologies.
Type of lecture	Scientific project, documentation and colloqium following the design guidelines as well as the guidelines for the execution and presentation of scientific works of the Faculty of Mechanical Engineering
Preconditions for attending	Certification of at least 65 CP from compulsory and compulsory chosen areas as well as 15 CP from internship
Preconditions for colloquium	Certification of all necessary 90 CP Existence of two assessments with at least mark „sufficient"
Usability of module	M-SEM
Prerequisites for the provision of ECTS	2 Assessments, Colloquium
ECTS and marks	30 CP Marks following Study and Examination Regulations
Efforts	Independent scientific project, documentation (thesis), presentation, defense It is recommended to execute the master thesis in cooperation with a company based on a company driven scientific problem.
Frequency of provision	Semester independent
Duration of module	20 weeks Provision of a master thesis subject definition with start and end date documented at Examinations Office of the Faculty of Mechanical Engineering
Responsible lecturer	Lecturer of the Faculty of Mechanical Engineering

Regelstudienplan		Umfang			1. Sem. WiSe			2. Sem. SoSe			3. Sem. WiSe			4. Sem. SoSe		
		V	S	P	CP	LN	PL	CP	LN	PL	CP	LN	PL	CP	LN	PL
Pflichtbereich		**Σ 25 CP**														
Mechanics of Materials		2	2					5		K						
Systems Engineering for Manufacturing Systems		2	1		5		K									
Material handling Systems		2	1		5		K									
Modelling and Simulation of Mechatronic Systems		1	1	1	5		K									
Material Selection		2	1					5		K						
Wahlpflichtbereich		**Σ 50 CP**														
FB 1: Mechanics	Simulation methods of dynamical systems	2	2		5		K									
	Engineering Design	4	4		5		K	5		K						
	Mechanics of Lightweight Structures	2	2					5		M						
FB 2: Digital systems	Finite Element Method	2	2		5		K									
	CAx Basics	2	2					5		K						
	Modeling and Simulation in Logistics Planning	2	2					5		W						
FB 3: Automation	Advanced Applications of Industry 4.0-Techn.	2	1		5		W									
	Factory automation and industrial robotics	2	1					5		K						
FB 4: Logistics	Logistics Networks	2						5	W							
	Collaboration in Supply Networks	2						5	W							
	Handling and Logistics of Bulk Materials	2	1					5	K							
FB5: Manufacturing technology	Micromanufacturing Technologies	2	1					5		K						
	Design and Additive Manufacturing Processes	2	1		5		K									
FB6: Information sciences	Introduction to Computer Science for Engineers	2	2		5		K									
	Evolutionary Multi-Objective Optimization	2	2		5		M									
	Swarm intelligence	2	2		5		M									
FB7: Scientific basics	Modul 7.1							5		◇						
	Modul 7.2							5		◇						
eLearning lectures		Σ 10 CP														
Digitalisation and Automation of Material Handling Systems											10		W			
Establishing digital engineering chains											10		W			
Materials: Requirements, consideration and selection of materials along engineering chains"											10		W			
Freier Wahlpflichtbereich		Σ 10 CP														
Modul 1								5		PL						
Modul 2					5		PL									
Praktikum/ Internship		**Σ 15 CP**														
Praktikum / Internship											15	W	W			
Masterarbeit		**Σ 30 CP**														
Masterarbeit incl. Kolloquium														30		
Gesamt-CP je Semester					30			35			25			30		

Legende | Legend

V|Ü|P Vorlesung | Übung | Praktikum V|Ü|P Lecture|Exercise|Practical course

PL – Prüfungsform entsprechend Modulhandbuch | Exam form according to module handbook

Prüfungsformen | Legend Forms of examination:

K – Klausur (angegebene Dauer in Minuten) | written exam (duration in minutes),

R – Referat | oral presentation, W – Wissenschaftliches Projekt | scientific project

M – Mündliche Prüfung | Oral examination ◇ – entspr. Modulbeschreibung | according to module description