Tentative Module Handbook for the Master's Degree Course 'Networked Production Engineering (M.Sc.)'

Track: Additive Manufacturing

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Compulsory Courses – First Semester

Program specific

Module: Mechatronic and Control Techniques for Production Plants

Module	Mechatronics and Control Techniques for Production Plants
Module level	Master
Subtitle	MCP
Lecture	See list of lectures and examinations of the module
Semester allocation	1
Person in charge	Univ.-Prof. Dr.-Ing. Christian Brecher
Lecturer	Univ.-Prof. Dr.-Ing. Christian Brecher
Language	English
Assignment to the curriculum	Compulsory module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 180h, Lecture hours 60h (4 SWS), Self-study 120h
Lecture hours	60h (4 SWS)
ECTS-Credit Points (CP)	6
Requirements according to examination regulation	-none-
Learning objectives	**Mechatronics and Control Techniques for Production Plants** *Overall goal: Students get familiar with the structure, the design and the engineering process of mechatronic systems.* After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students • understand the characteristics of the behavior and control of feed axes in machine tools;

	• know different types of sensors and their application within machine tools. Abilities / Skills Students • apply this knowledge to create control programs in different programming tools; • get to know the essential features and applications of logical, numerical and motion controls of machines.
Content	**Mechatronics and Control Techniques for Production Plants** *Introduction to Mechatronics and control for production* • Overview of mechatronic systems • Construction of feed drives *Information processing in mechatronic systems* • Theory and examples of embedded systems • Programmable logic circuits *Measurement systems and sensors* • Position and angle measuring systems • Acceleration and vibration measurement *Mechanical control* • Single and multi-spindle turning machines • Further developments *Gripping technology* • Gripping principles • Sensor technology and applications *Position control of feed drives* • Control concept of a machine axis • Accuracy and synchronous control of multi-axis *Numerical Control 1: structure, programming, CAM* • Construction of NC controls • NC programming process *Numerical Control 2: Interpolation* • Kinematic transformations and compensations • Interpolation *Industrial robots and handling systems, robot control* • Structure and kinematic transformations • RC programming *Programmable Logic Control (PLC) and motion control (MC)* • Basics of Information Processing • Programmable Controllers

	Signal processing, process and condition monitoring • Tasks of process and condition monitoring • Use of sensors and signal processing *Mechatronic Engineering, Simulation environments for virtual commissioning* • Basics of modeling of mechatronic systems • Behavior modeling and data management • Introduction: complexity of software and systems
Media	e-Learning L²P, Power Point
Literature	Lecture Notes Students also receive a list of relevant literature

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Mechatronics and Control Techniques for Production Plants	6	0	0	120 (written) or max. 60 (oral)
Lecture: Mechatronics and Control Techniques for Production Plants	0	2	60	0
Exercise: Mechatronics and Control Techniques for Production Plants	0	2	60	0

Teaching Unit / Examinations: Examination Mechatronics and Control Techniques for Production Plants

Title	Examination Mechatronics and Control Techniques for Production Plants
Sub-title	Exa MCT
Semester allocation	1
Connection to the curriculum	Compulsory module

Teaching Unit / Examinations: Lecture Mechatronics and Control Techniques for Production Plants

Title	Lecture Mechatronics and Control Techniques for Production Plants
Sub-title	L MCT

Semester allocation	1
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Exercise Mechatronics and Control Techniques for Production Plants	
Title	Exercise Mechatronics and Control Techniques for Production Plants
Sub-title	E MCT
Semester allocation	1
Connection to the curriculum	Compulsory module

Module: Manufacturing Technology I

Module	Manufacturing Technology I
Module level	Master
Subtitle	MT I
Lecture	See list of lectures and examinations of the module
Semester allocation	1
Person in charge	Univ.-Prof. Dr.-Ing. Thomas Bergs
Lecturer	Univ.-Prof. Dr.-Ing. Thomas Bergs
Language	English
Assignment to the curriculum	Compulsory module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 150h, Lecture hours 60h (4 SWS), Self-study 90h
Lecture hours	60h (4 SWS)
ECTS-Credit Points (CP)	5
Requirements according to examination regulation	-none-
Learning objectives	**Manufacturing Technology I** After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students • have an in-depth insight on manufacturing technologies. They know and understand the comply principles of cutting, forming, material removal and additive manufacturing; • know and understand process parameters, cutting and forming criteria, tool and work piece characteristics. <u>Abilities / Skills</u> Students

	• apply this knowledge and are able to choose the right manufacturing processes with regard to geometrical and functional work piece properties. • estimate the effects of process parameter variations on forces, tool life, wear mechanisms and rim zone characteristics. <u>Competencies</u> Students • critically analyze company decisions with technological background and communicate the assessments to non-specialist audiences; • optimize manufacturing processes and assess possible consequences on part functionality.
Content	**Manufacturing Technology I** • Introduction to manufacturing technology • Measuring and testing in manufacturing technology • Principles of machining with geometrically defined cutting edges • Cutting criteria • Cutting materials, tools and lubricants • Applications of processes with defined cutting edge • Principles of cutting with undefined cutting edges • Grinding tools and grinding wheel preparation • Applications of processes with undefined cutting edge • Material removal manufacturing processes (EDM, ECM) • Laser and high pressure water jet machining • Additive manufacturing (RP, RT)
Media	e-Learning L2P, Power Point
Literature	Lecture Notes Students also receive a list of relevant literature

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Manufacturing Technology I	5	0	0	90-120 (written), max. 60 (oral)

Lecture: Manufacturing Technology I	0	2	45	0
Exercise: Manufacturing Technology I	0	2	45	0

Teaching Unit / Examinations: Examination Manufacturing Technology I	
Title	Examination Manufacturing Technology I
Sub-title	Exa MT I
Semester allocation	1
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Lecture Manufacturing Technology I	
Title	Lecture Manufacturing Technology I
Sub-title	L MT I
Semester allocation	1
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Exercise Manufacturing Technology I	
Title	Exercise Manufacturing Technology I
Sub-title	E MT I
Semester allocation	1
Connection to the curriculum	Compulsory module

Compulsory Courses – First Semester

Track specific

Module: Laser Applications

Module	Laser Applications
Module level	Master
Subtitle	LAP
Lecture	See list of lectures and examinations of the module
Semester allocation	1
Person in charge	Univ.-Prof. Dr. rer. nat. Reinhart Poprawe
Lecturer	Univ.-Prof. Dr. rer. nat. Reinhart Poprawe, tbd
Language	English
Assignment to the curriculum	Compulsory module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 180h, Lecture hours 60h (4 SWS), Self-study 120h
Lecture hours	60h (4 SWS)
ECTS-Credit Points (CP)	6
Requirements according to examination regulation	-none-

Learning objectives	**Laser Applications** *Overall goal: Students gain basic knowledge about the generation, characteristics and applications of laser radiation.* After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students • understand the generation and properties of laser radiation; • know the fundamentals of light-matter interaction, heat transport and phase transitions; • gain knowledge about laser-based processing and manufacturing (like hardening, joining, drilling, cutting and additive manufacturing) and further fields of laser application (like measurement technology). <u>Abilities / Skills</u> Students • are able to evaluate manufacturing processes in order to identify those that benefit from the use of laser radiation; • can apply mathematical techniques to identify and optimise process-specific laser beam parameters. <u>Competencies</u> Students • are able to identify suitable laser parameters for specific tasks in materials processing; • can identify a laser source providing the desired parameters for a given process; • are able to work on current research problems, e.g. within a Master's thesis.
Content	**Laser Applications** • The laser principle • Properties of laser radiation (spectral, temporal and spatial) • Laser types and systems • Reflection, absorption, transmission • Temperature, heat conduction, mass diffusion and melt pool dynamics • Laser-based surface treatment

	• Additive Manufacturing • Joining • Cutting • Ablation • Measurement technology
Media	e-Learning Moodle, Power Point
Literature	Lecture notes R. Poprawe, K. Boucke, D. Hoffmann: Tailored Light 1 (Springer Verlag, 2018) R. Poprawe: Tailored Light 2 (Springer Verlag, 2011) Students receive a list of relevant literature

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Laser Applications	6	0	0	120 (written) or 30 (oral)
Lecture: Laser Applications	0	2	60	0
Exercise: Laser Applications	0	2	60	0

Teaching Unit / Examinations: Examination Laser Applications

Title	Examination Laser Applications
Sub-title	Exa LA
Semester allocation	1
Connection to the curriculum	Compulsory module

Teaching Unit / Examinations: Lecture Laser Applications

Title	Lecture Laser Applications
Sub-title	L LA
Semester allocation	1
Connection to the curriculum	Compulsory module

Teaching Unit / Examinations: Exercise Laser Applications

Title	Exercise Laser Applications
Sub-title	E LA
Semester allocation	1
Connection to the curriculum	Compulsory module

Module: Additive Manufacturing I - Technologies and Processes

Module	Additive Manufacturing I - Technologies and Processes
Module level	Master
Subtitle	AM I
Lecture	See list of lectures and examinations of the module
Semester allocation	1
Person in charge	Univ.-Prof. Dr.-Ing. Dipl.-Wirt.-Ing. Johannes Schleifenbaum
Lecturer	Univ.-Prof. Dr.-Ing. Dipl.-Wirt.-Ing. Johannes Schleifenbaum
Language	English
Assignment to the curriculum	Compulsory module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 180h, Lecture hours 60h (4 SWS), Self-study 120h
Lecture hours	60h (4 SWS)
ECTS-Credit Points (CP)	6
Requirements according to examination regulation	-none-

Learning objectives	**Additive Manufacturing I - Technologies and Processes** After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students • have knowledge of significant AM-technologies and their fundamental properties and applications; • the students have knowledge of AM-specific construction rules and simulation driven design processes; • know essential pre- and post processes and interdependencies along the digital and physical process chain; • the students know major factors of key determinants on the economic application of AM technology; • have knowledge of content-related aspects which correspond to present applications and expected developments. <u>Abilities / Skills</u> Students • develop own strategies and solutions to prescribed scientific issues. <u>Competencies</u> Students • the students are in the position to differentiate AM - technologies from conventional production processes.
Content	**Additive Manufacturing I - Technologies and Processes** • Introduction: motivation, market relevance, overview of relevant technologies • selective laser melting: process principle, develpoment of process strategies, quality and cost optimization, high power slm • laser metal deposition: process principle, workflow and productivity, best practice examples • selective laser sintering & stereolithography: process principle, workflow and productivity, best practice examples • thin film processing: process principle, workflow und productivity, best practice examples • material & process control: material classes, properties and applications, material production and quality assurance, quality aspects within additve manufacturing, system technology and sensor technology, controlling and monitoring of laser manufacturing processes

	• design for additive manufacturing I : agil project management within additive manufacturing, extension of the CAE process chain, AM software, AM confirm product development • design for additive manufacturing II : simulation driven design process (topology optimization, integration of lattice structures, function integration) • production planning I : job preperation (data control and mesh repair, CAM (SLM vs. LMD), part placement & material handling, work safety and environment • production planning II : simulation (mold dynamics, heat transfer, structure, tension, protective atmosphere and gas flow, und nozzle design) • subsequent processes: heat treatment, surface finishing, hybrid application, automatization concepts. • application and market: present applications & expectet developments, efficiency, intellectual property • summary and future trends: key properties of AM technologie, overview of the physical and digital process chain, outlook
Media	e-Learning Moodle, Power Point
Literature	Students receive a list of relevant literature

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Additive Manufacturing I - Technologies and Processes	6	0	0	90 (written) or 30 (oral)
Lecture: Additive Manufacturing I - Technologies and Processes	0	2	60	0
Exercise: Additive Manufacturing I - Technologies and Processes	0	2	60	0

Teaching Unit / Examinations: Additive Manufacturing I - Technologies and Processes

Title	Examination Additive Manufacturing I - Technologies and Processes
Sub-title	Exa AM I
Semester allocation	1

Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Lecture Additive Manufacturing I - Technologies and Processes	
Title	Lecture Additive Manufacturing I - Technologies and Processes
Sub-title	L AM I
Semester allocation	1
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Exercise Additive Manufacturing I - Technologies and Processes	
Title	Exercise Additive Manufacturing I - Technologies and Processes
Sub-title	E AM I
Semester allocation	1
Connection to the curriculum	Compulsory module

Elective Courses – First and Third Semester

Program specific

Module: Tribology

Module	Tribology
Module level	Master
Subtitle	TB
Lecture	See list of lectures and examinations of the module
Semester allocation	1 or 3
Person in charge	Univ.-Prof. Dr.-Ing. Georg Jacobs
Lecturer	Univ.-Prof. Dr.-Ing. Georg Jacobs
Language	English
Assignment to the curriculum	Elective module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 150h, Lecture hours 60h (4 SWS), Self-study 90h
Lecture hours	60h (4 SWS)
ECTS-Credit Points (CP)	5
Requirements according to examination regulation	-none-

Learning objectives	**Tribology**
	
	After successfully completing this course, the students will have acquired the following learning outcomes:
	
	<u>Knowledge / Understanding</u>
	Students
	• know fundamental mechanisms in the contact zone of tribosystems:
	  • hydrodynamics
	  • material deformation
	  • tribological stress

	• fluid / solid body friction • wear Abilities / Skills Students • employ the fundamental theories to design and analyze tribosystems; • design tribosystems in mechanical systems, like journal bearings, roller bearings, gear wheels and seals. Competencies Students • are capable of choosing and applying different suitable measuring- and test systems to investigate the tribosystems of journal bearings, roller bearings, gear wheels and seals; • are capable of choosing and applying different suitable calculation and simulation methods to investigate the tribosystems of journal bearings, roller bearings, gear wheels and seals; • are capable of estimating the quality of the tribosystem according to the test and simulation results and to optimize it with the background knowledge of a considerably large action catalogue; • design the tribosystems of the mechanical components of drive trains; • minimize friction and wear in mechanical drive trains. In that way, they can enhance the resource and energy efficiency of drive train systems.
Content	**Tribology** Basics of tribology: • Tribosystem in general and its analysis • Wear and friction processes • Test methods Interactions between base and contact bodies: • Contact processes and geometries, material strain, Hertzian theory, contact mechanics • Frictional processes and the results and influence on the tribosystem, wear processes and methods to avoid wear and losses Properties of base and contact bodies: • Tribomaterials and the analysis of technical surfaces, roughness, hardness definitions and test methods • Coating types and methods and their technical application, systematical methods and examples for the correct choice of material Properties of intermediate medium: • Basic properties, dependencies and test methods for the viscosity

	• Classification, properties and application examples for different lubricants (oils, greases and solid lubricants) <u>Basics of hydrodynamics and elastohydrodynamics:</u> • Fundamentals and principles of flow mechanisms, derivation of Navier-Stokes and Reynolds equations and continuity equation • Application of the hydrodynamic equations regarding the calculation of bearings • Basics of the elastohydrodynamics <u>Tribosystem journal bearings:</u> • Functionality and calculation of hydrodynamic axial and radial journal bearings • Damages and failures of hydrodynamic journal bearings • Choice of suitable lubricants for hydrodynamic journal bearings • Functionality and calculation of hydrostatic axial and radial journal bearings • Damages and failures of hydrostatic journal bearings • Choice of suitable lubricants for hydrostatic journal bearings <u>Tribosystem gear wheels:</u> • Lubricants and materials for gears and their influence and application • Application of the EHD-theory for gear stages • Damages and failures of gear wheels and suitable test methods for the analysis of gear stages <u>Tribosystem roller bearings:</u> • Design, materials and lubrication for roller bearings • Friction, damages and failures for roller bearings • Test methods for the analysis of roller bearings <u>Tribosystem seals:</u> • Different types and designs of seals • Specialties and application of different seals • Materials for seals
Media	e-Learning L^{2}P, Power Point
Literature	Lecture Notes Students also receive a list of relevant literature

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Tribology	5	0	0	120 (written) or max. 60 (oral)

Lecture: Tribology	0	2	45	0
Exercise: Tribology	0	2	45	0

Teaching Unit / Examinations: Examination Tribology	
Title	Examination Tribology
Sub-title	Exa TB
Semester allocation	1 or 3
Connection to the curriculum	Elective module
Teaching Unit / Examinations: Lecture Tribology	
Title	Lecture Tribology
Sub-title	L TB
Semester allocation	1 or 3
Connection to the curriculum	Elective module
Teaching Unit / Examinations: Exercise Tribology	
Title	Exercise Tribology
Sub-title	E TB
Semester allocation	1 or 3
Connection to the curriculum	Elective module

Module: Gear and Transmission Technology

Module	Gear and Transmission Technology
Module level	Master
Subtitle	GTT
Lecture	See list of lectures and examinations of the module
Semester allocation	1 or 3
Person in charge	Univ.-Prof. Dr.-Ing. Christian Brecher Univ.-Prof. Dr.-Ing. Thomas Bergs
Lecturer	Univ.-Prof. Dr.-Ing. Christian Brecher Univ.-Prof. Dr.-Ing. Thomas Bergs
Language	English
Assignment to the curriculum	Elective module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 180h, Lecture hours 60h (4 SWS), Self-study 120h
Lecture hours	60h (4 SWS)
ECTS-Credit Points (CP)	6
Requirements according to examination regulation	-none-
Learning objectives	**Gear and Transmission Technology** After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students • learn about the requirements on modern gears; • know the basics of calculation and test methods that are used in the development process of gears; • understand how test rigs for fatigue and gear noise tests will be introduced;

	• get knowledge about the gear production and the machine tools for gear production. <u>Abilities / Skills</u> Students • gain experience in simulation techniques in gear design and corresponding manufacturing processes; • gain experience in the analysis of gear tests.
Content	**Gear and Transmission Technology** • Gear Geometry - Spur Gears • Damage of gears • Basics of the gear development process I • Basics of the gear development process II • Investigation of gears - Fatigue tests • Investigation of gears - Running behavior • Gear Production • Gear Production – Finishing • Machine Tools for Gear Production • Simulation • Gear Geometry - Bevel Gears • Special Gears, Beveloids
Media	e-Learning L^{2}P, Power Point
Literature	Lecture Notes Students also receive a list of relevant literature

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Gear and Transmission Technology	6	0	0	120 (written) or max. 60 (oral)
Lecture: Gear and Transmission Technology	0	2	60	0
Exercise: Gear and Transmission Technology	0	2	60	0

Teaching Unit / Examinations: Examination Gear and Transmission Technology

Title	Examination Gear and Transmission Technology
Sub-title	Exa GTT

Semester allocation	1 or 3
Connection to the curriculum	Elective module
Teaching Unit / Examinations: Lecture Gear and Transmission Technology	
Title	Lecture Gear and Transmission Technology
Sub-title	L GTT
Semester allocation	1 or 3
Connection to the curriculum	Elective module
Teaching Unit / Examinations: Exercise Gear and Transmission Technology	
Title	Exercise Gear and Transmission Technology
Sub-title	E GTT
Semester allocation	1 or 3
Connection to the curriculum	Elective module

Module: Simulation Techniques in Manufacturing Technology

Module	Simulation Techniques in Manufacturing Technology
Module level	Master
Subtitle	STMT
Lecture	See list of lectures and examinations of the module
Semester	1 or 3
Person in charge	Univ.-Prof. Dr.-Ing. Thomas Bergs
Lecturer	Dr.-Ing. Mustapha Abouridouane
Language	English
Assignment to the curriculum	Elective Module
Teaching form	Written or oral examination, Lecture , Exercise
Workload	Total 180h, Lecture hours 45h (3 SWS), Self-study 135h
Lecture hours	45h (3 SWS)
ECTS-Credit Points (CP)	6
Requirements according to examination regulation	Recommended requirements (e.g., other modules, foreign language skills): • Englisch in word and writing • Manufacturing Technology I
Learning objectives	**Simulation Techniques in Manufacturing Technology** *Overall goal:* Teaching theory and practise in modelling and simulation of manufacturing processes After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students: • Revision of the fundamentals of materials science and manufacturing technology • Introduction to the basic methods of modeling and simulation of manufacturing processes • Procedure and application of the finite element method for the simulation of manufacturing processes • Possibilities and limits of modeling and simulation

	• Application of the simulation software DEFORM and ABAQUS for the simulation of different manufacturing processes Abilities / Skills Students: • independently select appropriate simulation methods for manufacturing processes and prove their selection on a scientific basis; • set up and evaluate an FE simulation. Competencies Students: • develop their own modelling approaches for manufacturing processes and to formulate them in research questions as well as to incorporate them in development activities.
Content	**Simulation Techniques in Manufacturing Technology** • Lecture 1: In the first lecture an introduction to the topic "Simulation Techniques in Manufacturing Technology" will be given • Lecture 2: The contents of the second lecture are the basic aspects and processes of forming technology • Lecture 3: After the student has learned the basics of forming technology, this lecture will focus on current simulation techniques during forming • Lecture 4: The fourth lecture deals with fundamental aspects and the simulation of sheet metal forming • Lecture 5: The fifth lecture gives an introduction to the basics and simulation methods of punching and fine blanking processes • Lecture 6: Contents of the sixth lecture are the principles of cutting processes • Lecture 7: Lecture 7 gives a general overview of different cutting processes • Lecture 8: One possibility to model cutting processes is the finite element method (FEM). This lecture shows various current examples of the FE simulation of cutting processes • Lecture 9: The ninth lecture gives an introduction to cutting with an undefined cutting edge • Lecture 10: Lecture 10 introduces current modeling methods for grinding

	• Lecture 11: In lecture 11 special attention will be paid to the methods of validation and optimization techniques • Lecture 12: The content of the last lecture is to learn in small groups the preparation and evaluation of FE machining simulation with the FE code ABAQUS
Media	Power-Point Presentation, Movies, FE Software
Literature	• Script of Manufacturing Technology I (For sale at WZL) • Script of Manufacturing Technology II (For sale at WZL) • S. Kobayashi, T. Altan, S. Kobayashi: Metal Forming and the Finite-Element Method, Oxford Series on Advanced Manufacturing, Oxford University Press, 1989 • T. Childs: Metal Machining (Theory and Applications), ISBN-13: 978-0340691595 • K. Cheng: Machining Dynamics (Fundamentals, Applications and Practices), ISBN: 978-1-84628-367-3

Lectures / Examinations

Title	**ECTS**	**Workload (SWS / h)**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Simulation Techniques in Manufacturing Technology	6	0	0	15 (oral) or 120 (written)
Lecture: Simulation Techniques in Manufacturing Technology	0	2	70	0
Exercise: Simulation Techniques in Manufacturing Technology	0	1	65	0

Teaching Unit / Examinations: Examination Simulation Techniques in Manufacturing Technology

Title	Examination Simulation Techniques in Manufacturing Technology
Sub-title	Exa STMT
Semester	1 or 3

Connection to the curriculum	Elective Module
Teaching Unit / Examinations: Lecture Simulation Techniques in Manufacturing Technology	
Title	Lecture Simulation Techniques in Manufacturing Technology
Sub-title	L STMT
Semester	1 or 3
Connection to the curriculum	Elective Module
Teaching Unit / Examinations: Exercise Simulation Techniques in Manufacturing Technology	
Title	Exercise Simulation Techniques in Manufacturing Technology
Sub-title	E STMT
Semester	1 or 3
Connection to the curriculum	Elective Module

Module: Process Analysis in Manufacturing Technology

Module	Process Analysis in Manufacturing Technology
Module level	Master
Subtitle	PAMT
Lecture	See list of lectures and examinations of the module
Semester	1 or 3
Person in charge	Univ.-Prof. Dr.-Ing. Thomas Bergs
Lecturer	Dr.-Ing. Guido Wirtz
Language	English
Assignment to the curriculum	Elective Module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 150h, Lecture hours 45h (3 SWS), Self-study 105h
Lecture hours	45h (3 SWS)
ECTS-Credit Points (CP)	5
Requirements according to examination regulation	Recommended: Manufacturing Technology I
Learning objectives	**Process Analysis in Manufacturing Technology** *Overall goal: Ability to analyse manufacturing processes* Students understand how process and workpiece properties can be measured and analysed. They get to know metrology as an essential part of modern production processes. After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> • Setup, functionality and application of technical sensors for the analysis of manufacturing processes • Components of a measuring chain, functionality, connection of the elements and estimation of the measuring deviation • Options on signal analysis of stationary and instationary processes in time and frequency domain

	• Characteristics of manufacturing technologies which require a scientific analysis Abilities / Skills Students are able to choose suitable measurement systems, to integrate them into manufacturing processes, to acquire and analyse the signals. In the laboratory, they gain the practical experience, which is required to apply the theoretical knowledge. Students are able to arrange the setup of a measuring chain, data acquisition in LabView and data analysis in the software Diadem. Competencies The students recognize correlations between process and part characteristics and can make conclusions on the part's quality. Furthermore, they recognize the impact of metrology on manufacturing processes, which results from the integration of certain measurement systems. They are able to describe changes of dynamical systems and critically evaluate these changes.
Content	**Process Analysis in Manufacturing Technology** • Introduction on the scope of the course to go for the elective or not Fundamentals: • Technical sensors: Strain, force, acceleration, acoustic emission, temperature, pressure, viscosity, clouding, moisture • Measuring chain : Components, setup, signal conditioning, analog-to-digital, parameterization, measuring deviation, application software LabView • Signal analysis: Time and frequency domain, bandwidth, spectral resolution, aliasing, analysis of stationary and instationary processes, application software Diadem Applications: • Turning: Force, acceleration, temperature and wear measurement, force and wear modelling, self-induced and forced vibrations, residual stress measurement, thin film integrated sensors • Drilling: Force, acceleration, temperature and wear measurement, telemetry, force and wear modelling, short and deep hole drilling, monitoring of the chip removal, scaling of force and torque at small diameters • Milling: Interrupted cut, dynamical system analysis, transfer function, stability theory , force and acceleration measurement • Grinding: Grinding burn, nital etching, Barkhausen noise, adaptive grinding, sensor assisted dressing and balancing • Powder metallurgy: Powder classification, analysis of the porosity distribution, non- destructive testing methods • Laser material processing: Beam quality and caustic measurement, power measurement in the continuous and pulsed wave mode, weld seam tracing and triangulation

	• Forming and blank cutting: Integration of force and distance sensors in forming and cutting tools, tribological effects, measurement of pressure, temperature, viscosity and clouding of hydraulic oils • Material removal technologies: Measurement of high-frequency voltage and current impulses, application of measurement systems in electromagnetically polluted environments, force and distance measurement in micro EDM sinking, passivation layer thickness measurement in ELID grinding
Media	Presentations, Laboratory: Data acquisition and analysis software
Literature	Klocke, F.; König, W.: Manufacturing Processes 1, 1st Ed., 2011 Klocke, F.; König, W.: Manufacturing Processes 2, 1st Ed., 2009 Klocke, F.; König, W.: Manufacturing Processes 4, 1st Ed., 2013

Lectures / Examinations

Title	**ECTS**	**Workload (SWS / h)**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Exam: Process Analysis in Manufacturing Technology	5	0	0	15 (oral) or 120 (written)
Lecture: Process Analysis in Manufacturing Technology	0	2	70	0
Exercise: Process Analysis in Manufacturing Technology	0	1	35	0

Teaching Unit / Examinations: Examination Process Analysis in Manufacturing Technology

Title	Examination Process Analysis in Manufacturing Technology
Sub-title	Exa PAMT
Semester	1 or 3
Connection to the curriculum	Elective Module

Teaching Unit / Examinations: Lecture Process Analysis in Manufacturing Technology

Title	Lecture Process Analysis in Manufacturing Technology
Sub-title	L PAMT
Semester	1 or 3

Connection to the curriculum	Elective Module
Teaching Unit / Examinations: Exercise Process Analysis in Manufacturing Technology	
Title	Exercise Process Analysis in Manufacturing Technology
Sub-title	E PAMT
Semester	1 or 3
Connection to the curriculum	Elective Module

Module: Modeling, Model Reduction and Simulation in Laser Processing - Applications

Module	Modeling, Model Reduction and Simulation in Laser Processing - Applications
Module level	Master
Subtitle	MMRSLP-A
Lecture	See list of lectures and examinations of the module
Semester	1 or 3
Person in charge	Univ.-Prof. Dr. rer. nat. Wolfgang Schulz
Lecturer	Univ.-Prof. Dr. rer. nat. Wolfgang Schulz
Language	English
Assignment to the curriculum	Elective Module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 150h, Lecture hours 60h (4 SWS), Self-study 90h
Lecture hours	60h (4 SWS)
ECTS-Credit Points (CP)	5
Requirements according to examination regulation	-none-
Learning objectives	**Modeling, Model Reduction and Simulation in Laser Processing – Applications** After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> • Free Boundary Problems and integral methods of solution, • non-linear stability analysis using spectral methods, • analysis of the structural stability of model equations and • 5 parameter pairs of optical material equations, transmission, reflection, absorption, Fresnel Formulae, polarisation of matter and radiation • Learning target 2: optical parameters • Slow surfaces in dynamical Systems: applications • for separation of time scales

	• Learning target 6: Thermal effect of large and small Peclet-number, • know and understand the 5 different, dominant phenomena of drilling, welding and cutting with laser radiation • Learning target 5: quality features • know the physical meaning of the terms contained in the Navier-Stokes equations for mass, momentum, and energy balance • know the main properties of the solution in the asymptotic case of thin film flow (boundary layer) and can explain the relation between dynamical properties of the solution and quality features of the product as well as productivity of the process for drilling and cutting • know the effect of dissipation in distributed dynamical systems (inertial manifold) and know examples for the application of methods for the reduction of the dimension in dissipative systems, understand and perform the separation of length and time scales in simple systems • Learning target 7: heating and melting phase of ablation • understand the interactive cooperation of scientists from engineering, physics and mathematics for application of model based methods for diagnosis in laser processing Learning target 8: reduced modelling <u>Abilities / Skills</u> Application of model based methods for solving practical tasks from discussion of project examples
Content	**Modeling, Model Reduction and Simulation in Laser Processing – Applications** Overview of contents, definition of the 10 learning targets • the contribution of the engineer to the interactive cooperation of scientific disciplines • main features of the theory of cognition (Karl Popper) • recapitulation of the 10 learning targets from Module I: Laser • Learning target 1: at least 10 industrial applications of laser radiation • Learning target 2: reduced model of the Fresnel Formulae for the limiting case of small displacement current, optical parameters • technical task and examples: cutting with laser radiation • Learning target 3: quality features of the high quality cut • physical task of cutting and identification of quality defined processing domains • Learning target 4: relation of physical phenomena to the built up of quality degradations • technical task and examples: drilling with laser radiation • physical task formulation and 5 dominant phenomena • Learning target 5: quality features of the drilled hole • mathematical modelling Ia: length and time scales

	• degrees of freedom in phase space of dependent variables • separation of time scales in simple dynamical systems • Learning target 6a: separation of time scales • mathematical modelling Ib: singular perturbation and asymptotic expansion • thermal boundary layer in heat conduction with moving boundaries • Learning target 6b: separation of length scales • mathematical modelling II: Free Boundary Problems (FBP) for the solid phase • reduced model for the FBP : motion of the melting front, integral methods, variational formulation • Learning target 7: heating and melting phase of ablation • mathematical modelling III: Meta-Modelling Morse-Smale-Complex • Learning target 8: reduced model of drilling and cutting • mathematical model reduction: melt flow • reduced model for thin film flow • Learning target 9: ripple and dross formation in cutting • model reduction and solution with controlled error: melt flow at low Reynolds-number • structural stability of the reduced model: lubrication approximation, fingering and droplet formation • global properties of the solution of balance equations for mass, momentum and thermal energy – example: cutting • Learning target 10: scales for parameter estimation in laser processing parameters in cutting and drilling • concluding discussion of the learning targets • actual research and development of laser processing
Media	Presentations, Laboratory: Data acquisition and analysis software
Literature	Lecture Notes, List of relevant literature

Lectures / Examinations

Title	**ECTS**	**Workload (SWS / h)**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Exam: Modeling, Model Reduction and Simulation in Laser Processing – Applications	5	0	0	Max. 60 (oral) or 120 (written)
Lecture: Modeling, Model Reduction and	0	2	45	0

Simulation in Laser Processing – Applications				
Exercise: Modeling, Model Reduction and Simulation in Laser Processing – Applications	0	2	45	0

Teaching Unit / Examinations: Examination Modeling, Model Reduction and Simulation in Laser Processing – Applications	
Title	Examination Modeling, Model Reduction and Simulation in Laser Processing – Applications
Sub-title	Exa MMRSLP-A
Semester	1 or 3
Connection to the curriculum	Elective Module
Teaching Unit / Examinations: Lecture Modeling, Model Reduction and Simulation in Laser Processing – Applications	
Title	Lecture Modeling, Model Reduction and Simulation in Laser Processing – Applications
Sub-title	L MMRSLP-A
Semester	1 or 3
Connection to the curriculum	Elective Module
Teaching Unit / Examinations: Exercise Modeling, Model Reduction and Simulation in Laser Processing – Applications	
Title	Exercise Modeling, Model Reduction and Simulation in Laser Processing – Applications
Sub-title	E MMRSLP-A
Semester	1 or 3
Connection to the curriculum	Elective Module

Module: Control Engineering

Module	Control Engineering
Module level	Master
Subtitle	CE
Lecture	See list of lectures and examinations of the module
Semester	1 or 3
Person in charge	Univ.-Prof. Dr.-Ing. Dirk Abel
Lecturer	Univ.-Prof. Dr.-Ing. Dirk Abel
Language	English
Assignment to the curriculum	Elective Module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 90h, Lecture hours 30h (2 SWS), Self-study 60h
Lecture hours	30h (2 SWS)
ECTS-Credit Points (CP)	3
Requirements according to examination regulation	Basic knowledge in mathematics as defined in the examination regulations.
Learning objectives	**Control Engineering** After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> • know, recognize and classify the most common linear control loop elements; • know the effects of feedback and apply different methods to set up feedback elements (controllers) such that predefined control goals are met. <u>Abilities / Skills</u> • analyze dynamical, biological and biomedical systems and identify the relevant causalities; • employ different mathematical descriptions of dynamical systems; • solve differential equations by means of Laplace transform;

	• assess of the stability of dynamical systems using different methods; • obtain, interpret and employ the frequency response of dynamical systems.
Content	**Control Engineering** Significance of control theory, examples of biological and biomedical control loops, functional diagrams, linearization, set up and solving of differential equations, stability, features in time domain of dynamical systems, Laplace transform, transfer function, frequency response, functional diagram algebra, features in frequency domain of dynamical systems, bode diagram, Nyquist plot, Linear control loop elements, principle and goals of controller design, algebraic stability criteria, steady state analysis and transient performance of a control loop, controller setting rules, Nyquist stability criterion, phase margin, gain margin, controller design in bode diagram.
Media	e-Learning L2P, Power Point
Literature	Lecture Notes, List of relevant literature

Lectures / Examinations

Title	**ECTS**	**Workload (SWS / h)**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Exam: Control Engineering	3	0	0	Max. 60 (oral) or 120 (written)
Lecture: Control Engineering	0	1	30	0
Exercise: Control Engineering	0	1	30	0

Teaching Unit / Examinations: Examination Control Engineering

Title	Examination Control Engineering
Sub-title	Exa CE
Semester	1 or 3
Connection to the curriculum	Elective Module

Teaching Unit / Examinations: Lecture Control Engineering

Title	Lecture Control Engineering
Sub-title	L CE

Semester	1 or 3
Connection to the curriculum	Elective Module
Teaching Unit / Examinations: Exercise Control Engineering	
Title	Exercise Control Engineering
Sub-title	E CE
Semester	1 or 3
Connection to the curriculum	Elective Module

Compulsory Course – First Semester

Language Course

Module: Language Course (1)

Module	Language Course (1)
Module level	Master
Subtitle	LC 1
Lecture	See list of lectures and examinations of the module
Semester allocation	1
Person in charge	RWTH Aachen University Language Center
Lecturer	-
Language	German (if not proficient/native speaker)
Assignment to the curriculum	Compulsory module
Teaching form	Written examination, Lecture, Exercise
Workload	Total 60h, Lecture hours 30h (2 SWS), Self-study 30h
Lecture hours	30h (2 SWS)
ECTS-Credit Points (CP)	2
Requirements according to examination regulation	-none-

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Language Course (1)	2	0	0	60-90 min. written
Lecture: Language Course (1)	0	1	15	0
Exercise: Language Course (1)	0	1	15	0

Teaching Unit / Examinations: Language Course (1)

Title	Examination Language Course (1)
Sub-title	Exa LC (1)
Semester allocation	1
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Language Course (1)	
Title	Lecture Language Course (1)
Sub-title	L LC (1)
Semester allocation	1
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Exercise Language Course (1)	
Title	Exercise Language Course (1)
Sub-title	E LC (1)
Semester allocation	1
Connection to the curriculum	Compulsory module

Compulsory Courses – Second Semester

Program specific

Module: Manufacturing Technology II

Module	Manufacturing Technology II
Module level	Master
Subtitle	MT II
Lecture	See list of lectures and examinations of the module
Semester allocation	2
Person in charge	Univ.-Prof. Dr.-Ing. Thomas Bergs
Lecturer	Univ.-Prof. Dr.-Ing. Thomas Bergs
Language	English
Assignment to the curriculum	Compulsory module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 180h, Lecture hours 60h (4 SWS), Self-study 120h
Lecture hours	60h (4 SWS)
ECTS-Credit Points (CP)	6
Requirements according to examination regulation	-none-
Learning objectives	**Manufacturing Technology II** After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students • have an extended understanding in technologically comprehensive topics like material science and tribology; • know and understand the mechanisms to improve the performance of powder metallurgical, cutting, forming and hybrid processes.

	Abilities / Skills Students • apply this knowledge properly and are able to assess manufacturing processes with regard to near surface damages and functional surfaces; • evaluate processes by calculation of key figures for productivity, profitability and reliability und thus are able to propose solutions.
Content	**Manufacturing Technology II** • Metal-based Materials • Tool Materials • Powder Metallurgy • Tribology • Near Surface Damages and Functional Surfaces • High-Speed Machining • Bulk and Sheet Metal Forming • Computer-aided Technology Planning • Hybrid Manufacturing Methods • Productivity and Profitability • Manufacturing of Optical Components • Manufacturing of Components for Mobility • Manufacturing Methods for Toolmaking
Media	e-Learning L^2P, Power Point
Literature	Lecture Notes Students also receive a list of relevant literature

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Manufacturing Technology II	6	0	0	120 (written) or max. 60 (oral)
Lecture: Manufacturing Technology II	0	2	60	0
Exercise: Manufacturing Technology II	0	2	60	0

Teaching Unit / Examinations: Examination Manufacturing Technology II

Title	Examination Manufacturing Technology II
Sub-title	Exa MT II
Semester allocation	2
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Lecture Manufacturing Technology II	
Title	Lecture Manufacturing Technology II
Sub-title	L MT II
Semester allocation	2
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Exercise Manufacturing Technology II	
Title	Exercise Manufacturing Technology II
Sub-title	E MT II
Semester allocation	2
Connection to the curriculum	Compulsory module

Module: Production Management B

Module	Production Management B
Module level	Master
Subtitle	PM B
Lecture	See list of lectures and examinations of the module
Semester allocation	2
Person in charge	Univ.-Prof. Dr.-Ing. Dipl.-Wirt. Ing. Günther Schuh
Lecturer	Univ.-Prof. Dr.-Ing. Dipl.-Wirt. Ing. Günther Schuh
Language	English
Assignment to the curriculum	Compulsory module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 150h, Lecture hours 60h (4 SWS), Self-study 90h
Lecture hours	60h (4 SWS)
ECTS-Credit Points (CP)	5
Requirements according to examination regulation	-none-
Learning objectives	**Production Management B** After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students • know and understand particular aspects of the domains design, process planning, production as well as program planning and investment planning; • understand the usefulness of modern planning methods, with emphasis on the application of computers (CAD, CAP, CAM etc.; • understand the boundary conditions in daily business and give the students an advanced and comprehensive basis to reflect advantages and disadvantages of the discussed systems. <u>Abilities / Skills</u>

	Students • analyse the structure of enterprise resources, make comparisons and give recommendations according to the results of the analysis.
Content	**Production Management B** • IT in Production Management • Customer Relations Management • Enterprise Resource Planning I • Enterprise Resource Planning II • Enterprise Resource Planning III • Supply Chain Management I • Supply Chain Management II • Product Lifecycle Management I • Product Lifecycle Management II • Product Lifecycle Management III • Digital Plant Planning and Simulation • Business Engineering - Method of selecting IT-Systems
Media	e-Learning L²P, Power Point
Literature	Lecture Notes Students also receive a list of relevant literature

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Production Management B	5	0	0	90-120 (written) or max. 60 (oral)
Lecture: Production Management B	0	2	45	0
Exercise: Production Management B	0	2	45	0

Teaching Unit / Examinations: Examination Production Management B

Title	Examination Production Management B
Sub-title	Exa PM B
Semester allocation	2

Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Lecture Production Management B	
Title	Lecture Production Management B
Sub-title	L PM B
Semester allocation	2
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Exercise Production Management B	
Title	Exercise Production Management B
Sub-title	E PM B
Semester allocation	2
Connection to the curriculum	Compulsory module

Compulsory Courses – Second Semester

Track specific

Module: Additive Manufacturing II - Engineering and Design

Module	Additive Manufacturing II - Engineering and Design
Module level	Master
Subtitle	AM II
Lecture	See list of lectures and examinations of the module
Semester	2
Person in charge	Univ.-Prof. Dr.-Ing. Dipl.-Wirt.-Ing. Johannes Schleifenbaum
Lecturer	Univ.-Prof. Dr.-Ing. Dipl.-Wirt.-Ing. Johannes Schleifenbaum
Language	English
Assignment to the curriculum	Compulsory Module
Teaching form	Lecture (L), Exercise (E)
Workload	Total 180h, Lecture hours 60h (4 SWS), Self-study 120h
Lecture hours	60
ECTS-Credit Points (CP)	6
Requirements according to examination regulation	-none-
Learning objectives	**Additive Manufacturing II - Engineering and Design** *Overall goal: Students gain knowledge about the essential methods in the product development process, Design for AM rules, methods and tools as well as enterprise management methods.* After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students: • knowledge of the essential methods in the product development process (PEP)

	• are familiar with the essential AM-specific design rules, simulation-driven design process chains as well as necessary software programs • have knowledge about the essential management methods for the integration of AM technology in PEP, production and business processes <u>Abilities / Skills</u> Students: • The students are able to independently work out solutions to given problems. <u>Competencies</u> Students: • able to apply conventional and new PEP approaches to additively manufactured components • can apply different Design for AM methods • are able to identify potential AM components as business cases and classify them economically using various calculation methods
Content	**Additive Manufacturing II - Engineering and Design** • 1) Introduction: Motivation, overview of relevant AM technologies • 2) Product development process (PEP) - conventional approaches: VDI2221, requirement specification, project planning, Gantt chart • 3) PEP - New approaches: Agile product development, scrum, sprint, MVP, design thinking • 4) PEP - Agile Product Development: Basics, procedure, roles, best practice • 5) Design for AM (DfAM): restrictions, design rules, support structures, best practice • 6) DfAM Methods I: Geometry Variation (Modular vs. integral, methods for function integration, feature design), CAD software, best practice • 7) DfAM Methods II: Topology Optimization (Basics, useful applications, procedure), CAD software, best practice • 8) DfAM methods III: Lattice structures (basics, practical applications, procedures), CAD software, best practice • 9) Business Case assessment I: Part identification • 10) Business Case assessment II: Reverse engineering • 11) Business Case assessment III: AM costing, calculation methods (process costs, machine rates, resource-oriented approaches) • 12) Enterprise Environment I: PLM (Basics, costing, project management), workflow - and change management • 13) Enterprise Environment II: ERP
Media	e-Learning L^2P, Power Point

Literature	Lecture Notes Students also receive a list of relevant literature

Lectures / Examinations

Title	Code	ECTS	Workload (SWS / h)		Duration of Exam (min)
			Lecture h. (SWS)	Self-Study (h)	
Examination: Additive Manufacturing II - Engineering and Design		6	0	0	90
Lecture: Additive Manufacturing II - Engineering and Design		0	2	45	0
Exercise: Additive Manufacturing II - Engineering and Design		0	2	45	0

Teaching Unit / Examinations: Examination Additive Manufacturing II - Engineering and Design	
Title	Examination Additive Manufacturing II - Engineering and Design
Sub-title	Exa AM II
Semester	2
Connection to the curriculum	Compulsory Module
Teaching Unit / Examinations: Lecture Additive Manufacturing II - Engineering and Design	
Title	Lecture Additive Manufacturing II - Engineering and Design
Sub-title	L AM II
Semester	2
Connection to the curriculum	Compulsory Module
Teaching Unit / Examinations: Exercise Additive Manufacturing II - Engineering and Design	
Title	Exercise Additive Manufacturing II - Engineering and Design
Sub-title	E AM II

Semester	2
Connection to the curriculum	Compulsory Module

Module: Welding and Joining Technologies

Module	Welding and Joining Technologies
Module level	Master
Subtitle	WJT
Lecture	See list of lectures and examinations of the module
Semester allocation	2
Person in charge	Univ.-Prof. Dr.-Ing. Uwe Reisgen
Lecturer	Univ.-Prof. Dr.-Ing. Uwe Reisgen
Language	English
Assignment to the curriculum	Compulsory module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 180h, Lecture hours 60h (4 SWS), Self-study 120h
Lecture hours	60h (4 SWS)
ECTS-Credit Points (CP)	6
Requirements according to examination regulation	-none-
Learning objectives	**Welding and Joining Technologies** Welding is an interdisciplinary technology. All fields of industrial manufacturing require the joining of individual parts to functional groups. Many welding and cutting technologies are applicable for this purpose. After successfully completing this course, the student will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students • understand the main welding technologies and know how to critically review the shown welding technologies. <u>Abilities / Skills</u> Students

	• select the suitable welding technologies for a welding task and to substantiate the selection by specifying the advantages and the disadvantages of the individual methods.
Content	**Welding and Joining Technologies** • Introduction • Welding of steel • Gas Fusion Welding • Manual Metal Arc Welding • Submerged Arc Welding • TIG Welding • Plasma Welding • MIG Welding • Electro Gas Welding • Electro Slag Welding • Pressure Welding • Resistance Welding • Electron Beam Welding • Laser Beam Welding • Special Processes • Mechanization / Automation • Sensor Technology • Brazing • Mechanical Joining / Adhesive Bonding • Design and Calculation
Media	e-Learning L^2P, Power Point
Literature	Lecture Notes Students also receive a list of relevant literature

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Welding and Joining Technologies	6	0	0	90-120 (written) or max. 60 (oral)
Lecture: Welding and Joining Technologies	0	2	60	0
Exercise: Welding and Joining Technologies	0	2	60	0

Teaching Unit / Examinations: Examination Welding and Joining Technologies	
Title	Examination Welding and Joining Technologies
Sub-title	Exa WJT
Semester allocation	2
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Lecture Welding and Joining Technologies	
Title	Lecture Welding and Joining Technologies
Sub-title	L WJT
Semester allocation	2
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Exercise Welding and Joining Technologies	
Title	Exercise Welding and Joining Technologies
Sub-title	E WJT
Semester allocation	2
Connection to the curriculum	Compulsory module

Elective Courses – Second and Fourth Semester

Module: Industrial Logistics

Module	Industrial Logistics
Module level	Master
Subtitle	IL
Lecture	See list of lectures and examinations of the module
Semester allocation	2 or 4
Person in charge	Univ.-Prof. Dr.-Ing. Dipl.-Wirt. Ing. Günther Schuh apl. Prof. Dr.-Ing. Volker Stich
Lecturer	Univ.-Prof. Dr.-Ing. Dipl.-Wirt. Ing. Günther Schuh apl. Prof. Dr.-Ing. Volker Stich
Language	English
Assignment to the curriculum	Elective module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 150h, Lecture hours 45h (3 SWS), Self-study 105h
Lecture hours	45h (3 SWS)
ECTS-Credit Points (CP)	5
Requirements according to examination regulation	-none-
Learning objectives	**Industrial Logistics** After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students • know objectives and tasks of industrial logistics as well as main aspects of industrial logistics from organisational involvement to logistics controlling.

	Abilities / Skills Students • understand the meaning and the effects of individual aspects of industrial logistics and can place them in the overall context. Competencies Students • apply the acquired knowledge in Industrial Logistics to practical problems.
Content	**Industrial Logistics** • Introduction - Objectives and Tasks of Logistics • Procurement • Distribution • Inventory Management • Process- and Information Management • Material Flow Planning • Smart Objects • Supply Chain Management
Media	e-Learning L^{2}P, Power Point
Literature	Lecture Notes Students also receive a list of relevant literature

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Industrial Logistics	5	0	0	90-120 (written) or max. 60 (oral)
Lecture: Industrial Logistics	0	2	60	0
Exercise: Industrial Logistics	0	1	45	0

Teaching Unit / Examinations: Examination Industrial Logistics

Title	Examination Industrial Logistics
Sub-title	Exa IL
Semester allocation	2 or 4

Connection to the curriculum	Elective module
Teaching Unit / Examinations: Lecture Industrial Logistics	
Title	Lecture Industrial Logistics
Sub-title	L IL
Semester allocation	2 or 4
Connection to the curriculum	Elective module
Teaching Unit / Examinations: Exercise Industrial Logistics	
Title	Exercise Industrial Logistics
Sub-title	E IL
Semester allocation	2 or 4
Connection to the curriculum	Elective module

Module: Multibody Dynamics

Module	Multibody Dynamics
Module level	Master
Subtitle	MD
Lecture	See list of lectures and examinations of the module
Semester allocation	2 or 4
Person in charge	Univ.-Prof. Dr.-Ing. Dr. h. c. (UPT) Burkhard Corves
Lecturer	Univ.-Prof. Dr.-Ing. Dr. h. c. (UPT) Burkhard Corves
Language	English
Assignment to the curriculum	Elective module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 180h, Lecture hours 60h (4 SWS), Self-study 120h
Lecture hours	60h (4 SWS)
ECTS-Credit Points (CP)	6
Requirements according to examination regulation	-none-
Learning objectives	**Multibody Dynamics** After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students • have a profound knowledge of theory of vibrations; • are capable of comprehending, describing and analyzing vibratory systems; • are familiar with the most important matrix based procedures for the calculation of eigen motions and the behaviour of linear systems under forced excitations; • select suitable program systems for the calculation of nonlinear system and carry out proper simulations. <u>Abilities / Skills</u>

	Students • describe mathematically any mechanical system with its inherent physical effects like elasticity, damping and friction; • properly interpret simulation results especially under consideration of simplifications within the model compared to the real system. <u>Competencies</u> Students • derive from their knowledge the necessary methods and proceedings for the analysis and synthesis of the systems in regard. Thus they are capable to solve - accessing their acquired theoretical knowledge - complex problems concerning the choice and design of industrial vibratory systems.
Content	**Multibody Dynamics** • Introduction • Fundamentals • Fields of application • Model Building • Methods of Approach for Equivalent Models • Multi-body Systems • Determination of the Model Parameters • General mathematical description • Kinematics of Multi Body Systems • Position and Orientation of Bodies • Translational Kinematics • Rotational Kinematics • Equations of Motion • Lagrangian Equations of 2nd Kind • Newton-Euler equations • Linearisation • Eigen Value Approach • Undamped non-gyroscopic systems • Damped gyroscopic systems • Eigen Value Stability Criteria Linear Systems with Harmonic Excitation • Real Frequency Matrix • Complex Frequency Matrix • State Equation • System Matrix • Eigen Value Approach • Fundamental Matrix • Modal Matrix • Theorem of Cayley-Hamilton • Analytical Solution • Numerical Solution • Step Excitation • Harmonic Excitation • Periodical Excitation

	Introduction of Multi Body Simulation Software • ADAMS • SIMPACK • SimMechanics Hands-On-Laboratory for Multi Body Simulation Software • ADAMS • SIMPACK • SimMechanics Example • Modelling • Determination of Parameters • Calculation Evaluation
Media	e-Learning L^2P, Power Point
Literature	Lecture Notes Students also receive a list of relevant literature

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Multibody Dynamics	6	0	0	120 (written) or max. 60 (oral)
Lecture: Multibody Dynamics	0	2	60	0
Exercise: Multibody Dynamics	0	2	60	0

Teaching Unit / Examinations: Examination Multibody Dynamics

Title	Examination Multibody Dynamics
Sub-title	Exa MD
Semester allocation	2 or 4
Connection to the curriculum	Elective module

Teaching Unit / Examinations: Lecture Multibody Dynamics

Title	Lecture Multibody Dynamics
Sub-title	L MD

Semester allocation	2 or 4
Connection to the curriculum	Elective module
Teaching Unit / Examinations: Exercise Multibody Dynamics	
Title	Exercise Multibody Dynamics
Sub-title	E MD
Semester allocation	2 or 4
Connection to the curriculum	Elective module

Module: Factory Planning

Module	Factory Planning
Module level	Master
Subtitle	FP
Lecture	See list of lectures and examinations of the module
Semester allocation	2 or 4
Person in charge	Univ.-Prof. Dr.-Ing. Dipl.-Wirt.-Ing. Achim Kampker
Lecturer	Univ.-Prof. Dr.-Ing. Dipl.-Wirt.-Ing. Achim Kampker
Language	English
Assignment to the curriculum	Elective module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 180h, Lecture hours 60h (4 SWS), Self-study 120h
Lecture hours	60h (4 SWS)
ECTS-Credit Points (CP)	6
Requirements according to examination regulation	-none-
Learning objectives	**Factory Planning** The lecture factory planning shows the state of the art of the particular topics. Best-practice methods and approaches are explained and reference solutions presented. After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students • know and understand the main scope and challenges of factory planning projects; • understand the basic principles and methods of the factory planning modules which are presented in the lectures goal definition & product/ process analysis, location planning & plant structure planning, industrial facility & building design, production structure planning & capacity planning, layout planning &

	workstation design, production logistics planning & production control, personnel planning & change management, implementation planning & ramp-up management and project management. Abilities / Skills Students • apply the gained knowledge to assess different factory planning solutions in industrial practice; • develop own factory planning concepts of lower complexity within the presented modules; • solve factory planning problems independently. Competencies Students • participate in factory planning projects and collaborate with other planners; • cope with the high complexity in factory planning projects and are able to develop creative solutions.
Content	**Factory Planning** L1/L2 - Introduction Comprehending the basic glossary, getting to know the content and understanding the challenges and requirements of modern factory planning and learn about the Aachen Factory Planning Methodology. L3/L4 - Definition of goals and Product and process analysis Getting to know methods for the definition of goals in early planning phases. Comprehending basic methods for the analysis of product and processes. L5/L6 – Location planning and plant structure planning The lecture focusses on the basic criteria for the selection of a specific plant location and methods for the planning of the particular plant structure. L7/8 – Industrial facility and Building design Getting to know the basic processes within industrial facility and building design and learning about different building concepts. L9/10 - Production structure planning and Capacity planning Introduction to production structure planning with an explanation of different concepts, understanding methods for the quantitative planning of production capacities and resources.

	L11/12 - Layout planning and Workstation design Introduction to challenges and targets of layout planning and acquiring knowledge of design and assessment of factory layouts. Getting to know basic targets and methods for the design of single workstations. L13/L14 - Production logistics planning and Production control Comprehend the basics of logistics planning, getting to know the development of logistic strategies and principles from sourcing to recycling processes and learning about basic principles in production control. L15/16 - Personnel planning and change management Introduction to personnel planning with its specific challenges and methods, learning about problems and solution approaches within change management processes. L17/18 - Implementation planning and ramp-up management Getting to know basic methods of implementation planning and understanding challenges within the ramp-up of new products. Learning about tools and methods within ramp-up management. L19/20 - Project management Understanding basic methods and principles within project management for the project planning and project execution & controlling.
Media	e-Learning L²P, Power Point
Literature	Lecture Notes Students also receive a list of relevant literature

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Factory Planning	6	0	0	120 (written) or max. 60 (oral)
Lecture: Factory Planning	0	2	60	0
Exercise: Factory Planning	0	2	60	0

Teaching Unit / Examinations: Examination Factory Planning

Title	Examination Factory Planning
Sub-title	Exa FP

Semester allocation	2 or 4
Connection to the curriculum	Elective module
Teaching Unit / Examinations: Lecture Factory Planning	
Title	Lecture Factory Planning
Sub-title	L FP
Semester allocation	2 or 4
Connection to the curriculum	Elective module
Teaching Unit / Examinations: Exercise Factory Planning	
Title	Exercise Factory Planning
Sub-title	E FP
Semester allocation	2 or 4
Connection to the curriculum	Elective module

Module: Modeling, Model Reduction and Simulation in Laser Processing - Laser

Module	Modeling, Model Reduction and Simulation in Laser Processing - Laser
Module level	Master
Subtitle	MMRSLP-L
Lecture	See list of lectures and examinations of the module
Semester allocation	2 or 4
Person in charge	Univ.-Prof. Dr. rer. nat. Wolfgang Schulz
Lecturer	Univ.-Prof. Dr. rer. nat. Wolfgang Schulz
Language	English
Assignment to the curriculum	Elective module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 150h, Lecture hours 60h (4 SWS), Self-study 90h
Lecture hours	60h (4 SWS)
ECTS-Credit Points (CP)	5
Requirements according to examination regulation	-none-
Learning objectives	**Modeling, Model Reduction and Simulation in Laser Processing - Laser** After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students • experimental evidence of Maxwell equations • refraction, diffraction and scattering, Fresnel- number Nf, and applications • can perform the derivation of SVE-approximation • Laser light, can perform the calculation imaging and focussing • know at least 3 types of laser systems, temporal and spatial distribution of laser radiation, Fresnel-number, invariant quantity of light propagation

	• understand the structure of solution for the Helmholtz-equation, diffraction, 5 parameter pairs of optical material equations, transmission, reflection, absorption, Fresnel Formulae, polarisation of matter and radiation • know the main properties of the solution in the asymptotic case of paraxial light propagation and can explain the relation between optical and material parameters • know the effect of coupling between atoms and can explain the relation between band structure and optical properties • understand the interactive cooperation of scientists from engineering, physics and mathematics for application of model based methods for diagnosis in laser processing Abilities / Skills Students • Application of model based methods for solving practical tasks of laser design from discussion of project examples
Content	**Modeling, Model Reduction and Simulation in Laser Processing - Laser** Overview of contents, definition of the 10 learning targets • the contribution of the engineer to the interactive cooperation of scientific disciplines • main features of the theory of cognition (Karl Popper) • Light: amplitude and phase, Fermat's principle, laser radiation, Helmholtz equation, diffraction, Fresnel- number Nf,, reduced model: SVE-approximation • Learning target 1: experimental origin of Maxwell equations, Rayleigh scattering, Laser Principle • Learning target 2: ABCD-matrix, ABCD-law • Learning target 3: beam parameter product, optical invariant • Matter: emission spectra, band structure, reflection, transmission and absorption of light, • Learning target 4: isolator, semiconductor, metal, gas • Learning target 5: Rydberg constant, Planck's law • Learning target 6: reduced model of the Fresnel Formulae for the limiting case of small displacement current, optical parameters • Gaussian Beam: beam quality, beam guiding and forming • Learning target 7: quality features of light, Plane-, spherical- and Gouy-phase

	Quality number K and focussing F-number • Resonator: frequency filter, axial mode structure • Learning target 8: feedback-axial mode structure, g-parameter, aperture-lateral mode, Fresnel number Nf, rod and tube design • Active Medium: entropy, phase transition of 2. Kind, Einstein rate equations • Learning target 9: Gas and Solid-state and Diode Laser • Learning target 10: laser threshold, cooling, pumping • Modulation: Gain switch µs, Q-Switch ns, Mode locking fs • Learning target 11: phase coupling • concluding discussion of the learning targets • actual research and development of laser processing
Media	e-Learning L^2P, Power Point
Literature	Lecture Notes Students also receive a list of relevant literature

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Modeling, Model Reduction and Simulation in Laser Processing - Laser	5	0	0	90-120 (written) or max. 60 (oral)
Lecture: Modeling, Model Reduction and Simulation in Laser Processing - Laser	0	2	45	0
Exercise: Modeling, Model Reduction and Simulation in Laser Processing - Laser	0	2	45	0

Teaching Unit / Examinations: Examination Modeling, Model Reduction and Simulation in Laser Processing - Laser

Title	Examination Modeling, Model Reduction and Simulation in Laser Processing - Laser

Sub-title	Exa MMRSLP-L
Semester allocation	2 or 4
Connection to the curriculum	Elective module
Teaching Unit / Examinations: Lecture Modeling, Model Reduction and Simulation in Laser Processing - Laser	
Title	Lecture Modeling, Model Reduction and Simulation in Laser Processing - Laser
Sub-title	L MMRSLP-L
Semester allocation	2 or 4
Connection to the curriculum	Elective module
Teaching Unit / Examinations: Exercise Modeling, Model Reduction and Simulation in Laser Processing - Laser	
Title	Exercise Modeling, Model Reduction and Simulation in Laser Processing - Laser
Sub-title	E MMRSLP-L
Semester allocation	2 or 4
Connection to the curriculum	Elective module

Module: Production Metrology

Module	Production Metrology
Module level	Master
Subtitle	PM
Lecture	See list of lectures and examinations of the module
Semester allocation	2 or 4
Person in charge	Univ.-Prof. Dr.-Ing. Robert Schmitt
Lecturer	Univ.-Prof. Dr.-Ing. Robert Schmitt
Language	English
Assignment to the curriculum	Elective module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 150h, Lecture hours 60h (4 SWS), Self-study 90h
Lecture hours	60h (4 SWS)
ECTS-Credit Points (CP)	5
Requirements according to examination regulation	-none-
Learning objectives	**Production Metrology** The aim of this module is to create the awareness, that “measuring” comprehends a lot more than plain data acquisition and metrology is a vital part of modern production processes. After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students • know the function and the responsibility of metrology for production; • know the theoretical fundamentals which have to be taken into consideration while the measuring process is planned, controlled, analysed, are discussed;

	• know current measuring principles and devices in the field of industrial production; • know statistical fundamentals being necessary for analysis of the measured values. <u>Abilities / Skills</u> Students • define measuring task on the basis of given features; • select adequate measuring devices for measuring tasks; • interpret measuring results. <u>Competencies</u> Students • make their decision (having arguments) for using metrology within production; • have learned to make decisions concerning measurement on the base of different parameters.
Content	**Production Metrology** <u>Introduction</u> • Relevance of metrology for quality assurance and its integration in production processes. <u>Metrological Basics</u> • Metrological concepts and definitions (Calibration, Uncertainty etc.) <u>Tolerancing</u> • Form and positional tolerances, tolerancing principles and basics <u>Inspection Planning</u> • Tasks and workflow of inspection planning, Procedure for creation of inspection plans <u>Shop floor measuring devices/ Measuring sensors</u> • Commonly used manual inspection devices for the shop floor, Function and application of inductive, capacitive and pneumatical sensors <u>Optoelectronic inspection devices</u> • Optical inspection systems for geometry testing and applications <u>Form and surface inspection devices</u> • Tactile and optical system for the characterisation of forms and surfaces, surfaces parameters

	Coordinate measurement technology • Principles, types and applications of coordinate measuring machines Gauging inspection • Form and positional gauging, Gauging Procedures Statistical basics • Statistical parameters for the description of production and • measuring processes, tests on normal distribution SPC, Process Capability • Statistical analysis and control of processes, Process capability indices Inspection device management • Tasks and procedures of inspection device management, Calculation of measuring device capability, Calibration chain
Media	e-Learning L²P, Power Point
Literature	Lecture Notes Students also receive a list of relevant literature

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Production Metrology	5	0	0	90-120 (written) or max. 60 (oral)
Lecture: Production Metrology	0	2	45	0
Exercise: Production Metrology	0	2	45	0

Teaching Unit / Examinations: Examination Production Metrology

Title	Examination Production Metrology
Sub-title	Exa PM
Semester allocation	2 or 4
Connection to the curriculum	Elective module

Teaching Unit / Examinations: Lecture Production Metrology

Title	Lecture Production Metrology
Sub-title	L PM
Semester allocation	2 or 4
Connection to the curriculum	Elective module
Teaching Unit / Examinations: Exercise Production Metrology	
Title	Exercise Production Metrology
Sub-title	E PM
Semester allocation	2 or 4
Connection to the curriculum	Elective module

Module: Intelligent Monitoring of Engineering Systems

Module	Intelligent Monitoring of Engineering Systems
Module level	Master
Subtitle	IMES
Lecture	See list of lectures and examinations of the module
Semester	2
Person in charge	Univ.-Prof. Dr.-Ing. Bernd Markert
Lecturer	Univ.-Prof. Dr.-Ing. Bernd Markert; Daniel Hesser; Arnd Koeppe
Language	English
Assignment to the curriculum	Elective Module
Teaching form	Written and oral examination (Exam; Written/Oral Examination: 80% Presentation: 20%), Lecture (L), Exercise (E)
Workload	Total 150h, Lecture hours: 3 SWS
Lecture hours	3 SWS
ECTS-Credit Points (CP)	5
Requirements according to examination regulation	Programming experience, particularly in Python and/or Matlab, is recommended.
Learning objectives	**Intelligent Monitoring of Engineering Systems** *The students will get an overview over current trends in structural health monitoring (SHM) and understand their theoretical foundation in the context of engineering applications* After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students: • Are familiar with sensing systems, filtering methods and computational intelligence <u>Abilities / Skills</u> Students:

	• analyze engineering, mainly mechanical, systems and to monitor the relevant system parameters • apply fundamental methods of structural health monitoring <u>Competencies</u> Students: • transfer their knowledge to new engineering applications in science and industry. • independently plan, advance and complete research in the Monitoring of Engineering Systems
Content	**Intelligent Monitoring of Engineering Systems** The course “Intelligent Monitoring of Engineering Systems” is available for students enrolled in the Master programmes of RWTH Aachen University. It provides insights into recent monitoring strategies, which are closely linked to the field of structural health monitoring and computational intelligence. The course will be taught interactively, engaging the students using practical example projects. The following topics are covered: + Sensing and Data acquisition - Sensors - Sensing Systems + Data Preparation - Filtering - Feature Engineering + Classification and Learning + Structural Health Monitoring + Predictive Maintenance + Case Studies The course curriculum consists of interactive seminar lectures accompanied by semester project works. During the seminar lectures, the students will receive the necessary theoretical information and supervision to independently plan, advance and complete the projects in small groups. In addition, the seminars offer the opportunity to discuss challenges and problems arising during the course of the projects. Finally, the achievements and results obtained within the student projects will be presented by the students in the scope of the seminar lectures and the accompanying computer lab exercises.
Media	e-Learning L^{2}P, Power Point
Literature	Farrar, C.R. and Worden, K., 2012. Structural Health Monitoring: A Machine Learning Perspective. Wiley. Lecture Notes, Slides Students also receive a list of relevant literature

Lectures / Examinations					
Title	**Code**	**ECTS**	**Workload (SWS / h)**		**Duration of Exam (min)**
			Lecture h. (SWS)	**Self-Study (h)**	
Examination: Intelligent Monitoring of Engineering Systems		5	0	0	60 min. written or 30 min. oral
Lecture: Intelligent Monitoring of Engineering Systems		0	2	55	0
Exercise: Intelligent Monitoring of Engineering Systems		0	1	40	0

Teaching Unit / Examinations: Intelligent Monitoring of Engineering Systems	
Title	Examination Intelligent Monitoring of Engineering Systems
Sub-title	Exam IMES
Semester	2
Connection to the curriculum	Elective Module

Teaching Unit / Examinations: Intelligent Monitoring of Engineering Systems	
Title	Lecture Intelligent Monitoring of Engineering Systems
Sub-title	L IMES
Semester	2
Connection to the curriculum	Elective Module

Teaching Unit / Examinations: Intelligent Monitoring of Engineering Systems	
Title	Exercise Intelligent Monitoring of Engineering Systems
Sub-title	E IMES
Semester	2
Connection to the curriculum	Elective Module

Compulsory Course – Second Semester

Language Course

Module: Language Course (2)

Module	Language Course (2)
Module level	Master
Subtitle	LC 2
Lecture	See list of lectures and examinations of the module
Semester allocation	2
Person in charge	RWTH Aachen University Language Center
Lecturer	-
Language	German (if not proficient/native speaker)
Assignment to the curriculum	Compulsory module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 60h, Lecture hours 30h (2 SWS), Self-study 30h
Lecture hours	30h (2 SWS)
ECTS-Credit Points (CP)	2
Requirements according to examination regulation	-none-

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Language Course (2)	2	0	0	60-90 min. written
Lecture: Language Course (2)	0	1	15	0
Exercise: Language Course (2)	0	1	15	0

Teaching Unit / Examinations: Language Course (2)	
Title	Examination Language Course (2)
Sub-title	Exa LC (2)
Semester allocation	2
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Language Course (2)	
Title	Lecture Language Course (2)
Sub-title	L LC (2)
Semester allocation	2
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Exercise Language Course (2)	
Title	Exercise Language Course (2)
Sub-title	E LC (2)
Semester allocation	2
Connection to the curriculum	Compulsory module

Compulsory Course – Third Semester

Program specific

Module: Industrial Intelligence Interlaced Quality Management

Module	Industrial Intelligence Interlaced Quality Management
Module level	Master
Subtitle	iQM
Lecture	See list of lectures and examinations of the module
Semester allocation	3
Person in charge	Univ.-Prof. Dr.-Ing. Robert Schmitt
Lecturer	Univ.-Prof. Dr.-Ing. Robert Schmitt
Language	English
Assignment to the curriculum	Compulsory module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 180h, Lecture hours 60h (4 SWS), Self-study 120h
Lecture hours	60h (4 SWS)
ECTS-Credit Points (CP)	6
Requirements according to examination regulation	-none-
Learning objectives	**Industrial Intelligence Interlaced Quality Management** Professional and methodical competence: The students develop an operational understanding of the different forms of the concept of quality and classify them with regard to "industrial intelligence". They are able to identify and classify problems in the corporate context. They have basic knowledge in the field of machine learning, are familiar with related advanced quality management methods and can describe their specific applicability and effectiveness. Application competence: Students will be able to understand applications in the quality management domain with the help of the theoretical and practical knowledge imparted. They are able to build up the structure of an

	"industrial intelligence" in the company context by means of quality management methods, to evaluate its effectiveness and to further develop and to connect methods of quality management. Competence to act: On the basis of their sound methodological and organizational knowledge, the students are able to intervene in value chains in order to improve them. They can recognize and evaluate situations, strengths and weaknesses of an existing quality management system and formulate suitable measures for further development. After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students • know important standards and guidelines in "Quality Management" and understand the structure of standards (High-Level Structure) • distinguish between system, process and product quality; • recognize quality-relevant data and data sources along the product life cycle; • explain statistical and methodological basics of "Industrial Intelligence" as a central task of quality management • understand basic data analytics and machine learning methods • know the legal implications • understand the concept of Internet of Production • understand the importance of quality and quality management in networked, adaptive production • name the classification of typical problems <u>Abilities / Skills</u> Students • apply data collection (e.g. gain customer insights in the product development process and during product use, data-driven procurement management); • apply of selected data analytics and machine learning methods (e.g. tor risk quantification and analyse problematic quality issues: prediction, process control) • organize quality management for services • undertake decision support of the "Smart Quality Expert" (e.g. Predictive Quality, Predictive Maintenance) <u>Competencies</u> Students

	• critically assess topics such as quality planning, quality costs and quality legal questions via discussions; • critically reflect approaches, methods and guiding principles while communicating their opinions.
Content	**Industrial Intelligence Interlaced Quality Management** The module is based on the research content of the "Internet of Production" cluster of excellence. Against this background, the participants should take the intellectual transformation step from the application of tools (methodological competence) to the shaping of the underlying principles and interrelations in value chains (action competence).
Media	e-Learning L^{2}P, Power Point
Literature	Lecture Notes Students also receive a list of relevant literature

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Industrial Intelligence Interlaced Quality Management	6	0	0	120 (written) or max. 60 (oral)
Lecture: Industrial Intelligence Interlaced Quality Management	0	2	60	0
Exercise: Industrial Intelligence Interlaced Quality Management	0	2	60	0

Teaching Unit / Examinations: Examination Industrial Intelligence Interlaced Quality Management

Title	Industrial Intelligence Interlaced Quality Management
Sub-title	Exa iQM
Semester allocation	3
Connection to the curriculum	Compulsory module

Teaching Unit / Examinations: Lecture Industrial Intelligence Interlaced Quality Management

Title	Lecture Industrial Intelligence Interlaced Quality Management
Sub-title	L iQM
Semester allocation	3
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Exercise Industrial Intelligence Interlaced Quality Management	
Title	Exercise Industrial Intelligence Interlaced Quality Management
Sub-title	E iQM
Semester allocation	3
Connection to the curriculum	Compulsory module

Compulsory Course – Third Semester

Track specific

Module: Materials for Additive Manufacturing

Module	Materials for Additive Manufacturing
Module level	Master
Subtitle	MfAM
Lecture	See list of lectures and examinations of the module
Semester allocation	3
Person in charge	Univ.-Prof. Dr.-Ing. Dipl.-Wirt.-Ing. Johannes Schleifenbaum, Dr. C. Haase
Lecturer	Univ.-Prof. Dr.-Ing. Dipl.-Wirt.-Ing. Johannes Schleifenbaum, Dr. C. Haase
Language	English
Assignment to the curriculum	Compulsory module
Teaching form	Written or oral examination, Lecture, Exercise
Workload	Total 150h, Lecture hours 45h (3 SWS), Self-study 105h
Lecture hours	60h (4 SWS)
ECTS-Credit Points (CP)	6
Requirements according to examination regulation	-none-
Learning objectives	**Materials for Additive Manufacturing** After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students • understand the correlation between the AM process, microstructure development and properties of materials for additive manufacturing. In addition to the actual additive manufacturing processes, post-treatment processes are also considered; • learn about the causes of material defects and their effect on their properties;

	• learn the relevant properties of the input materials, e.g. powder, and understand their influence on the material behaviour along the additive manufacturing process chain. <u>Abilities / Skills</u> Students • describe the differences between additive and conventionally manufactured materials and parts. <u>Competencies</u> Students • independently work out solutions to given problems.
Content	**Materials for Additive Manufacturing** • Introduction: Motivation, additive manufacturing processes and material classes • Input materials for additive manufacturing process, their properties, determination and evaluation of these properties • Material defects, their causes and effects • General microstructure and texture development during the additive manufacturing and post-treatment process, influencing factors on the microstructures formed and textures in materials manufactured using additives • Correlation between microstructure, texture and properties of additive materials • Production, properties, finishing, applications of additive steels • Production, properties, finishing, fields of application of additive aluminium alloys • Production, properties, finishing, fields of application of additive titanium alloys • Production, properties, post-processing, fields of application of additive nickel-based alloys • Production, properties, post-processing, fields of application of additive manufactured other metallic alloys • Failure behaviour of additive materials • Simulation of material behaviour during and after additive manufacturing
Media	e-Learning L^{2}P, Power Point
Literature	Lecture Notes Students also receive a list of relevant literature

Lectures / Examinations			
Title	**ECTS**	**Workload**	

		Lecture h. (SWS)	Self-Study (h)	Duration of Exam (min)
Examination: Materials for Additive Manufacturing	5	0	0	90 (written) or 30 (oral)
Lecture: Materials for Additive Manufacturing	0	2	45	0
Exercise: Materials for Additive Manufacturing	0	1	60	0

Teaching Unit / Examinations: Examination Materials for Additive Manufacturing	
Title	Examination Materials for Additive Manufacturing
Sub-title	Exa MfAM
Semester allocation	3
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Lecture Materials for Additive Manufacturing	
Title	Lecture Materials for Additive Manufacturing
Sub-title	L MfAM
Semester allocation	3
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Exercise Materials for Additive Manufacturing	
Title	Exercise Materials for Additive Manufacturing
Sub-title	E MfAM
Semester allocation	3
Connection to the curriculum	Compulsory module

Elective Courses – Third Semester

Practical Experiences or Elective Courses

Note: Instead of an internship, students may take elective modules in the scope of at least 12 Credit Points.

Module: Internship

Module	Internship
Module level	Master
Subtitle	I
Lecture	See list of lectures and examinations of the module
Semester	3
Person in charge	Univ.-Prof. Dr.-Ing. Thomas Bergs
Lecturer	Univ.-Prof. Dr.-Ing. Thomas Bergs
Language	English
Assignment to the curriculum	Elective module
Teaching form	Internship report (Examination) (Exa), Internship (I)
Workload	Total 12 weeks
Lecture hours	-
ECTS-Credit Points (CP)	12
Requirements according to examination regulation	-none-
Learning objectives	**See guidelines for practical training in the examination regulations**
Content	**See guidelines for practical training in the examination regulations**
Media	-
Literature	-
Lectures / Examinations	

Title	ECTS	Workload (SWS / h)		Duration of Exam (min)
		Lecture h. (SWS)	Self-Study (h)	
Examination: Internship	12	0	0	-
Internship: Internship	0	0	360	0
Teaching Unit / Examinations: Examination Internship				
Title	Examination Internship			
Sub-title	Exa I			
Semester	3			
Connection to the curriculum	Elective module			

Compulsory Course – Third Semester

Language Course

Module: Linguistic Elective

Module	Linguistic Elective
Module level	Master
Subtitle	LE
Lecture	See list of lectures and examinations of the module
Semester allocation	3
Person in charge	RWTH Aachen University Language Center
Lecturer	-
Language	Freely selectable
Assignment to the curriculum	Compulsory module
Teaching form	Written examination, Lecture, Exercise
Workload	Total 60h, Lecture hours 30h (2 SWS), Self-study 30h
Lecture hours	30h (2 SWS)
ECTS-Credit Points (CP)	2
Requirements according to examination regulation	-none-

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Linguistic Elective	2	0	0	60-90 min. written
Lecture: Linguistic Elective	0	1	15	0
Exercise: Linguistic Elective	0	1	15	0

Teaching Unit / Examinations: Linguistic Elective

Title	Examination Linguistic Elective
Sub-title	Exa LE
Semester allocation	3
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Linguistic Elective	
Title	Lecture Linguistic Elective
Sub-title	L LE
Semester allocation	3
Connection to the curriculum	Compulsory module
Teaching Unit / Examinations: Exercise Linguistic Elective	
Title	Exercise Linguistic Elective
Sub-title	E LE
Semester allocation	3
Connection to the curriculum	Compulsory module

Compulsory Course – Fourth Semester

Master Thesis

Module: Master Thesis

Module	Master Thesis
Module level	Master
Subtitle	MaTh
Lecture	See list of lectures and examinations of the module
Semester allocation	4
Language	English
Assignment to the curriculum	Compulsory module
Workload	6 Months
ECTS-Credit Points (CP)	30
Requirements according to examination regulation	The topic of the Master Thesis cannot be assigned until 85 CP have been successfully completed.
Learning objectives	**Master Thesis** The students learn how to independently approach and work on academic topics, document their progress and finalize the entire project within a given deadline. They acquire systematic academic research skills.
Content	**Master Thesis** Complete academic paper to show that the students are capable of independently working on a problem related to their subject using academic methods.