Hochschule Düsseldorf
University of Applied Sciences

Fachbereich Maschinenbau
und Verfahrenstechnik
Faculty of Mechanical
and Process Engineering

MODULHANDBUCH WAHLFÄCHER MASTERSTUDIENGÄNGE

MODULE MANUAL COMPULSORY ELECTIVE MODULES MASTER'S PROGRAMMES

Übersicht/Catalogue							
Module	**Modulnr. /Module no.**	**Studiengang / Study programme**					
		UMI		**IWI**			**ME**
		EUT	**UPT**	**EUT**	**UPT**	**PUI**	
Advanced Business English	40131	X	X	X	X	X	X
Advanced Computational Methods	40211	X	X	X	X	X	X
Advanced English for Engineers	40291	X	X	X	X	X	X
Advanced Machine Learning		X	X	X	X	X	X
Automation with Microcontrollers	40151	X	X	X	X	X	X
Behavioural Economics	40311			X	X	X	
Computational Fluid Dynamics (Modulhandbuch UMI + ME / Module Manual UMI + ME)	11301 11302	X*	X*	X	X	X	
Control Theory	40041	X	X	X	X	X	X
Digital Business Transformation in Industry 4.0	40281	X	X	X	X	X	X
Elektrische Energie – Umwandlung, Speicherung, Verteilung (Modulhandbuch IWI + UMI / Module Manual IWI + UMI)			X		X	X	
Energie- und umwelttechnische Prozessoptimie-rung (Energy and Environmental Process Optimisation) (Modulhandbuch UMI / Module Manual UMI)	21111	X					
Engineering Mathematics (Modulhandbuch UMI + ME / Module Manual UMI + ME)	11401 11402	X*	X*	X	X	X	
Fatigue Strength of Components	40331						X
Finite Element Method (FEM) (Modulhandbuch ME / Module Manual ME)	12101 12102	X	X	X	X	X	
Heat and Mass Transfer in Two Phase Flows (Modulhandbuch UMI + IWI / Module Manual UMI + IWI)	21001						X
Heterogeneous Catalysis	40241	X	X	X	X		
Hydrogen Economy	40341	X	X	X	X	X	X
Industrial Robots in Industry 4.0 Environments	40321	X	X	X	X	X	X
Industrial Services Marketing & Business Develop-ment	40201	X	X	X	X	X	X
Innovation and Technology Management (Modulhandbuch IWI / Module Manual IWI)	17001 17002	X	X				X
Innovative Product Development	40031	X	X	X	X	X	X
Intercultural Competence	40081	X	X	X	X	X	X
International Standards in Artificial Intelligence	40371	X	X	X	X	X	X
International Technical Sales Management (Module Manual IWI)	17201	X	X				X
Lean Agile Framework – Strategieumsetzung und Prozessoptimierung in Organisationen	40391			X	X	X	
Life Cycle and Services Management (Module Manual Master IWI)	17301	X	X				X
Low-Noise Design	40071	X	X	X	X	X	X

Nachhaltige Energiewirtschaft (Modulhandbuch UMI / Module Manual UMI)	40301		X	X	X		X (d)
Optimierung und Simulation (Modulhandbuch UMI / Module Manual UMI)	11001	X*	X*	X	X	X	X (d)
Plain Bearing Technology – Design, Dimensioning and Testing	40381						X
Pollutant Sensors in Ambient Air Control and Auto-mobiles	40171	X	X	X	X	X	X
Polymer Technology	40091	X	X	X	X		X
Prozessführung und Prozessautomation	40161	X	X	X	X	X	X (d)
Qualitätsmanagement im internationalen Umfeld (Modulhandbuch IWI / Module Manual IWI)	17101	X	X				X (d)
Simulation of Mechanical Systems (Modulhandbuch ME / Module Manual ME)	12001 12002	X	X	X	X	X	
Software Lab	40221	X	X	X	X	X	X
Turbulent Combustion	40361						X
Turbulent Flows	40021						X
Versuchsplanung und -auswertung (Modulhandbuch UMI + IWI / Module Manual UMI + IWI)	11101 11102	X*	X*	X	X	X	X (d)

Agenda / Key:

Studiengänge / Study programmes:
UMI = Umweltingenieurwesen / Environmental Engineering,
IWI = Internationales Wirtschaftingenieurwesen / International Industrial Engineering,
ME = Mechanical Engineering
Schwerpunkte / Focus:
EUT = Energie- und Umwelttechnik / Energy and Environmental Technology,
UPT = Umwelt- und Prozesstechnik / Environmental and Process Technology,
PUI = Produktion und Innovation / Production and Innovation
Sprache / Language of instruction: X (d) = German

*Im Masterstudiengang UMIUMI müssen im Block der Methodenfächer 3 aus 5 Fächern ausgewählt werden. Die nicht gewählten 4. und 5. Fächer können als Wahlpflichtfach belegt werden. Die Modulbeschreibungen aller 5 Methodenfächer enthält das Modulhandbuch für die Pflichtfächer.

*In the master's programme UMI, within the block of methodology modules (*Methodenfächer*), students must select 3 out of 5 modules. The modules they did not select (modules 4 and 5) can be chosen as an elective module. The module descriptions of all 5 methodology modules are to be found in the module manual for compulsory modules.

Die Gültigkeit von Wahlfächern ist generell auf zwei Studienjahre beschränkt. Der Fachbereichsrat kann eine Modulbeschreibung für ein Wahlfach, für das laufende Studienjahr oder für das jeweils nächste Studienjahr beschließen bzw. deren Gültigkeit verlängern.

The validity of the elective modules is generally limited to two academic years. The Faculty Council can determine the description of an elective module for the current academic year or extend its validity for the following academic year.

INHALTSVERZEICHNIS/TABLE OF CONTENTS

Advanced Business English					
Module no.		**Workload**	**Credits**	**Semester**	**Offered in**
40131		180 h	6	Sem. 1/2	SoSe/ WiSe
1	**Courses**		**Attendance**	**Self-study**	**Duration**
	Seminar 4 SWS		4 SWS / 60 h	120 h	1 sem.
2	**Learning outcomes / competences** The students • are able to communicate successfully in English in a wide range of business situations, • gained confidence in using the language of international business, • know important business words and phrases relevant for engineers • have good knowledge of important grammar topics, • are able to write business e-mails • improved their listening skills • are competent to read and understand authentic business articles				
3	**Contents** • Authentic articles on a variety of current business topics • Listening comprehension exercises and interviews • Grammar exercises • Business correspondence				
4	**Forms of teaching and learning** • Lecture • Group work • Discussion • Videos • Conducted online, or in the classroom, or blended learning.				
5	**Prerequisites** **Formal prerequisites:** None **Subject-related prerequisites:** Good knowledge of English (at least level B2)				
6	**Types of examination** Presentation. The presentation might be conducted online or in the classroom. Details to be announced at the beginning of the course.				
7	**Requirements for award of credits** Passed examination				
8	**Module allocated to other study programmes** Open for all master's programmes of the department of mechanical and process engineering.				

	This module gives students the confidence and the ability to participate in other courses held in English.
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Britta Zupfer, M.A.
11	**Language of instruction** English
12	**Further information and recommended literature** • Brook-Hart, Guy: *Business Benchmark Advanced*. Student´s Book and Personal Study Book. Cambridge University Press 2016.

Advanced Computational Methods

Module no.	Workload	Credits	Semester	Offered in
40211	180 h	6	Sem. 1/2	SoSe/WiSe

	Courses	Attendance	Self-study	Duration
1	Seminar 4 SWS	4 SWS / 60 h	120 h	1 sem.

2 Learning outcomes / competences

The participants have a basic understanding and scientific insight to numerical simulation methods in engineering and science beyond the standard principles of the Finite Element Method. They have advanced knowledge in the following fields of computational engineering:

(i) development, implementation and application of finite element methods of higher order (p-version),

(ii) the interaction of geometric modelling & structural analysis,

(iii) the design of freeform structures with B-splines and NURBS

(iv) geometrically and physically non-linear problems

Furthermore, they have knowledge about the fundamentals of embedded domain methods and isogeometric analysis. The acquired competences and skills are ideal pre-requisites for academic and industrial research and development in all fields of numerical analysis & simulation in mechanical, civil and aerospace engineering.

3 Contents

- Theory, properties, choice and application of hierarchical higher order approximation spaces
- Element formulation and implementation aspects
- Refinement aspects, convergence behaviour and error estimation
- Theory, geometric and numerical modelling aspects of isogeometric analysis
- Theory and implementation aspects of non-linear problems
- Application of higher order approximation in the context of embedded domain methods for analysis domains of high geometric complexity

4 Forms of teaching and learning

- Lecture
- Seminar
- Discussion forum
- Independent preparation

5 Prerequisites

Formal prerequisites: None

Subject-related prerequisites: Strong background of mathematics and engineering mechanics, differential equations, finite element method

6 Types of examination

Written exam (duration: 90 min.) OR Software project with oral defense, multiple-choice problems

7	**Requirements for award of credits** Passed examination
8	**Module allocated to other study programmes** Open for all master's programmes at the department of mechanical and process engineering.
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. habil. Martin Ruess
11	**Language of instruction** English
12	**Further information and recommended literature** • Lecture slides • J. Austin Cottrell, Thomas J. R Hughes, Yuri Bazilevs. Isogeometric Analysis: Toward Integration of CAD and FEA, Wiley 2009 • Bathe, K.-J., Finite Element Procedures, Prentice-Hall, New Jersey, 2007

Advanced English for Engineers				
Module no. 40291	**Workload** 180 h	**Credits** 6	**Semester** Sem. 1/2	**Offered in** WiSe/SoSe
1	**Courses** Seminar 4 SWS	**Attendance** 4 SWS / 60 h	**Self-study** 120 h	**Duration** 1 sem.
2	**Learning outcomes / competences** The students • are able to read and understand a wide range of authentic technical texts on engineering topics • have a profound knowledge on technical issues presented in current videos or TV contributions • widened their field of technical vocabulary to communicate in international business situations • improved their listening skills • are fluent in using technical English • are able to present and debate relevant engineering topics			
3	**Contents** • Authentic technical texts at an advanced level of English • Current audivisual media • Advanced grammar topics			
4	**Forms of teaching and learning** • Lecture • Group work • Discussion • Presentations • Conducted online, or in the classroom, or blended learning.			
5	**Prerequisites** **Formal prerequisites:** None **Subject-related prerequisites:** Good knowledge of English (at least level B2)			
6	**Types of examination** Presentation. The presentation might be conducted online or in the classroom. Details to be announced at the beginning of the course.			
7	**Requirements for award of credits** Passed examination			
8	**Module allocated to other study programmes**			

	Open for all master's programmes of the department of mechanical and process engineering. This module enables the students to better understand and analyse the English material presented in other courses.
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Britta Zupfer, M.A.
11	**Language of instruction** English
12	**Further information and recommended literature** • www.asme.org • Current articles and videos on technical issues

Advanced Machine Learning				
Module no.	**Workload**	**Credits**	**Semester**	**Offered in**
	180 h	6	Sem. 1/2	SoSe
1	**Courses** a) Lecture 4 SWS b) Practical Training 2 SWS	**Attendance** 5 SWS / 75 h	**Self-study** 105 h	**Duration** 1 sem.
2	**Learning outcomes / competences** The students • learn basic approaches theoretically as well as practice-relevant procedures of machine learning and can explain them, • can distinguish between the learned ML methods and choose them according to a given task, • are familiar with the typical workflow (data preprocessing, training, validation, testing) and software tools for solving practical ML problems, • are able to critically assess a solution in terms of plausibility and contextualize it back to the original problem statement, • can independently apply machine learning to new application scenarios.			
3	**Contents** The lecture covers in-depth fundamentals of machine learning and practical methods relevant to real-world applications. In addition to theoretical considerations, application-oriented examples such as image recognition or learning game strategies are used to apply the learned methods. This enables acquiring the competence to explain, contextualize, and transfer these methods to other application scenarios. Specifically, the following topics are addressed: • Stochastic Decision/Learning Theory: Bayesian decision theory, classification and regression, un/supervised learning • Maximum Likelihood and Bayesian Parameter Estimation: LDA, PCA • Non-parametric methods: k-Nearest-Neighbor, Parzen Windows, Decision Trees, Ensemble Methods • Kernel-based approaches: Support Vector Machines, Kernel-PCA, Kernel-FDA • Neural Networks: Deep NN, Convolutional NN, Recurrent NN, Autoencoders, GANs • Boltzmann Learning, Restricted Boltzmann Machines • Reinforcement Learning: (Deep) Q-Learning			
4	**Forms of teaching and learning** • Oral presentation with slides • Programming examples and exercises • Practical evaluation of ML methods by students themselves • Guidance to independent scientific work Conducted online, or in the classroom, or blended learning.			

5	**Prerequisites** **Formal prerequisites:** None **Subject-related prerequisites:** • Mathematics • Computer Science (Matlab or Python skills)
6	**Types of examination** Oral examination
7	**Requirements for award of credits** Passed examination
8	**Module allocated to other study programmes** Open for all master's programmes of the department of mechanical and process engineering.
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. André Stuhlsatz
11	**Language of instruction** English (German optional)
12	**Further information and recommended literature** • DUDA, Richard O., Peter E. HART und David G. STORK, 2001. Pattern classification. 2. ed. New York [u.a.]: Wiley. ISBN 0-471-05669-3 • HASTIE, Trevor, Robert TIBSHIRANI und Jerome H. FRIEDMAN, 2017. The elements of statistical learning: data mining, inference, and prediction. Second edition, corrected at 12th printing 2017. New York, NY: Springer. ISBN 978-0-387-84857-0 • SCHÖLKOPF, Bernhard und Alexander J. SMOLA, 2002. Learning with kernels: support vector machines, regularization, optimization, and beyond. Cambridge, Mass. [u.a.]: MIT Press. ISBN 0-262-19475-9 • MACKAY, David J. C., 2008. Information theory, inference, and learning algorithms. 7. print. Cambridge [u.a.]: Cambridge Univ. Press. ISBN 978-0-521-64298-9 • AGGARWAL, Charu C., 2018. Neural networks and deep learning: a textbook. Cham, Switzerland: Springer. ISBN 978-3-319-94462-3 • CALIN, Ovidiu L., 2020. Deep learning architectures: a mathematical approach. Cham: Springer. ISBN 978-3-030-36721-3 • SUTTON, Richard S. und Andrew BARTO, 2018. Reinforcement learning: an introduction. Second edition. Cambridge, Massachusetts; London, England: The MIT Press. ISBN 978-0-262-03924-6

Automation with Microcontrollers				
Module no. 40151	**Workload** 180 h	**Credits** 6	**Semester** Sem. 1/2	**Offered in** Each WiSe
1	**Courses** Seminar 4 SWS	**Attendance** 4 SWS / 60 h	**Self-study** 120 h	**Duration** 1 sem.
2	**Learning outcomes / competences** The students • know the architecture of microcontrollers (µC) represented by the ARM-microcontroller family. • have basic skills in C/C++ programming of microcontrollers. • can use digital and analogue I/O-ports and know how to program timers and interrupts. • can exchange data via serial bus and read in as well as process analogue signals (such as sensor data) via AD converters. The subjects have been applied in practical exercises and programming tasks. • have built up a functional microcontroller project with actuators and sensors. Due to relatively low cost of the equipment used (<50€) and the use of open source software, students could optionally use their own equipment and could literally 'take their project home'. The students have worked out practical tasks in small groups. This has supported their capacity for teamwork and communication skills.			
3	**Contents** • Range of application for µC • µC architecture, µC programming • Basics C-programming language • Cross compilation • Real-time systems • I/O ports • System clock, timers and interrupts • Basic electronics in the peripheral µC-context (transistor circuits, pull-up, pull-down, dc motor control, analogue filters,…) • Acquisition of analogue data (ADC), output of analogue data (DAC, PWM) • Communication via interfaces (serial bus, I^2C, SPI, UART, …) • µC as embedded system • Networking with µCs • Rapid prototyping of automation algorithms on µC using MATLAB and Simulink • PID control with µC • Basics of Artificial Intelligence on µC: soft sensors, neuronal networks, fuzzy logic and machine learning			

4	**Forms of teaching and learning** Seminar with computer exercises including electronic practice sessions in small groups
5	**Prerequisites** **Formal prerequisites:** / **Subject-related prerequisites:** Basic knowledge of PLC or other industrial automation systems and basic programming skills are of advantage.
6	**Types of examination** Oral or written examination. Details to be announced at the beginning of the course.
7	**Requirements for award of credits** Passed examination
8	**Module allocated to other study programmes** Open for all master's programmes of the department of mechanical and process engineering.
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. Wolfgang Grote-Ramm
11	**Language of instruction** English
12	**Further information and recommended literature** • Blum, Jeremy: *Exploring Arduino: Tools and Techniques for Engineering Wizardry*, Wiley, 2019 • Langbridge, James A.: *Arduino Sketches*, Wiley, 2015 • https://www.arduino.cc/ • https://beagleboard.org/ • https://www.mikrocontroller.net/

Behavioural Economics				
Module no. 40311	**Workload** 180 h	**Credits** 6	**Semester** Sem. 1/2	**Offered in** Each WiSe
1	**Courses** Seminar 4 SWS	**Attendance** 4 SWS / 60 h	**Self-study** 120 h	**Duration** 1 sem.

2 Learning outcomes / competences

The students

- know the basics of behavioural economics and classical games from economics.
- can distinguish between different forms of cognitive biases which contradict classical economic theory.
- are able to use empirical research methods to set up and realize an economic experiment.
- are able to use statistical methods to analyse data from economic experiments.
- are able to interpret data from economic experiments and discuss the results.

3 Contents

- Cognitive biases which contradict classical economic theory (especially the rationality of "homo oeconomicus") such as
  - Loss aversion (Prospect Theory)
  - Anchoring
  - Endowment effect
  - Status quo bias
  - Confirmation bias
  - Mental accounting
  - Availability heuristic
  - Overconfidence
- Classical games from economics and game theory used in economic experiments to examine economic cooperation such as
  - Prisoner's Dilemma
  - Ultimatum Game
  - Dictator Game
  - Trust Game
  - Public Goods Game
- Set-up, realisation and analysis of economic experiments

4 Forms of teaching and learning

Introductory lecture, practical examples, practical case study, group work

5 Prerequisites

Formal prerequisites: None

	Subject-related prerequisites: Business Studies (Grundlagen der BWL), Statistics (Statistik)
6	**Types of examination** Practical work in groups with presentation and/or term paper. The applicable type of examination will be announced at the beginning of the course.
7	**Requirements for award of credits** Passed examination
8	**Module allocated to other study programmes** IWI
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. Carsten Deckert
11	**Language of instruction** English
12	**Further information and recommended literature** Number of participants limited to 12. • Lecture script (available on moodle) • Ariely, D., Kreisler, J. (2018). Dollars and Sense. How We Misthink Money and How to Spend Smarter. New York: HarperCollins. • Axelrod, R. (1990). The Evolution of Cooperation. London: Penguin Books. • Corr, P., Plagnol, A. (2019). Behavioral Economics – the basics. New York: Routledge. • Cramer, E., Kamps, U. (2017). Grundlagen der Wahrscheinlichkeitsrechnung und Statistik: eine Einführung für Studierende der Informatik, der Ingenieur- und Wirtschaftswissenschaften. Berlin: Springer. • Dobelli, R. (2014). The Art of Thinking Clearly. New York: HarperCollins. • Kahneman, D. (2012). Thinking, Fast and Slow. London: Penguin Books. • Thaler, R.H. (2016). Misbehaving. The Making of Behavioral Economics. New York: Norton.

Control Theory				
Module no.	**Workload**	**Credits**	**Semester**	**Offered in**
40041	180 h	6	Sem. 1./2	Each WiSe

1	**Courses**	**Attendance**	**Self-study**	**Duration**
	Seminar 4 SWS	4 SWS / 60 h	120 h	1 sem.

2 Learning outcomes / competences

- Students are able to solve rather complex control-technique tasks.
- Therefore, the SISO system is extended to multiple-state systems and different control strategies are possible.
- Different techniques to evaluate the stability of a system.

3 Contents

- Multiple-input-multiple-output systems
- Adaptive control
- Optimal control
- Controllability and observability
- Lyapunov stability
- State-space representation
- Digital control

4 Forms of teaching and learning

- Lecture (PC with projector, overhead slides, blackboard)
- Exercises

5 Prerequisites

Formal prerequisites: None

Subject-related prerequisites: Knowledge of control techniques and mathematics

6 Types of examination

Oral examination (30 min.) or written examination (120 min.)

The type of examination will be announced at the beginning of the course.

7 Requirements for award of credits

Passed examination

8 Module allocated to other study programmes

Open for all master's programmes of the department of mechanical and process engineering.

9 Weighting for overall grade

6/90

10 Person responsible for the module and examiner(s)

Prof. Dr.-Ing. Jürgen Kiel

11	**Language of instruction** English or German
12	**Further information and recommended literature** Lecture notes

Digital Business Transformation in Industry 4.0 Environments				
Module no.	**Workload**	**Credits**	**Semester**	**Offered in**
40281	180 h	6	Sem. 1/2	Each SoSe

1	**Courses**	**Attendance**	**Self-study**	**Duration**
	Seminar 4 SWS	4 SWS / 60 h	120 h	1 sem.

2 Learning outcomes / competences

After having successfully finished the course, students will

- have acquired a scientific understanding and scientific insight on the on the digital business and its disruptive impact with regard to production systems
- be able to analyse and evaluate the importance of professional digital value streams in production management and its role in the revenue stream of industrial enterprises.
- be able to apply methods on how to identify profitable business areas and how to develop a successful communication strategy for industrial services to the customers.
- be able to evaluate the impact of platform economy on global industries
- be able to apply and create strategies to master the change and develop new digital business segments

3 Contents

- Industry 4.0
- Platform economies
- B2B digital value streams
- Software support in digital environments
- Design thinking to create digital structures and business models

4 Forms of teaching and learning

Lectures, presentations, discussions, group work

5 Prerequisites

Formal prerequisites: None

Subject-related prerequisites: Knowledge in the area of production management and economic evaluation of production performance is recommended

6 Types of examination

- Written examination (90 min.)

or

- Oral presentation and written documentation of group work

Scope and extend will be announced at begin of semester

7 Requirements for award of credits

Passed examination

8 Module allocated to other study programmes

	Open for all master's programmes at the department of mechanical and process engineering. The course has links to and deepens the modules "Life Cycle & Service Management" and "International Technical Sales" on in the Master programmes as well as the "Marketing & Vertrieb" and the "Service Management" module in the Bachelor programmes.
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. Jörg Niemann
11	**Language of instruction** English or German. Language will be announced at the beginning of the course.
12	**Further information and recommended literature** • Steven, M. Industre 4.0: Grundlagen Teilbereiche, Perspektiven. Kohlhammer, 2019 • Fischer Thomas et al.: Service Business Development, Strategies for Value Creation in Manufacturing Firms, Cambridge Press, 2012 • Köhler-Schulte, C. Industrie 4.0: Ein praxisorientierter Ansatz, KS Energy Verlag, 2015 • Huber, W.: Industrie 4.0 kompakt – Wie Technologien unsere Wirtschaft und unsere unternehmen verändern, SpringerViehweg, 2018 • Manzei, C.: Industrie 4.0 im internationalen Kontext. VDI VDE Verlag, 2016 • Brenner, Hatto; Misu, Cecilia: Internationales Business Development, Berlin, Heidelberg, Springer, 2015 • Heinemann, G.: B2B eCommerce: Grundlagen, Geschäftsmodelle und Best practice. SringerGabler, 2020 • Niemann, Jörg: Die Services-Manufaktur, Industrielle Services planen –entwickeln –einführen. Ein Praxishandbuch Schritt für Schritt mit Übungen und Lösungen. Aachen, Shaker Verlag, 2016

Fatigue Strength of Components				
Module no. 40341	**Workload** 180 h	**Credits** 6	**Semester** Sem. 1/2	**Offered in** Each WiSe
1	**Courses** Seminar 4 SWS	**Attendance** 4 SWS / 60 h	**Self-study** 120 h	**Duration** 1 sem.
2	**Learning outcomes / competences** • The students know the theoretical foundations of fatigue strength and damage accumulation and terms and designations of dynamic strength. • They are able to ○ apply durability- and strength-time charts, ○ explain the theoretical basics of crack growth (Paris/Erdogan), stress – intensity - factors of fracture mechanics, ○ develop representations of Tension-elongation - , Weibull-, Wöhler and crack-growth diagrams, ○ know the influence of stress concentration and material as well weakness detection of components, ○ operate a high-frequency vertical-dynamic- (Zwick Röll) and/or low frequency torsional dynamic test bench, ○ apply the DIN EN 743.			
3	**Contents** • Historical background of fatigue strength • Optimisation of component geometry to increase lifetime with theoretical basics and in a practical experiment • Characterisation of materials • Stress concentrations • Surface and material effects • Variable amplitude loading • Fatigue analysis of welded structures • Basic probability and statistics • Statistical techniques • Analysis methods • Sources of variability • Case studies • Fatigue Calculation Model			
4	**Forms of teaching and learning** Theory and practice in the laboratory			
5	**Prerequisites**			

	Formal prerequisites: None **Subject-related prerequisites:** Knowledge in material science and strength analysis of components
6	**Types of examination** Presentation of the test results and oral examination
7	**Requirements for award of credits** Passed examination
8	**Module allocated to other study programmes** ME
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. Robert Bongartz
11	**Language of instruction** English or German. Language will be announced at the beginning of the course.
12	**Further information and recommended literature** • DIN EN 743 • Lecture documents • Haibach - Betriebsfestigkeit • Schijve - Fatigue of Structures and Materials

Heterogeneous Catalysis				
Module no. 40221	**Workload** 180 h	**Credits** 6	**Semester** Sem. 1/2	**Offered in** Each WiSe (SoSe by request)
1	**Courses** a) Lectures 2 SWS b) Seminar 2 SWS	**Attendance** 4 SWS / 60 h	**Self-study** 120 h	**Duration** 1 sem.

2 Learning outcomes / competences

Heterogeneous catalysis plays a decisive role for more than 80% of large-scale processes in the chemical industry.

In this module, the students have gained sound insight into the fundamentals of heterogeneous catalysis. They know all essential aspects of the selection, preparation and characterisation of catalysts, their application in important industrial reactions and the evaluation of kinetic measurement data for further process optimisation.

During the accompanying seminar, the students have

- transferred the acquired contents to selected sample processes independently and
- discussed them based on the current state of research.

This module has enabled students to

- study the highly interdisciplinary field of heterogeneous catalysis thoroughly and
- pursue their own research activities in this field.

3 Contents

- Introduction to heterogeneous catalysis: beginnings of catalysis research; industrial significance; concepts and definitions in heterogeneous catalysis
- Fundamentals of heterogeneous catalysis: reaction course; physisorption and chemisorption; adsorption equilibria; elementary steps
- Catalysts: classification, preselection and preparation; methods of catalyst synthesis; promoters and catalyst poisons
- Characterisation: methods to determine catalyst parameters; texture, porosity and surface; volume methods; surface methods
- Catalyst performance: selection of reactors; experimental design and optimisation; evaluation of kinetic measurement data; catalyst testing
- Kinetics and reaction mechanisms: a. microkinetics (surface reaction, structure-activity relationship, kinetic approaches); b. macrokinetics (film and pore diffusion)
- Consideration of important heterogeneously catalysed reactions: hydrogenation reactions; oxidation reactions; acid-base catalysis; bifunctional catalysis
- Concepts for laboratory-scale and industrial-scale rectors
- *Seminar*: oral presentation of selected industrial processes including current research activities and patent applications

4 Forms of teaching and learning

	• Lectures • Oral presentations and discussions
5	**Prerequisites** **Formal prerequisites:** None **Subject-related prerequisites (*recommended but not mandatory*):** General and industrial chemistry; mechanical, thermal and chemical process engineering
6	**Types of examination** Combined examination: oral examination (30 min.), 50%, and oral presentation during seminar (45 min.), 50%
7	**Requirements for award of credits** Passed examination
8	**Module allocated to other study programmes** Module is open for UMI (EUT, UPT) and IWI (EUT, UPT)
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Prof. Dr. Stefan Kaluza
11	**Language of instruction** English or German (depending on participants)
12	**Further information and recommended literature** • All presentations and lecture notes in Moodle • W. Reschetilowski, „Einführung in die Heterogene Katalyse“, 2015, Springer Verlag • A. Behr, D.W. Agar, J. Jörissen, A.J. Vorholt, „Einführung in die Technische Chemie“, 2016, Springer Verlag • M. Bearns, A. Behr, A. Brehm, J. Gmehling, H. Hofmann, U. Onken, A. Renken, K.-O. Hinrichsen, R. Palkovits, „Technische Chemie“, 2013, Wiley-VCH

Hydrogen Economy				
Modulnr. 40341	**Workload** 180 h	**Credits** 6	**Semester** Sem. 1/2	**Offered in** Each SoSe
1	**Courses** Seminar 4 SWS (block)	**Attendance** 4 SWS / 60 h	**Self-study** 120 h	**Duration** 1 Sem.
2	**Learning outcomes / competences** • The attendees have developed in-depth insight into current trends and future opportunities of the hydrogen economy. • The attendees have gained in-depth knowledge of a broad range of currently available hydrogen technologies with regard to production, storage and conversion. They are able to recall the basic theory behind different systems. So they can ○ explain their functional principles, ○ state application areas as well as (dis)advantages and ○ evaluate their need, potential and cost in energy systems or industry, in particular in systems based on renewable energy.			
3	**Contents** • Hydrogen economy • Hydrogen production and storage • Electrochemical conversion • Fuel cell and electrolyzer technology • Hydrogen in the (future) industry • Options for the future hydrogen economy			
4	**Forms of teaching and learning** • Block seminar • Lecture • Discussion			
5	**Prerequisites** Formal prerequisites: None Subject-related prerequisites: Thermodynamics, chemistry, English			
6	**Types of examination** Written examination (duration: 90 min.) or oral examination (duration: 30 min.). To be announced at the beginning of the course. The type of examination will be announced at the beginning of the course.			
7	**Requirements for award of credits** Passed examination			
8	**Module allocated to other study programmes**			

	Open for all master's programmes at the department of mechanical and process engineering.
9	**Weighting for overall grade** 6/180
10	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. Franziska Schaube
11	**Language of instruction** English
12	**Further information and recommended literature** D. Stolten, B. Emons. *Hydrogen Science and Engineering: Materials, Processes, Systems and Technology*, Wiley-VCH Verlag, 2016.

Industrial Robots in Industry 4.0 Environments				
Module no. 40321	**Workload** 180 h	**Credits** 6	**Semester** Sem. 1/2	**Offered in** Each WiSe
1	**Courses** a) Lectures 2 SWS b) Seminar 2 SWS	**Attendance** 4 SWS / 60 h	**Self-study** 120 h	**Duration** 1 sem.

2 Learning outcomes / competences

After having successfully passed the course examination, students.

- understand the basic principles of Robotic structures and functionalities,
- understand the basic principles of Robots applications in international context,
- understand the importance of Robotics in an industrial environment,
- understand the importance of the I4.0 impact and implication on robots' design and robots' applications,
- are able to analyse and evaluate the automation and robotisation trends in international context,
- are able to analyse and describe the degree of innovation acceptance according with the customer needs,
- are able to develop and evaluate robotised solutions according to customer needs,
- are able to analyse cobots in I4.0 with implications on human related factors,
- are enabled to apply concepts and instruments to develop and evaluate industrial life cycle concepts with regards to robotisation and business models on an international level.

3 Contents

- Meaning and benefits of robotics for global industrial enterprises
- Robotics characterization, performances and human factors in industry 4.0
- Basics of the Robotics systems and control
- Analysis and evaluation of robotics systems integration within manufacturing lines
- Robots and applications outside the industrial environment
- Methods and principles of Robotics life cycle management
- Methods and management of I4.0 related aspects in automation and robot applications

4 Forms of teaching and learning

- Lecturing (a)
- Practical exercises and case studies (b)
- Student presentations
- Team project

5 Prerequisites

Formal prerequisites: None

	Subject-related prerequisites: General knowledge of mathematics and physical mechanics; knowledge in the area of production management and economic evaluation of production performance is recommended
6	**Types of examination** Written examination (duration: 1,5 h) or oral presentation and written documentation of group work. Scope and extend will be announced at the beginning of the class
7	**Requirements for award of credits** Passed examination
8	**Module allocated to other study programmes** Open for all master's programmes at the department of mechanical and process engineering.
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. Jörg Niemann, Adrian Pisla (adjunct lecturer)
11	**Language of instruction** English
12	**Further information and recommended literature** Extension for the mandatory course of „Life Cycle and Services Management" Matches with elective courses of „Industrial Service Marketing & Business Development" and/or „Digital Business Transformation" **Literature** • Niemann, J.; Pisla, A.: PLM Machines and Mechanisms. Berlin, Heidelberg, Springer, 2020 • Kravets, A.: Robotics: Industry 4.0 Issues & New Intelligent Control Paradigms. Heidelberg. Berlin, Springer, 2020 • Nayyar, A., Kumar, A.:A Roadmap to Industry 4.0: Smart Production, Sharp Business and Sustainable Development. Berlin, Heidelberg, 2020 • Sartal, A.: Enabling Technologies for the Successful Deployment of Industry 4.0. Boca Raton, CRS Press, 2020 • Pisla, D., Bleuler, H., Rodić, A., Vaida, C., Pisla, A., New Trends in Medical and Service Robots - Theory and Integrated Applications, Springer International Publishing, Series, 2014. • Pisla A. Covaciu F.: Manual Programming, Computer Numerical Control, UT Press, 2015. • Niemann, Jörg; Tichkiewitch, Serge; Westkämper Engelbert: Design of Sustainable Product Life Cycles, Springer Verlag, Heidelberg Berlin, 2009 • Morar L, Westkämper E, Abrudan I.,Pisla A, Niemann J, Manole I.: Planning and Operation of the Production Systems, IRB Fraunhofer Verlag, Stuttgart, 2007.

Industrial Services Marketing & Business Development				
Modulnr. 40201	**Workload** 180 h	**Credits** 6	**Semester** Sem. 1/2	**Offered in** Each SoSe
1	**Courses** Seminar 4 SWS	**Attendance** 4 SWS / 60 h	**Self-study** 120 h	**Duration** 1 Sem.

2 Learning outcomes / competences

After having successfully finished the course, students

- have acquired a scientific understanding and scientific insight into the marketing and business development of industrial services.
- are able to analyse and evaluate the importance of professional services and their role in the revenue stream of industrial enterprises.
- are able to apply methods of how to identify profitable business areas and how to develop a successful communication strategy for industrial services for the customers.

3 Contents

- Role and importance of services in the business of industrial firms (industry focus on mechanical and electrical engineering. medical device technology & information/telecommunication sectors)
- Methods and technologies of industrial services marketing (e.g. 7P Method).
- Methods and technologies of industrial business development, service strategies for manufacturing companies, strategic fit between strategy and capabilities, exploitation approaches
- Case studies of industrial service companies, service strategy and process planning and execution
- Current trends in industrial services (e.g. smart + digital services, servitization, subscription models etc.)
- The students will apply the theoretical results of the course to practical interviews with practitioners in industry.

4 Forms of teaching and learning

Lectures, presentations, discussions, group work, interviews in industry

5 Prerequisites

Formal prerequisites: None

Subject-related prerequisites: Knowledge in the area of production management and economic evaluation of production performance is recommended. Basic knowledge + understanding of marketing & business management is helpful.

6 Types of examination

Oral presentation and written documentation of group work

The applicable type of examination will be announced at the beginning of the course.

7 Requirements for award of credits

Passed examination

8	**Module allocated to other study programmes** Open for all master's programmes at the department of mechanical and process engineering. The course has links to and deepens the lectures of "Life Cycle & Service Management" and "International Technical Sales" on Master level as well as the "Marketing & Vertrieb" and the "Service Management" lectures on Bachelor level.
9	**Weighting for overall grade** 6/180
10	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. Jörg Niemann Lecturer: Dipl. Betriebswirt Wilhelm Taurel (visiting lecturer)
11	**Language of instruction** English or German. Course language will be announced on the beginning of the course
12	**Further information and recommended literature** • Alan Wilson, Valarie A. Zeithaml et. Al.: Services Marketing: Integrating Customer Focus Across the Firm – Third European Edition, Mcgraw-Hill Education Ltd 2016 • Fischer Thomas et al.: Service Business Development, Strategies for Value Creation in Manufacturing Firms, Cambridge Press, 2012 • Erwin Matys: Dienstleistungsmarketing: Kunden finden, gewinnen und binden - Mit Leitfaden zum Marketingkonzept, Redline Verlag 2018 • Brodel, Dietmar; Schwarz-Musch, Alexander: Business Development: Grundlagen – Konzepte – Methoden, Berlin, Heidelberg, Springer, 2014 • Bruhn, Manfred et al.: Services Marketing: Managing the Service Value Chain, Pearson, 2006 • Peppels, W.: Service Management, Oldenbourg, 2012 • Schuh, Günther, Gudergan, Gerhard, Kampker, Achim (Hrsg.): Management industrieller Dienstleistungen - Handbuch Produktion und Management, Springer, 2016 • Shaun West - Paolo Gaiardelli - Nicola Saccani: Modern Industrial Services - A Cookbook for Design, Delivery, and Management Springer, 2022 • Christian Kowalkowski and Wolfgang Ulaga: Service Strategy in Action - A Practical Guide for Growing Your B2B Service and Solution Business, 2017 • Thomas Lah & J.B. Wood: Technology-as-a-Service Playbook: How to Grow a Profitable Subscription Business, 2016 • Stephan M. Lizou and Wolfgang Ulaga: Monetizing Data - A practical Roadmap for Framing, Pricing & Selling Your B2B Digital Offers, 2018 • Niemann, Jörg: Die Services-Manufaktur, Industrielle Services planen –entwickeln – einführen. Ein Praxishandbuch Schritt für Schritt mit Übungen und Lösungen. Aachen, Shaker Verlag, 2016

Innovative Product Development					
Module no.		**Workload**	**Credits**	**Semester**	**Offered in**
40031		180 h	6	Sem. 1./2	Each WiSe
1	**Courses**		**Attendance**	**Self-study**	**Duration**
	Seminar 4 SWS		4 SWS / 60 h	120 h	1 sem.
2	**Learning outcomes / competences** The students know • the theoretical and practical foundations of product development. They can • apply this foundations efficiently to examples, • communicate with clients and suppliers systematically and in a structured way about costs, time schedules, and controlling, • work scientifically in this area.				
3	**Contents** Development of a specific industrial product, typically in cooperation with a 'contracting' company				
4	**Forms of teaching and learning** • Oral presentation with slides, computer based simulations • Counselling and guiding students in project work and in project groups				
5	**Prerequisites** **Formal prerequisites:** None **Subject-related prerequisites:** Knowledge of technical design and production technology as well as project management				
6	**Types of examination** Maximum of two intermediate presentations according to planned milestones and one final presentation in front of the cooperation partners. Examination (30 min.). Details to be announced at the beginning of the course.				
7	**Requirements for award of credits** Passed examination				
8	**Module allocated to other study programmes** IWI, ME				
9	**Weighting for overall grade** 6/90				
10	**Person responsible for the module and examiner(s)** Prof. Dr. Bastian Leutenecker-Twelsiek				
11	**Language of instruction**				

	English or German. Course language will be announced on the beginning of the course
12	**Further information and recommended literature** All documents on Moodle Recommended literature (latest edition): • Pahl/Betz/Feldhusen/Grote: *Engineering Desing*, Springer 2004 • VDI 2221: Design of technical products and systems, 2019 • VDI 2206: Design methodology for mechatronic systems, 2004 • Brown, T.: "Design Thinking", *Harvard Business Review* 86 (2008), 84 • Tathagat Varma: *Agile Product Development*, Apress 2015 Further literature will be recommended with regard to the specific task.

Intercultural Competence				
Module no.	**Workload**	**Credits**	**Semester**	**Offered in**
40081	180 h	6	Sem. 1/2	SoSe

1	**Courses**	**Attendance**	**Self-study**	**Duration**
	Seminar 4 SWS	4 SWS / 60 h	120 h	1 sem.

2 Learning outcomes / competences

The students

- understand the basic principles of intercultural communication
- know theories of culture types and cultural values
- have gained profound cultural awareness
- have insight into the diversity in global business
- are able to handle communication issues and can strive for solutions in a business environment

3 Contents

- Intercultural competence is one of the crucial soft skills anyone should have who would like to be successful in a leading position in the globalised business world – independent of his/her job-specific skills.
- In particular students who would like to be part of an international team – in Germany or abroad – need additional skills in order to communicate successfully with members of different cultures.
- What is culture? Different types of cultures are studied with regard to power distance; individualism, collectivism; uncertainty avoidance; orientations to time etc. Especially by focusing on selected examples, the students will be enabled to deal with different corporate cultures.
- Focus on current business situations in companies

4 Forms of teaching and learning

- Lecture
- Case studies
- Presentations
- Videos
- Conducted online, or in the classroom, or blended learning.

5 Prerequisites

Formal prerequisites: None

Subject-related prerequisites: Good knowledge of English (at least level B 2)

6 Types of examination

Presentation and/or written and oral contributions during the semester. The presentation is conducted online or in the classroom.

Applicable type of examination to be announced at the beginning of the course.

7	**Requirements for award of credits** Passed examination
8	**Module allocated to other study programmes** Open for all master's programmes at the department of mechanical and process engineering. This module contributes to enhancing the soft skills of engineers
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Britta Zupfer, M.A.
11	**Language of instruction** English
12	**Further information and recommended literature** • Hofstede, Geert: *Cultures and Organizations – Software of the Mind*. McGraw-Hill Education Ltd. 2010. • Neuliep, James W.: *Intercultural Communication. A Contextual Approach*. SAGE Publications 2014. • Meyer, Erin: *The Culture Map*. Public Affairs 2015.

International Standards in Artificial Intelligence					
Module no.		**Workload**	**Credits**	**Semester**	**Offered in**
40371		180 h	6	Sem. 1/2	WiSe
1	**Courses** a) Lecture 1 SWS b) Seminar 3 SWS		**Attendance** 4 SWS / 60 h	**Self-study** 120 h	**Duration** 1 sem.
2	**Learning outcomes / competences** Technical standards play an important role in all types of industries. The basic functions of standards address quality/reliability, harmonisation of information, compatibility/interoperability and the needs of variety reduction. The most influential international standards are developed and maintained by the International Organization for Standardization (ISO / iso.org). Most technical standards in Artificial Intelligence (AI) are still under development. They face untypical challenges as the research in the field of AI is very dynamic and some AI standards will touch societal, ethical and political issues. In this context students will learn and comprehend: • the role of international standards for high-tech applications using AI technologies, • the scope of the AI standardization currently addressed by ISO, • the needs for standardization in AI from the perspective of the industry and the • regulators, • why AI systems are different to conventional IT systems, • how AI standards can be beneficial for the technical advances in many application areas, e.g. energy, production, mobility, health, administration, environmental protection.				
3	**Contents** • History of AI as a research field • Basic concepts and methods of AI • Use cases of AI systems • Overview of the standardization projects run by the ISO/IEC JTC1/SC42 Artificial • Intelligence • Selected topics: Foundational Standards, Trustworthiness and Robustness of AI, Ethical and Societal concerns, EU Artificial Intelligence Act				
4	**Forms of teaching and learning** Lecture, course work, student presentations, experiential learning				
5	**Prerequisites** **Formal prerequisites:** None **Subject-related prerequisites:** None				
6	**Types of examination** Seminar paper and presentation				

7	**Requirements for award of credits** Passed examination
8	**Module allocated to other study programmes** Open for all master's programmes at the department of mechanical and process engineering.
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. Thomas Zielke
11	**Language of instruction** English
12	**Further information and recommended literature** • Zielke, T.: Is Artificial Intelligence Ready for Standardization? In: Communications in Computer and Information Science. pp. 259–274. Springer International Publishing (2020). https://www.researchgate.net/publication/341616218_Is_Artificial_Intelligence_Ready_for_Standardization • Khamis, A. et al.: AI: A Key Enabler of Sustainable Development Goals, Part 1 [Industry Activities]. IEEE Robotics & Automation Magazine. 26, 95–102 (2019). • Michael L. Littman et al.: Gathering Strength, Gathering Storms: The One Hundred Year Study on Artificial Intelligence (AI100) 2021 Study Panel Report. Stanford University, Stanford, CA, USA (2021). http://ai100.stanford.edu/2021-report • Floridi, L. et al. : AI4People — An Ethical Framework for a Good AI Society: Opportunities, Risks, Principles, and Recommendations. Minds and Machines. 28, 689–707 (2018). https://www.researchgate.net/publication/329192820_AI4People-An_Ethical_Framework_for_a_Good_AI_Society_Opportunities_Risks_Principles_and_Recommendations • Ellul, J.: Should we regulate Artificial Intelligence or some uses of software? Discover Artificial Intelligence. 2, (2022). https://www.researchgate.net/publication/359092453_Should_we_regulate_Artificial_Intelligence_or_some_uses_of_Software • On Artificial Intelligence - A European approach to excellence and trust. European Commission (2020). https://ec.europa.eu/info/sites/default/files/commission-white-paper-artificial-intelligence-feb2020_en.pdf • ISO/IEC 22989, Artificial intelligence concepts and terminology. https://www.iso.org/standard/74296.html?browse=tc • https://www.iso.org/committee/6794475/x/catalogue/p/0/u/1/w/0/d/0

Lean Agile Framework – Strategieumsetzung und Prozessoptimierung in Organisationen				
Modulnr. 40391	**Workload** 180 h	**Credits** 6	**Studiensemester** 1./2. Sem.	**Häufigkeit des Angebots** Jedes Wi-Se
1	**Lehrveranstaltungen** a) Vorlesung 2 SWS b) Übung 2 SWS	**Präsenzzeit** 4 SWS / 60 h	**Selbststudium** 120 h	**Dauer** 1 Sem.

2 Lernergebnisse (Learning outcomes) / Kompetenzen

Die Teilnehmenden erhalten einen praxisnahen Überblick über zeitgemäße Methoden der Strategieumsetzung, End-to-End Wertstromoptimierung und Umsetzung im Unternehmen

Sie verstehen den Nutzen der verschiedenen Methoden in typischen Anwendungsfeldern wie bspw. Sales, Operations und Administration mit Blick auf ihr Zusammenspiel in der Aufbau- wie Ablauforganisation von Unternehmen

Die Teilnehmenden erkennen die Wirkprinzipien der Methoden und können diese auf verschiedene Situationen anwenden

Sie sind in der Lage, erste Methoden in der Praxis (auch ihrer Studienpraxis) anzuwenden

Die Teilnehmenden lernen Moderations- und Präsentationstechniken für die beratende Tätigkeit in Organisationen

3 Inhalte

- Nutzen und Wirkungsweise von Lean und Agile für Organisationen
- Umsetzung von Lean und Agile im Unternehmen mit Hilfe der 7 Kernkompetenzen
  - Lean Leadership – Reflektierende Führung vor Ort entlang des Ziel-Zustands
  - Agile Solution Delivery – Iterative Umsetzung von Lösungen in kurzen synchronen und getakteten Lernzyklen
  - End-to-End Value Stream Optimization – Optimierung des Wertstroms mit dem Ziel der Durchsatzmaximierung im Engpass
  - Shopfloor Management – Umsetzung von Lösungen und Stabilisierung der Unternehmensprozesse durch verlässliche Kommunikation und Eskalation
  - Lean Six Sigma – Lösung schwieriger technischer und prozessualer Probleme mit Hilfe systematischer Herangehensweisen
  - Customer Centricity – Marktanalyse und Identifikation von Kundenbedürfnissen und Entwicklung zielgerichteter Kundenlösungen
  - Lean Portfolio Management – Nachvollziehbare Entwicklung und Umsetzung der Strategie des Unternehmens in die tägliche Arbeitspraxis
- 10 Lean Agile Prinzipien in der Praxis
- Präsentations- und Moderationstechniken als wichtige Werkzeuge der Unternehmensentwicklung

4 Lehr- und Lernformen

- Fokussierte Schulungsinhalte interaktiv präsentiert am Flip-Chart

	• Darstellung von Beispielen aus der Beratungspraxis • Anschließende Übung in Kleingruppen anhand praxisnaher Beispiele und Simulationen • Abschließende Kurzpräsentation vor der Gesamtgruppe
5	**Teilnahmevoraussetzungen** Formal: Inhaltlich: • Interesse an effektiven Methoden modernen Managements • Bereitschaft zur Teamarbeit
6	**Prüfungsformen** 90-min. virtueller Multiple Choice Test mit 45 Fragen
7	**Voraussetzungen für die Vergabe von Kreditpunkten** • Anwesenheit über den gesamten Vorlesungszeitraum • Erfolgreicher Abschluss des Multiple Choice Tests
8	**Verwendung des Moduls** (in anderen Studiengängen) Wahlfach im Studiengang IWI
9	**Stellenwert der Note für die Endnote** 6/90
10	**Modulbeauftragte/r und hauptamtlich Lehrende** Prof. Dr.-Ing. Carl Justus Heckmann; Lehrender: Dr.-Ing. Stephan Pötschke
11	**Sprache** Deutsch
12	**Sonstige Informationen und Literaturangaben**

Low Noise Design

Module no.	Workload	Credits	Semester	Offered in
40071	180 h	6	Sem. 1./2	Each WiSe

	Courses	Attendance	Self-study	Duration
1	Seminar 4 SWS	4 SWS / 60 h	120 h	1 sem.

2 Learning outcomes / competences

The students have fundamental knowledge of low-noise design with applications for

- industrial machinery,
- HVAC,
- automotive industry,
- aviation industry.

The participants can evaluate noise and noise sources with experimental and numerical methods.

3 Contents

- Noise and vibration generation
- Theoretical approaches
- Prediction of noise levels
- Noise and vibration measurement technique

4 Forms of teaching and learning

Counselling and guiding students in project work and project groups

5 Prerequisites

Formal prerequisites: None

Subject-related prerequisites: Computer-based measurement technology

6 Types of examination

Written assignment and presentation (30 min.)

7 Requirements for award of credits

Passed examination (feedback talk)

8 Module allocated to other study programmes

Open for all master's programmes at the department of mechanical and process engineering

9 Weighting for overall grade

6/90

10 Person responsible for the module and examiner(s)

Prof. Dr.-Ing. Frank Kameier

11 Language of instruction

English

12	**Further information and recommended literature** • Bendat, Julius S., Piersol, Allan G.: Engineering applications of correlation and spectral analysis, New York, 1980. • Blauert, Jens, Xiang, Ning, Acoustics for Engineers, 2009Fletcher, Rossing, The Physics of Musical Instruments, 2008 . • Lucas et al.: Handbook of the Acoustic Characteristics of Turbomachinery Cavities, 1997. • Nguyen-Schäfer, Hung, Aero and Vibroacoustics of Automotive Turbochargers, 2013. • Smith, M.J.T. Aircraft Noise, 1989.

Plain Bearing Technology – Design, Dimensioning and Testing					
Module no.		**Workload**	**Credits**	**Semester**	**Offered in**
		180 h	6	Sem. 1/2	WiSe
1	**Courses** a) Lecture 2 SWS b) Seminar 2 SWS		**Attendance** 4 SWS / 60 h	**Self-study** 120 h	**Duration** 1 sem.
2	**Learning outcomes / competences** Students learn the fundamentals of tribology and the practical use of it. After the course students will be able • to design plain bearings including the theoretical and experimental determination of friction and wear behavior • to select appropriate tests to determine either material properties or behavior of complete tribo systems. Furthermore, students learn how to design innovative spring energized bearings. They will be able • to use fundamental mechanical approaches such as beam theory to describe the mechanical behavior of spring type bearings • to select appropriate methods to design the bearings. Students learn advantages and limitations of simple analytical approaches and the options of numerical approaches in practical comparison. • to select appropriate tests to identify material properties including fatigue and the corresponding methods to design parts accordingly.				
3	**Contents** • Plain bearings • Types of friction - Dry and lubricated friction (Stribeck curve) • Characterization of surface roughness • Wear mechanisms & k-Factor • PV-Limit • Testing pyramid for tribological tests • Approaches to simulate tribo systems • Characterization of spring stiffness by analytical vs. numerical approaches • The conflict of tolerance compensation vs. load requirements • Benefits of numerical and analytical approaches • Material parameter characterization including Fatigue • Design of mechanical systems including fatigue				
4	**Forms of teaching and learning** • Lecture • Group work				

	• Excursions
5	**Prerequisites** **Formal prerequisites:** / **Subject-related prerequisites:** Good knowledge of English, Fundamentals of mechanics (statics and strength of materials), Materials science, Physics, FEM (not mandatory)
6	**Types of examination** Presentations (duration: 30 min.) and/or written examination (duration: 120 min.) and/or oral examination (duration: 30 min.). Written and/or oral examination might be conducted online. To be announced at the beginning of the course. Written examination or multiple-choice examination (duration: 120 min.). Written and/or oral examination might be conducted online. Details to be announced at the beginning of the seminar.
7	**Requirements for award of credits** Passed examination
8	**Module allocated to other study programmes** Elective course for ME students
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Person responsible: Prof. Dr.-Ing. Carl Justus Heckmann; lecturer: Dr.-Ing. André Gabener
11	**Language of instruction** English
12	**Further information and recommended literature** Dietmar Gross, Werner Hauger, Jörg Schröder, Wolfgang A. Wall: „Technische Mechanik 1: Statik“, Springer 2009 Dietmar Gross, Werner Hauger, Jörg Schröder, Wolfgang A. Wall: „Technische Mechanik 2: Elastostatik“, Springer 2009 Horst Czichos, Karl-Heinz Habig: „Tribologie-Handbuch - Tribometrie, Tribomaterialien, Tribotechnik“, Springer 2015

Pollutant Sensors in Ambient Air Control and Automobiles					
Modul no. 40171		**Workload** 180 h	**Credits** 6	**Semester** Sem. 1/2	**Offered in** WiSe/SoSe
1	**Courses** a) Seminar 4 SWS b) Exercise 2 SWS		**Attendance** 4 SWS / 60 h	**Self-study** 120 h	**Duration** 1 Sem.
2	**Learning outcomes / competences** The students • know and understand the design and function of low-cost sensors, • know the potential and limitations of low-cost sensors – especially in comparison with expensive certified analytical instruments used by official environmental agencies, • know the design, function and importance of sensors used in automobiles for air pollution control.				
3	**Contents** • Overview of low-cost sensors in air pollution control • Function and design of low-cost sensors for gaseous air pollutants, especially of electrochemical sensors • Function and design of different low-cost sensors for measuring particles • Networks of low-cost sensors and visualisation of measurement results in Google Maps and Google Earth • Limitations of low-cost sensors • Comparison of low-cost sensors with certified expensive analytical instruments • Formation and emission of air pollutants from automobiles and use of sensors for air pollution control in automobiles • Requirements for sensors for automobiles and short overview of sensors for automobiles.				
4	**Forms of teaching and learning** • Impulse lecture • Seminar • Discussion				
5	**Prerequisites** Formal prerequisites: Bachelor's degree Subject-related prerequisites: Fundamentals of physics, electrical engineering, electronics				
6	**Types of examination** Oral examination or written assignment Type of examination to be announced at the beginning of the course.				
7	**Requirements for award of credits**				

	Passed examination
8	**Module allocated to other study programmes** Open for all master's programmes at the department of mechanical and process engineering.
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** N.N.
11	**Language of instruction** English; on demand also in English and German
12	**Further information and recommended literature** • Moretto, Ligia, Kalcher, Kurt, Environmental Analysis by Electrochemical Sensors and Biosensors, Springer-Verlag 2017 • Mead, M.I. et al.: The use of electrochemical sensors for monitoring urban air quality in low-cost, high density networks, Atmospheric Environment 70 (2013) 186-2013 • Reif, K., Sensoren im Kraftfahrzeug, Springer Vieweg 2012 • LUBW Hrsg., LUBW-Bericht zu Feinstaubsensoren, Stuttgart 2017 Internet resources such as • http://alphasense.com; http://www.citi-sense.eu/ • www.luftdaten.info • http://www.ch.cam.ac.uk/files/aw534/RLJ%20AAMG%20 More literature to be announced at the beginning of the course.

Polymer Technology

Module no.	Workload	Credits	Semester	Offered in
40091	180 h	6	Sem. 1/2	Each WiSe

1	Courses	Attendance	Self-study	Duration
	Seminar 4 SWS	4 SWS / 60 h	120 h	1 sem.

2 Learning outcomes / competences

- This seminar has provided the students with basic knowledge of polymer properties, synthesis processes, polymer processing and main technologies in this field.
- It has enabled them to design fundamental polymer processes, considering the impact of the specific properties of polymers on the processes.
- During the seminar, the students have learned to correlate the structure of polymers with their corresponding properties.
- They know the essential methods to determine chemical and physical polymer properties and get an insight into polymer blends.
- Concerning polymer processing, the students have learned the essential dimensionless numbers and how to use them to design extrusion processes.
- Besides, they know how to calculate pressure losses of flowing polymers.
- Finally, the students are aware of the main characteristics of the most important polymer processing technologies (injection moulding, blow moulding etc.).
- After this course, the students have the necessary fundamental knowledge of polymer technology – and are well prepared to start working in the polymer industry.

3 Contents

- Chemical structure of polymers
- Physical and chemical properties of polymers
- Rheological behaviour of polymers
- Relationship of structure and properties of polymers
- Chemistry of polymer synthesis
- Processes for polymer synthesis
- Polymer compounds
- Extrusion of polymers
- Main polymer processing technologies (injection moulding, blow moulding etc.)

4 Forms of teaching and learning

- Seminar
- Discussions
- Excursion

5 Prerequisites

Formal prerequisites: None

	Subject-related prerequisites: Fluid mechanics, Chemistry, Physics, Mathematics
6	**Types of examination** Combined examination: • Short written assignment with presentation (15 min.), 40% • Written examination (60 min.), 60%
7	**Requirements for award of credits** Passed examination
8	**Module allocated to other study programmes** IWI (UPT/EUT), ME, UMI
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. Maren Heinemann
11	**Language of instruction** English or German (depending on participants)
12	**Further information and recommended literature** • Material science of polymers for engineers, Tim A. Osswald, Georg Menges, ISBN 978-1-56990-514-2 • Understanding polymer processing: processes and governing equations, Tim A. Osswald, ISBN 978-1- 56990-472-5 • International plastics handbook: the resource for plastics engineers, Tim A. Osswald, ISBN 978-3- 446-22905-1 • Kunststoffchemie für Ingenieure: Von der Synthese bis zur Anwendung, Wolfgang Kaiser, ISBN 978-3446446380 • Kunststofftechnik: Einführung und Grundlagen, Christian Bonten, ISBN 978-3446440937 • Menges Werkstoffkunde Kunststoffe, Georg Menges, Edmund Haberstroh, Walter Michaeli, Ernst Schmachtenberg, ISBN 978-3446427624 • Polymer-Werkstoffe: Struktur - Eigenschaften – Anwendung, Gottfried Wilhelm Ehrenstein, ISBN 978- 3446422834

Prozessführung und Prozessautomation				
Modulnr.	**Workload**	**Credits**	**Studiensemester**	**Häufigkeit des Angebots**
40161	180 h	6	2. Sem.	Jedes WiSe

1	**Lehrveranstaltungen**	**Präsenzzeit**	**Selbststudium**	**Dauer**
	Seminar 2 SWS	4 SWS / 60h	120 h	1 Sem.

2 Lernergebnisse (Learning outcomes) / Kompetenzen

- Den Teilnehmer*innen werden Methoden der Prozessautomation aus Energie- und Verfahrenstechnik vermittelt.
- Sie werden befähigt, Probleme der Prozessautomation zu erkennen, Lösungsvorschläge zu erarbeiten und diese zu erproben. Dies geschieht am Beispiel verfahrenstechnischer Anlagen und deren Simulationsmodellen. Neben industrieller Prozessleittechnik, den Methoden der 'Advanced Process Control' werden Methoden vermittelt, die auf der mathematischen Optimierung basieren: Optimalsteuerung und modellprädiktive Regelung.
- In dieser Veranstaltung werden Team- und Kommunikationsfähigkeit durch die Bildung von Zweiergruppen innerhalb der Software-Anwendung gefördert, da die Lösungen gruppenübergreifend vorgestellt und diskutiert werden müssen.

3 Inhalte

Es werden Methoden zur Prozessführung und Prozessleittechnik behandelt und an energie- und verfahrenstechnischen Simulationsmodellen angewendet. Der zweite Teil der Veranstaltung vertieft dabei Methoden der Prozessautomation, die auf der mathematischen Optimierung basieren, darunter modellprädiktive Regelung und Optimalsteuerung. Die Anwendung und Erprobung der Methoden in den Übungen erfolgen hauptsächlich unter Nutzung von MATLAB-Anwendungen

Gliederung:

- Einleitung in die Prozessführung
- Prozessleittechnik (Leitsysteme, SPS, Feldgeräte) und deren Automatisierungspyramide
- Kommunikation von Feldgeräten und Steuerungsebenen; Prozessmodelle und totzeitbehaftete Prozesse, praxistaugliche Regleralgorithmen, Modifikationen von Regelkreisstrukturen (Kaskade, Smith-Prädiktor, Störgrößenaufschaltung, ...), Regler-Tuning
- Rezeptsteuerung von kontinuierlichen und Batch-Prozessen
- Regelung und Entkopplung von Mehrgrößensystemen
- Optimalsteuerung
- modellprädiktive Regelung (MPC)

4 Lehr- und Lernformen

Seminaristischer Unterricht und Übungen mit Computernutzung (MATLAB / Simulink)

5 Teilnahmevoraussetzungen

Formal: B.Eng. oder vergleichbarer Abschluss

Inhaltlich: Grundlagen Regelungstechnik

6	**Prüfungsformen** Mündliche Prüfung oder Klausur Wird zu Beginn der Veranstaltung festgelegt.
7	**Voraussetzungen für die Vergabe von Kreditpunkten** Bestandene Modulprüfung
8	**Verwendung des Moduls** (in anderen Studiengängen) Für alle Masterstudiengänge des FB MV geöffnet
9	**Stellenwert der Note für die Endnote** 6/90
10	**Modulbeauftragte/r und hauptamtlich Lehrende** Prof. Dr.-Ing. Wolfgang Grote-Ramm
11	**Sprache** Deutsch
12	**Sonstige Informationen und Literaturangaben** • Schuler, H., Prozessführung, Oldenbourg-Verlag • Seborg, D. E. et al., Process Dynamics and Control • Dittmar, R., Pfeiffer, B.-M. Modellbasierte prädiktive Regelung: Eine Einführung für Ingenieure, De Gruyter • Dittmar, R.: *Advanced Process Control*, De Gruyter Oldenbourg, 2017

Software Lab

Module no.	Workload	Credits	Semester	Offered in
40221	180 h	6	Sem. 2	WiSe/SoSe

1	Courses	Attendance	Self-study	Duration
	Project-based seminar 4 SWS	60 h / 4 SWS	105 h	1 sem.

2 Learning outcomes / competences

The participants have a basic understanding of software development in the context of engineering and/or industrial problems. Moreover, they have

- advanced knowledge in various relevant fields of computational engineering
- advanced programming skills of a high-level programming language & object-oriented modeling
- knowledge of project-oriented co-operative software design & development, including efficient algorithms & data-structures
- the ability to assess critically
  - the accuracy & reliability of computational results
  - the computational complexity of numerical analysis & simulation
- the ability to present the mathematical & physical models and computational results used in computational engineering problems

3 Contents

Computer-based and project-related software development. Research-driven or industry-driven problems with or without external cooperation partners. Cooperative design and development of software solutions.

4 Forms of teaching and learning

Seminar with review sessions and individual guidance through the project supervisor

5 Prerequisites

Formal prerequisites: None

Subject-related prerequisites: Proficiency in English. Solid programming background with a high-level programming language (Java, C, C++)

6 Types of examination

Two review presentations (15 min. presentation + 10 min. discussion about project specification, project planning & milestones, bottlenecks etc.) on the project status and a final presentation of the project results (30 min.).

7 Requirements for award of credits

Passed examination

8 Module allocated to other study programmes

Open for all master's programmes of the department of mechanical and process engineering.

The module is well-suited for cooperation with all engineering design and analysis modules.

9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. Martin Ruess
11	**Language of instruction** English
12	**Further information and recommended literature** • Lecture slides • Project-related literature is recommended and partly provided with the project specification

Turbulent Combustion				
Module no.	**Workload**	**Credits**	**Semester**	**Offered in**
	180 h	6	Sem. 1/2	Each WiSe
1	**Courses**	**Attendance**	**Self-study**	**Duration**
	Seminar 4 SWS	4 SWS / 60 h	120 h	1 sem.

2 Learning outcomes / competences

After successful completion of the module, the students are capable of

- understanding the mechanisms of combustion as an interdisciplinary science and background of technological applications in different fields
- understanding the methods for the mathematical description of turbulent combustion.
- applying the learned material to solve laminar and turbulent combustion problems, via a commercial CFD software as well as specialized chemical kinetics codes and make a qualified analysis and evaluation of the obtained results.
- communicating in English on the course subject.

3 Contents

- Role of Combustion in Energy Technology and Other
- Review of Basic Concepts
- Thermochemistry and Chemical Kinetics
- Gaseous Fuels
- Lumped Thermochemical Analysis of Combustion Systems
- Mass Transfer
- Multi-Dimensional Field Equations
- Laminar Premixed and Diffusion Flames
- Introduction to Turbulence and Turbulence Modelling
- Challenges in Turbulent Combustion
- Turbulent Premixed and Diffusion Flames
- Turbulent Combustion Modelling
- Turbulent Combustion Models for Premixed, Diffusion and Partially Premixed Flames
- Modelling Pollutant Formation

4 Forms of teaching and learning

Lecture (Power point, overhead, blackboard), seminar, discussion, independent elaboration

5 Prerequisites

Formal prerequisites: /

Subject-related prerequisites: Thermodynamics, Fluid Mechanics, Heat Transfer, Mathematics

6 Types of examination

	Written examination, or e-examination, or e-open-book-examination in English (in parts or in full multiple-choice, duration: 90 min.) or oral exam (duration: 30 min.), or term paper. The Type of examination will be announced at the beginning of the course.
7	**Requirements for award of credits** Passed examination
8	**Module allocated to other study programmes** ME
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)** Prof. Dr.-Ing. Ali Cemal Benim
11	**Language of instruction** English
12	**Further information and recommended literature** K. K. Kuo, *Principles of Combustion*, Wiley.

Turbulent Flows				
Module no. 40021	**Workload** 180 h	**Credits** 6	**Semester** Sem. 1/2	**Offered in** Each WiSe
1	**Courses** Seminar 4 SWS	**Attendance** 4 SWS / 60 h	**Self-study** 120 h	**Duration** 1 sem.

2 Learning outcomes / competences

After successful completion of the module, the students are capable of

- understanding the physics of turbulent flows encountered in nature and engineering applications.
- understanding the methods of the mathematical description of turbulent flows.
- applying the learned material to solve technical flow problems, via a commercial CFD software and make a qualified analysis and evaluation of the obtained results.
- communicating in English on the course subject.

3 Contents

- Governing equations of fluid flow with initial and boundary conditions
- Introduction to turbulence phenomenon
- Turbulent flows in nature and engineering with their important characteristics
- Vortex stretching
- Energy cascade
- Turbulence eddies
- Turbulence mechanisms
- Characterisation of turbulence
- Averaging procedures
- Reynolds averaging
- The Schwarz inequality
- The probability density function
- Statistically steady and unsteady flows
- Favre averaging
- Morkovin hypothesis
- Ensemble averaging
- Phase averaging
- Short time averaging
- Filtering
- Root mean square values
- Turbulence kinetic energy

	• Turbulence intensity • Homogeneous turbulence • Isotropic turbulence • Dissipation rate and length scale • Two-point correlation functions • Integral scales of turbulence • Spectral density, turbulence energy spectrum • Near-wall turbulent flow • Direct numerical simulation • Reynolds averaged equations • Turbulent viscosity models • Zero-equation models • One-equation models • Two-equation models • Boundary conditions • Advanced eddy viscosity models • Algebraic and differential Reynolds stress models • Large eddy simulations • Hybrid models
4	**Forms of teaching and learning** Lecture, seminar, discussion, independent elaboration (in oral or written form)
5	**Prerequisites** **Formal prerequisites:** / **Subject-related prerequisites:** Mathematics, differential equations, fluid dynamics, Computational Fluid Dynamics (CFD), English
6	**Types of examination** Written examination, or e-examination, or e-open-book-examination in English (in parts or in full multiple-choice, duration: 90 min.) or oral exam (duration: 30 min.), or term paper. The Type of examination will be announced at the beginning of the course.
7	**Requirements for award of credits** Passed examination
8	**Module allocated to other study programmes** ME
9	**Weighting for overall grade** 6/90
10	**Person responsible for the module and examiner(s)**

	Prof. Dr.-Ing. Ali Cemal Benim
11	**Language of instruction** English
12	**Further information and recommended literature** S. B. Pope, *Turbulent Flows*, Cambridge University Press.