Hochschule Düsseldorf
University of Applied Sciences

Fachbereich Maschinenbau
und Verfahrenstechnik
Faculty of Mechanical
and Process Engineering

Stand: November 17

Wahlfächer / Elective Courses
„Masterstudiengänge"
„Master Degree Programs"

Module	**Course**					
	SET		**IWI**			**ME**
Schwerpunkte:	**EUT**	**UPT**	**EUT**	**UPT**	**PUI**	
Combustion Science and Technology						**X**
Turbulent Flows						**X**
Innovative Product Development					**X**	**X**
Control Theory	**X**	**X**	**X**	**X**	**X**	**X**
Thermoelektrik und Energierückgewinnung	**X**		**X**		**X**	**X (d)**
Virtual Reality für die Anlagentechnik		**X**				
Low Noise Design	**X**	**X**	**X**	**X**	**X**	**X**
Intercultural Competence	**X**	**X**	**X**	**X**	**X**	**X**
Polymer Technology	**X**	**X**	**X**	**X**		**X**
Two-Phase Flows						**X**
Brush up your Business English	**X**	**X**	**X**	**X**	**X**	**X**
Non-metallic Materials	**X**	**X**	**X**	**X**	**X**	**X**
Automation with microcontrollers	**X**	**X**	**X**	**X**	**X**	**X**
Prozessführung und Prozessautomation	**X**	**X**	**X**	**X**	**X**	**X (d)**
Pollutant Sensors in Ambient Air Control and Automobiles (Schadstoff-Sensoren in der Luftreinhaltung und bei Automobilen)	**X**	**X**	**X**	**X**	**X**	**X**
Energie- und umwelttechnische Prozessoptimierung (Modulhandbuch Master SET)	**X**					
Finite Element Method (FEM) (Module guide Master ME)	**X**	**X**	**X**	**X**	**X**	
Engineering Mathematics (Module guide Master SET/ME)	**X***	**X***	**X**	**X**	**X**	
Innovation and Technology Management (Module guide Master IWI)	**X**	**X**				**X**
Computerbased measurement technology (Module guide Master SET/ME)	**X***	**X***	**X**	**X**	**X**	
Computational Fluid Dynamics (Module guide Master SET/ME)	**X***	**X***	**X**	**X**	**X**	
Versuchsplanung und –auswertung (Modulhandbuch Master SET)	**X***	**X***	**X**	**X**	**X**	**X (d)**
Life Cycle and Service Management (Modul guide Master IWI)	**X**	**X**				**X**
International Technical Sales Management (Module guide Master IWI)	**X**	**X**				**X**
Methoden des Qualitätsmanagement (Modulhandbuch Master IWI)	**X**	**X**				**X (d)**
Optimierung und Simulation (Module guide SET)	**X***	**X***	**X**	**X**	**X**	**X (d)**
Simulation of Mechanical Systems (Module guide Master ME)	**X**	**X**	**X**	**X**	**X**	

Agenda:

Studiengänge/Courses: SET=Simulations- und Experimentaltechnik, IWI=Internationales Wirtschaftingenieurwesen, ME=Mechanical Engineering
Schwerpunkte/Specialisation: EUT=Energie- und Umwelttechnik, UPT=Umwelt- und Prozesstechnik, PUI=Produktion und Innovation
Sprache/Language: X (d) = held in german

*Im Masterstudiengang SET müssen im Block der Methodenfächer 4 aus 5 Fächern ausgewählt werden. Das nicht gewählte 5. Fach kann als Wahlpflichtfach belegt werden. Die Modulbeschreibungen aller 5 Methodenfächer enthält das Modulhandbuch für die Pflichtfächer.

*In the Master Degree Program SET, within the block of methodic courses (Methodenfächer), 4 out of 5 must be selected. The 5, not selected course can be taken as an elective course. The module descriptions of all 5 methodic courses can be found in the module handbook for compulsory courses.

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 courses is restricted to two academic years, in general. The faculty council can decide on the description of an elective course for the current academic year, or extend its validity for the next academic year.

Combustion Science and Technology						
Modulnummer (Modulnumber)	**Workload**	**Präsenzzeit (Attendence time)**	**Selbststudium (Self-study)**	**Studiensemester (Study semester)**	**Angebot im (Offered in)**	**Dauer (Duration)**
40011	180 h	60 h	120 h	1./2. Semester	SS / WS	1 Semester
Lehrveranstaltungen (Courses)		**Credits**	**Zuordnung zu den Curricula (Allocation to the curricula)**			
Seminar 4 SWS		6 LP	Master ME			

1	**Lernergebnisse (Learning outcomes) / Kompetenzen (Competences)** The attendees acquire a scientific understanding and scientific insight on the combustion phenomena, at graduate level, including combustion of gaseous, liquid and solid fuels, as well as gasification, which goes far beyond the basic combustion course normally taught at the bachelor level. They also gain a deep knowledge on a very broad range of all important engineering applications in combustion technology, in detail. These competences are the ideal pre-requisites for an employment in a research or development position in an industrial company in the area of combustion technology.
2	**Inhalte (Contents)** Chemical thermodynamics. Chemical kinetics. Oxidation mechanisms of fuels. Transport phenomena. Conservation equations. Laminar non-premixed flames. Laminar premixed flames. Limit phenomena. Asymptotic structure of flames. Aerodynamics of laminar flames. Combustion in turbulent flows. Combustion in boundary layer flows. Combustion in two-phase flows. Combustion in supersonic flows Basic combustor aerodynamics (non-swirling and swirling jets). Atomization techniques for spray combustion. Internal combustion engines. Gas turbine combustion. Coal pulverization. Pulverized solid combustion. Fluidized bed combustion. Grate combustion. Biomass combustion systems. Gasification techniques. Waste incineration. Fires.
3	**Lehrformen (Teaching Forms)** Lecture. Seminar. Discussion. Independent elaboration.
4	**Empfohlene Voraussetzungen (Recommended prerequisites)** Bachelor Degree in Mechanical Engineering (or in a relevant discipline). Mathematics. Differential Equations.Fluid Dynamics. Computational Fluid Dynamics (CFD). Heat Transfer. Chemistry. English.
5	**Prüfungsformen (Examination forms)** Written Multiple-Choice Exam (90 min duration).
6	**Voraussetzungen für die Vergabe von Leistungspunkten (Requirements for awarding credits)** Passed examination (100%)
7	**Modulverantwortliche(r) (Responsible person for the module)** Prof. Dr.-Ing. Ali Cemal Benim
8	**Sprache (Language)** English
9	**Sonstige Informationen / Literaturempfehlungen (other information and references)** K. K. Kuo, “Principles of Combustion”, 2nd Ed., Wiley, 2005.

Turbulent Flows						
Modulnummer (Modulnumber)	**Workload**	**Präsenzzeit (Attendence time)**	**Selbststudium (Self-study)**	**Studiensemester (Study semester)**	**Angebot im (Offered in)**	**Dauer (Duration)**
40021	180 h	60 h	120 h	2. Semester	SS / WS	1 Semester
Lehrveranstaltungen (Courses)		**Credits**	**Zuordnung zu den Curricula (Allocation to the curricula)**			
Seminar 4 SWS		6 LP	Master ME			

1	**Lernergebnisse (Learning outcomes) / Kompetenzen (Competences)** The attendees acquire a fundamental understanding of the physics and mathematical description of turbulent flows encountered in nature and engineering applications. They have a detailed insight on different philosophies of turbulence modelling and deep knowledge on a broad range of applied turbulence models. Thus, they are able to analyse and interpret turbulent flow data maturely, as well as apply turbulence models to analyse turbulent flows and design technical devices. In a competent manner.
2	**Inhalte (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. Characterization 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.
3	**Lehrformen (Teaching Forms)** Lecture. Seminar. Discussion. Independent elaboration.
4	**Empfohlene Voraussetzungen (Recommended prerequisites)** Bachelor Degree in Mechanical Engineering (or in a relevant discipline). Mathematics. Differential Equations. Fluid Dynamics. Computational Fluid Dynamics (CFD). English.
5	**Prüfungsformen (Examination forms)** Written Multiple-Choice Exam (90 min duration).
6	**Voraussetzungen für die Vergabe von Leistungspunkten (Requirements for awarding credits)** Passed examination (100%)
7	**Modulverantwortliche(r) (Responsible person for the module)** Prof. Dr.-Ing. Ali Cemal Benim
8	**Sprache (Language)** English

9	**Sonstige Informationen / Literaturempfehlungen (other information and references)** S. B. Pope, “Turbulent Flows”, Cambridge University Press, 2011.

Innovative Product Development						
Modulnummer (Modulnumber) 40031	**Workload** 180 h	**Präsenzzeit (Attendence time)** 60 h	**Selbststudium (Self-study)** 120 h	**Studiensemester (Study semester)** 2. Semester	**Angebot im (Offered in)** SS / WS	**Dauer (Duration)** 1 Semester
Lehrveranstaltungen (Courses) Seminar:4 SWS		**Credits** 6 LP	**Zuordnung zu den Curricula (Allocation to the curricula)** Master ME, IWI			

1	**Lernergebnisse (learning outcomes) / Kompetenzen (compentencies)** The students know • the theoretical and practical foundations of product development They can • communicate systematicly und structured with clients and supplier about costs, time schedules, and controlling • work scientifically in that area
2	**Inhalte (content)** • Development of a specific industrial product, typically in colaboration with a „contracting“ company
3	**Lehrformen (teaching format)** • consulting and guiding in the project work and in project groups
4	**Empfohlene Voraussetzungen (recommended prerequisities)** • Knowledge of technical design and production technology, as well as project management
5	**Prüfungsformen (type of exams)** • Maximum of two intermediate presentations according planned milestones and one final presentation in front of collaborating partners. This will be defined at begin of the module. Examination duration 30 minutes.
6	**Voraussetzungen für die Vergabe von Leistungspunkten (requirements for credits)** • examination passed (100%)
7	**Modulverantwortliche(r) (instructor in charge)** • Prof. Dr.-Ing. Andreas Jahr, lecturer
8	**Sprache (language)** • English

9	**Sonstige Informationen / Literaturempfehlungen (other information and references)** • All documents in MOODLE References (latest edition): • Pahl/Betz/Feldhusen: Konstruktionslehre, Springer 2007 • VDI 2221: 2221: Methodik zum Entwickeln und Konstruieren • VDI 2206: Entwicklungsmethodik für mechatronische Systeme • Weitere Literatur wird zur konkreten Aufgabenstellung angegeben

Control theory						
Modulnummer (Modulnumber) 40041	**Workload** 180 h	**Präsenzzeit (Attendenceti me)** 60 h	**Selbststudium (Self-study)** 120 h	**Studiensemester (Study semester)** 1. Semester	**Angebot im (Offered in)** SS	**Dauer (Duration)** 1 Semester
Lehrveranstaltungen (Courses) Seminar: 4 SWS		**Credits** 6 LP	**Zuordnung zu den Curricula (Allocation to the curricula)** Master SET, IWI, ME			

1	**Lernergebnisse (learning outcomes) / Kompetenzen (compentencies)** • Students are able to solve more 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.
2	**Inhalte (content)** • Multiple-input-multiple-output-systems • Adaptive control • Optimal control • Controlbility and Observability • Lyapunov stability • State-space representation • Digital control
3	**Lehrformen (teaching format)** • lecture (PC with Beamer, overhead/blackboard), Exercises
4	**Empfohlene Voraussetzungen (recommended prerequisites)** • Control technic, mathematics
5	**Prüfungsformen (types of exams)** • Oral (30 min) or written exam (120 min) (will be fixed at the beginning of the lecture)
6	**Voraussetzungen für die Vergabe von Leistungspunkten (requirements for credits)** • Passed exam (feedback talk) (100%)
7	**Modulverantwortliche(r) (instructor in charge)** • Prof. Dr.-Ing. Jürgen Kiel
8	**Sprache (language)** • Englisch or German
9	**Sonstige Informationen / Literaturempfehlungen (other information and references)** • Lecture notes

Thermoelektrik und Energierückgewinnung						
Modulnummer (Modulnumber) 40051	**Workload** 180 h	**Präsenzzeit (Attendencetime)** 60 h	**Selbststudium (Self-study)** 120 h	**Studiensemester (Study semester)** 2. Semester	**Angebot im (Offered in)** WS	**Dauer (Duration)** 1 Semester
Lehrveranstaltungen (Courses) Seminar 4 SWS		**Credits** 6 LP	**Zuordnung zu den Curricula (Allocation to the curricula)** Masterstudiengang: SET / IWI (nur Schwerpunkt EUT), ME			

1	**Lernergebnisse (learning outcomes) / Kompetenzen (compentencies)** Nach erfolgreicher Absolvierung des Moduls haben die Studierenden • Verständnis für die verwendeten Materialien entwickelt • den Aufbau und die Optimierung von Bauelementen kennengelernt • Methoden zur Systemintegration kennengelernt. • die notwendigen Fähigkeiten und Kenntnisse, thermoelektrische Systeme zu analysieren, zu entwerfen und zu optimieren
2	**Inhalte (content)** Was ist Thermoelektrik, welche Größen bestimmen die Thermoelektrik? • Grundlagen Aufbau der Materie, • Seebeckkoeffizient, • Peltiereffekt, • Elektrischer Transport, • Wärmeleitung, • Charakterisierungsverfahren, • Bauelemente, • Anwendungen: o Prinzip Kühlschrank, Elektronik-Kühlung, o Low power TEG (energieautarke Sensorik), o High Power TEG (z.B. Energierückgewinnung im Auto)
3	**Lehrformen (teaching format)** • Seminaristischer Unterricht und Übungen (a)
4	**Empfohlene Voraussetzungen (recommended prerequisites)** • Keine Vorkenntnisse
5	**Prüfungsformen (types of exams)** • Je nach Teilnehmerzahl Klausur (120 min) oder Projektarbeit mit Vortrag (30 min)
6	**Voraussetzungen für die Vergabe von Leistungspunkten (requirements for credits)** • Bestandende Modulprüfung (100%)
7	**Modulverantwortliche(r) (instructor in charge)** • Dr. Dirk Ebling

8	**Sprache (language)** • Englisch/Deutsch
9	**Sonstige Informationen / Literaturempfehlungen (other information and references)** • pdf-Dateien der Vorlesungsfolien für das Fach Empfohlene Literatur (jeweils neueste Auflage): [1] D.M.Rowe, “Thermoelectrics Handbook - macro to nano”; Taylor and Francis 2006, Kapitel 2 und Kapitel 14 [2] K.Seeger, „Semiconductor Physics“; (1985) Springer Verlag [3] C. Herring, “ Theory of thermoelectric power of semiconductors”, Phys. Rev. 96 (1954) 1163 [4] R.P. Hübener; “Thermoelectricty in metals and alloys”; Solid State Physics 27 (1972) 63 [5] U.Birkholz, „Thermoelektrische Bauelemente“, (1984), in „Amorphe und polykristalline Halbleiter“, W. Heywang (Hrsgb.) Serie „Halbleiter-Elektronik“, Springer Verlag [6] N.W.Ashcroft, et al., „Solid State Physics“; (1976), Saunders College [7] Ch. Kittel, H. Krömer; „Thermodynamik“, (2001), Oldenburg Verlag

Virtual Reality für die Anlagentechnik						
Modulnummer (Modulnumber)	**Workload**	**Präsenzzeit (Attendence time)**	**Selbststudium (Self-study)**	**Studiensemester (Study semester)**	**Angebot im (Offered in)**	**Dauer (Duration)**
40061	180 h	60 h	120 h	2. Semester	WS	1 Semester
Lehrveranstaltungen (Courses)		**Credits**	**Zuordnung zu den Curricula (Allocation to the curricula)**			
Seminar 4 SWS		6 LP	Master SET (nur Schwerpunkt UPT)			

1	**Lernergebnisse (learning outcomes) / Kompetenzen (compentencies)** Die Studierenden • kennen die Einsatzfelder von Virtual Reality (VR) – Anwendungen in der Prozess- und Anlagentechnik • sind in der Lage, VR-Szenarien zur konzipieren • haben Methoden der VR-Anwendungsprogrammierung kennengelernt • besitzen die notwendigen Fähigkeiten, an aktuellen Forschungs- und Entwicklungsarbeiten im Bereich Virtual Reality mitzuwirken
2	**Inhalte (content)** • Grundlagen der VR-Szenenentwicklung • Daten-Preprocessing für effektiven VR-Einsatz • Hard- und Softwaresysteme für die Realisierung von VR-Projekten im Anlagenbau • Programmierung und Bedienung von Demonstrations-VR-Anlagen
3	**Lehrformen (teaching format)** • Seminar mit Praktikumsanteil unter Nutzung des Virtual Reality-Pools
4	**Empfohlene Voraussetzungen (recommended prerequisites)** • Rechnergestützte Prozess- und Anlagenplanung (Schwerpunkt Umwelt- und Prozesstechnik)
5	**Prüfungsformen (types of exams)** • mündliche Prüfung (30 min) zu den oben genannten Inhalten. Die Prüfungsform wird zu Beginn der Lehrveranstaltung festgelegt
6	**Voraussetzungen für die Vergabe von Leistungspunkten (requirements for credits)** • Bestandende Modulprüfung (100%)
7	**Modulverantwortliche(r) (instructor in charge)** • Prof. Dr.- Ing. Martin Nachtrodt
8	**Sprache (language)** • deutsch
9	**Sonstige Informationen / Literaturempfehlungen (other information and references)** • notwendige Unterlagen zur Aufgabenstellung unter MOODLE Empfohlene Literatur: • TAUER,H: Stereo 3D, Schiele & Schön • DÖRNER, R.: Virtual und Augmented Reality (VR/AR), Springer Verlag • Sherman, William R.; Craig, Alan. Understanding Virtual Reality: Interface, Application and Design, Morgan Kaufman Publishers, San Francisco, 2003

Low Noise Design						
Modulnummer (Modulnumber) 40071	**Workload** 180 h	**Präsenzzeit (Attendence time)** 60 h	**Selbststudium (Self-study)** 120 h	**Studiensemester (Study semester)** 2. Semester	**Angebot im (Offered in)** WS	**Dauer (Duration)** 1 Semester
Lehrveranstaltungen (Courses) Seminar 4 SWS		**Credits** 6 LP	**Zuordnung zu den Curricula (Allocation to the curricula)** Master SET, ME, IWI			

1	**Lernergebnisse (learning outcomes) / Kompetenzen (compentencies)** The students have a fundamental knowledge of low noise design with several applications for - industrial machinery - HVAC - automotive industry - aviation industry The participants can evaluate noise and noise sources with experimental and numerical methods.
2	**Inhalte (content)** Noise and vibration generation, theoretical approaches, prediction of noise levels, noise and vibration measurement technique
3	**Lehrformen (teaching format)** Consulting and guiding in project work and project groups
4	**Empfohlene Voraussetzungen (recommended prerequisites)** Computerbased measurement technology
5	**Prüfungsform (types of exams)** Term paper and presentation (30 min duration)
6	**Voraussetzungen für die Vergabe von Leistungspunkten (requirements for credits)** Passed exam (feedback talk)
7	**Modulverantwortliche(r) (instructor in charge)** Prof. Dr.-Ing. Frank Kameier
8	**Sprache (language)** English
9	**Sonstige Informationen / Literaturempfehlungen (other information and references)** Smith, M.J.T. Aircraft Noise, 1989 Fletcher, Rossing, The Physics of Musical Instruments, 2008 Nguyen-Schäfer, Hung, Aero and Vibroacoustics of Automotive Turbochargers, 2013 Bendat, Julius S., Piersol, Allan G.: Engineering applications of correlation and spectral analysis, New York, 1980 Lucas et al.: Handbook of the Acoustic Characteristics of Turbomachinery Cavities, 1997. Blauert, Jens, Xiang, Ning, Acoustics for Engineers, 2009

Intercultural Competence						
Modulnummer (Modulnumber)	**Workload** 180 h	**Präsenzzeit (Attendenceti me)** 60 h	**Selbststudium (Self-study)** 120 h	**Studiensemester (Study semester)** 1. Semester	**Angebot im (Offered in)** SS	**Dauer (Duration)** 1 Semester
Lehrveranstaltung (Courses) Seminar 4 SWS		**Credits** 6 LP	**Zuordnung zu den Curricula (Allocation to the curricula)** Masterstudiengänge: SET, IWI, ME			

1	**Lernergebnisse (learning outcomes) / Kompetenzen (compentencies)** The students have knowledge of theories of culture types and cultural values. They understand the basic principles of intercultural communication and gained cultural awareness. They have insight into the diversity in global business. They are able to handle communication issues and can strive for solutions in a business environment.
2	**Inhalte (content)** Intercultural Competence is one of the crucial soft skills anyone should have who would like to be successful in a leading position in the globalized 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. These are issues the class wants to study. Especially by focusing on selected examples the students will be enabled to deal with different corporate cultures.
3	**Lehrformen (teaching format)** • Presentations, case studies, lecture, videos
4	**Empfohlene Voraussetzungen (recommended prerequisites)** • Good knowledge of English
5	**Prüfungsformen (types of exams)** • Presentations (30 min) and/or written exam (120 min) and /or oral exam (30 min). To be announced at the beginning of the seminar
6	**Voraussetzungen für die Vergabe von Leistungspunkten (requirements for credits)** • Past exam • Regular participation is required (min. 80 %)
7	**Modulverantwortliche(r) (instructor in charge)** Frau Zupfer M.A.
8	**Sprache (language)** English
9	**Sonstige Informationen / Literaturempfehlungen (other information and references)** none

Polymer Technology

Number of module	Workload	Attendence	Self-study	Semester	Offered	Duration
40091	180 h	60 h	120 h	1./2. Semester	WS	1 Semester

Course	Credits	Allocation to curricula
Seminar 4 SWS	6 LP	Master SET, Master ME, Master IWI (UPT/EUT)

1 **Learning outcomes / Competencies**

After this seminar the students will have basic knowledge on polymer properties, syntheses processes and polymer processing. With this the students will be able to do fundamental designs of polymer processes by considering the impact of the specific properties of polymers on the processes. The students will have knowledge about the main polymer processing technologies.

Specifically, the students will learn to correlate the structure of polymers to their corresponding properties. They will get to know the essential methods to determine chemical and physical polymer properties and get an insight in polymer bends. Concerning polymer processing, the students will lean the essential dimensionless numbers and how to use them to design extrusion processes. Besides, they will learn how to calculate pressure losses of flowing polymers. Finally, the students will get to know the main characteristics of the most important polymer processing technologies like injection molding, blow mouling etc.

With this course the students are well prepared to start working in the polymer industry by getting the necessary fundamental knowledge on polymer technology.

2 **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 molding, blow moulding, etc.)

3 **Form of teaching**

- Seminar, discussions. excursion

4 **Recommended prerequisites**

- Fluid mechanics, Chemistry, Physics, Mathematics

5 **Type of examination**

- Combined examination: Short term paper with presentation (15 min duration) (40%) and written exam (60 minutes) (60%)

6 **Requirements for award of credits**

- Passed exam, term paper or oral presentation

7 **Responsible person for the module**

- Prof. Dr.-Ing. Maren Heinemann

8	**Language** • English or German (depends on participants)
9	**Other information and references** • 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- 446-22905-1Kunststoffchemie 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

Two-Phase Flows						
Modulnummer	**Workload**	**Präsenzzeit**	**Selbststudium**	**Studiensemester**	**Angebot im** WiSe/SoSe	**Dauer**
	180 h	60 h	120 h	2. Semester		1 Semester
Lehrveranstaltungen		**Credits**	**Zuordnung zu den Curricula**			
Seminar 4 SWS		6 LP	Master ME			

1	**Lernergebnisse (Learning outcomes) / Kompetenzen (Competences)** The attendees acquire an understanding and insight on fluid dynamics and heat transfer of two-phase flows, which goes beyond the introductory information provided at bachelor level. They can apply the fundamental principles to a variety of homogeneous mixture as well as separated liquid-liquid, gas-solid, liquid-solid, and gas-liquid flow problems. They can read and understand publications on two-phase flows and apply the knowledge in their own research and development work. They can apply these skills in a wide range of industrial applications involving two-phase flows including areas such as power generation, combustion technology, heat exchanger technology, fluidized beds, separation technology, hydrology, environmental problems, food processing, media transport..
2	**Inhalte (Contents)** Review of important topics in single-phase flow, heat and mass transfer. Introduction to two-phase flows. Gas-liquid interfacial phenomena. Some basic definitions in two-phase flows. Two-phase flow patterns and flow maps. Homogeneous flow. Separated flow. The concept of drift flux. Flooding in two-phase flow. Introduction to boiling, pool boiling. Critical heat flux in boiling. Condensation. Gas-Solid two-phase flows. Gas-Liquid dispersed two-phase flows (Sprays). Multi-dimensional field equations for describing two-phase flows in different regimes with phase coupling. Special topics and applications.
3	**Lehrformen (Teaching Forms)** Lecture. Seminar. Discussion. Independent elaboration.
4	**Empfohlene Voraussetzungen (Recommended prerequisites)** Bachelor Degree in Mechanical Engineering (or in a relevant discipline). Mathematics. Differential Equations. Fluid Dynamics. Heat Transfer. English.
5	**Prüfungsformen (Examination forms)** Written Multiple-Choice Exam (90 min) or oral exam (30 min) and presentation. To be announced at the beginning of the course
6	**Voraussetzungen für die Vergabe von Leistungspunkten (Requirements for awarding credits)** Passed examination (100%)
7	**Modulverantwortliche(r) (Responsible person for the module)** Prof. Dr.-Ing. Ali Cemal Benim
8	**Sprache** English
9	**Sonstige Informationen / Literaturempfehlungen** S. M. Ghiaasiaan, “Two Phase Flow, Boiling and Condensation”, Cambridge University Press, 2007.

Stand: November 17

Brush up your Business English						
Modulnummer	**Workload**	**Präsenzzeit**	**Selbststudium**	**Studiensemester**	**Angebot im**	**Dauer**
	180 h	60 h	120 h		So-SEM	1 Semester
Lehrveranstaltungen		**Credits**	**Zuordnung zu den Curricula**			
Seminar 4 SWS			Masterstudiengang:			

1	**Learning outcomes / Competencies** The students • are able to communicate 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 a good knowledge of important grammar topics • are able to write business e-mails • improved their listening skills • are able to read and understand authentic business articles
2	**Content** • Authentic articles on a variety of current business topics • Listening comprehension exercises and interviews • Grammar exercises • Business correspondence
3	**Teaching forms** • Seminar • Lecture • Group work • Discussion • Videos
4	**Recommended prerequisites** • Good knowledge of English
5	**Types of exams** • Written Exam or Multiple-Choice Exam (120 min). • The details will be announced at the beginning of the seminar.
6	**Requirements for credits** Passed examination (100%)
7	**Person responsible for this module** • B. Zupfer M.A.

8	**Language** • **English**
9	**Additional information and references** • *Market Leader.* Business English Course Book. 3rd edition. FT Publishing. Pearson Education Limited 2014. • *Basis for Business.* Cornelsen Professional. Berlin 2012. • *Business Spotlight* • *The Local*

Non-metallic Materials: Ceramics and Glasses, Polymers, and Composite Materials						
Modulnummer (Module number)	**Workload**	**Präsenzzeit (Attendance time)**	**Selbststudium (Self-study)**	**Studiensemester (Study semester)**	**Angebot im (Offered in)**	**Dauer (Duration)**
	180 h	60 h	120 h	1./2. Semester	WS	1 Semester
Lehrveranstaltungen (Courses)		**Credits**	**Zuordnung zu den Curricula (Allocation to the curricula)**			
Seminar 4 SWS		6 LP	Master ME, SET, IWI			

1	**Lernergebnisse (Learning outcomes) / Kompetenzen (Competences)** At the end of the module, students know the applications of ceramics, glasses, polymers, and composite materials, as well as the respective materials' composition(s). They understand how the microscopic structure of the materials determines/influences the macroscopic properties of the materials and can explain both various preparation techniques and possibilities to modify/optimize given materials according to individual needs.
2	**Inhalte (Contents)** Fundamentals of atomic interactions (chemical bond, metals & non-metals), chemical structures, phase transitions; Ceramics: composition and structures, applications and characteristic properties, processing and manufacturing, varying types of ceramics; Glasses: composition and structures, applications and characteristic properties, the glass transition temperature, production and modification, glass ceramics, piezo ceramics; Polymers: composition and structures, properties and applications, production and introduction to processing and preparation, properties and application; Composite materials: characteristics and (anisotropic) properties, failure types, applications; selected special topics: manufacturing of synthetic diamonds, ceramic joining, ceramic coating
3	**Lehrformen (Teaching Forms)** Lecture (2 SWS) + Seminar (2 SWS) with students' presentations and discussion.
4	**Empfohlene Voraussetzungen (Recommended prerequisites)** Fundamentals of chemistry (e.g. „Chemistry I – General Chemistry" from the Bachelor degree course)
5	**Prüfungsformen (Examination form / assessment)** Presentation to be given by the students (30 min duration incl. discussion).
6	**Voraussetzungen für die Vergabe von Leistungspunkten (Requirements for awarding credits)** Successful presentation (100%)
7	**Modulverantwortliche(r) (Responsible person for the module)** Dekan / Dean + Dr. U. Ritgen
8	**Sprache (Language)** English
9	**Sonstige Informationen / Literaturempfehlungen (other information and references)** M.F. Ashby, D.R.H. Jones, Engineering materials: 1 – An introduction to properties, application and design, 4th ed., 2012 2 – An introduction to microstructures and processing, 4th ed, 2013

	(In German: Werkstoffe 1: Eigenschaften, Mechanismen und Anwendungen, 3. Aufl., 2013; Werkstoffe 2: Metalle, Keramiken und Gläser, Kunststoffe und Verbundwerkstoffe, 3. Aufl., 2012.)

Automation with microcontrollers

Modulnummer	Workload	Präsenzzeit	Selbststudium	Studiensemester	Angebot im	Dauer
	180 h	60 h	120 h	2. Semester	Wi-SE	1 Semester

Lehrveranstaltungen	Credits	Zuordnung zu den Curricula
a) Seminar 4 SWS	6 LP	Alle Masterstudiengänge

1	**Lernergebnisse (learning outcomes) / Kompetenzen (competencies)** The students know the architecture of microcontrollers (µC) represented by the ARM-microcontroller family. Students have basic skills in Python- and C-programming of microcontrollers. They can use digital and analog I/O-ports and know how to program timers and interrupts. Students can exchange data via serial bus and read in, and process analog signals (such as sensor data) via AD converters. The subjects are accompanied with practical exercises and programming tasks. At the end of the course, students have built up a functional microcontroller project with actuators and sensors. Due to relatively low cost of the used equipment (<100€) and the use of open source software students may optionally use their own equipment and can 'take their project home'. Students work out practical tasks in small teams. This supports the capacity for teamwork and communication skills.
2	**Inhalte (contents)** Range of application for µC; µC architecture, programming of µC; basics of Python and C programming languages; cross compilation; real time systems; I/O ports; system clock; timers and interrupts; basic electronics in the peripheral µC-context; acquisition of analog data (ADC); output of analog data (DAC, PWM); communication via interfaces (serial bus, I²C, RS485…); µC as embedded system; networking with µCs; rapid prototyping of automation algorithms on µC using Matlab / Simulink. Basics of Artificial Intelligence on µC: soft sensors, neuronal networks, fuzzy logic and machine learning
3	**Lehrformen (form of teaching)** • Seminar with computer exercises (Embedded Linux / Eclipse / Matlab / Simulink) including electronic practice sessions in small teams.
4	**Empfohlene Voraussetzungen (recommended prerequisites)** • B.E. / B.Sc. or similar degree, basic knowledge of PLC or other industrial automation systems is of advantage.
5	**Prüfungsformen (form of examination)** • Oral or written exam. Will be announced at the beginning of the course.
6	**Voraussetzungen für die Vergabe von Leistungspunkten (condition for credit points)** • Passed exam
7	**Modulverantwortliche(r) (Responsible person for the module)** • Prof. Dr.-Ing. Wolfgang Grote
8	**Sprache (language)** English / German on demand
9	**Sonstige Informationen / Literaturempfehlungen (bibliography)** • *Embedded Controller*, R. Asche, Springer-Verlag • https://beagleboard.org/ https://www.mikrocontroller.net/

Prozessführung und Prozessautomation

Modulnummer	Workload	Präsenzzeit	Selbststudium	Studiensemester	Angebot im	Dauer
	180 h	60 h	120 h	2. Semester	Wi-SE	1 Semester

Lehrveranstaltungen	Credits	Zuordnung zu den Curricula
a) Seminar 4 SWS	6 LP	Alle Masterstudiengänge

1	**Lernergebnisse (learning outcomes) / Kompetenzen** Den Teilnehmern werden Methoden der Prozessautomation aus Energie- und Verfahrenstechnik vermittelt. Sie sollen befähigt werden, 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 modell-prädiktive Regelung. In dieser Veranstaltung sollen Team- und Kommunikationsfähigkeit durch die Bildung von Zweiergruppen innerhalb der Software-Anwendung gefördert werden, da die Lösungen gruppenübergreifend vorgestellt und diskutiert werden müssen.
2	**Inhalte** Es werden Methoden zur Prozessführung und Prozessleittechnik behandelt und an 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 erfolgt 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, ...), Reglertuning; Rezeptsteuerung von kontinuierlichen und Batch-Prozessen; Regelung und Entkopplung von Mehrgrößensystemen; Optimalsteuerung; modellprädiktive Regelung (MPC)
3	**Lehrformen** • Seminaristischer Unterricht und Übungen mit Computernutzung (Matlab / Simulink)
4	**Empfohlene Voraussetzungen** • B.E oder vergleichbarer Abschluss, Grundlagen Regelungstechnik
5	**Prüfungsformen** • Mündliche Prüfung oder Klausur, wird zu Beginn der Veranstaltung festgelegt.
6	**Voraussetzungen für die Vergabe von Leistungspunkten** • Bestandende Modulprüfung
7	**Modulverantwortliche(r)** • Prof. Dr.-Ing. Wolfgang Grote
8	**Sprache** deutsch
9	**Sonstige Informationen / Literaturempfehlungen**

	Prozessführung, Hans Schuler, Oldenbourg-Verlag *Process Dynamics and Control*, D.E. Seborg, D.A. Mellichamp und T.F. Edgar, John Wiley and Sons *Modellbasierte prädiktive Regelung: Eine Einführung für Ingenieure*, R. Dittmar, B-M. Pfeiffer, De Gruyter

Pollutant Sensors in Ambient Air Control and Automobiles
Schadstoff-Sensoren in der Luftreinhaltung und bei Automobilen

Modulnummer (Modulnumber)	Workload	Präsenzzeit (Attendence time)	Selbststudium (Self-study)	Studiensemester (Study semester)	Angebot im (Offered in)	Dauer (Duration)
	180 h	60 h	120 h	1./2. Semester	WS/SS	1 Semester

Lehrveranstaltungen (Courses)	Credits	Zuordnung zu den Curricula (Allocation to the curricula)
Seminar 4 SWS	6 LP	Master ME, SET, IWI

1	**Lernergebnisse (Learning outcomes) / Kompetenzen (Competences)** The attendees know and understand the design and function of low-cost sensors. They know the potential and limitations of low-cost sensors especially in comparison with expensive certified analytical instruments used by official environmental agencies. Moreover, they know the design, function and importance of sensors, which are used in automobiles for air pollution control. Die Studierenden kennen und verstehen den Aufbau und die Funktionsweise von low-cost Sensoren. Sie können Möglichkeiten und Grenzen von low-cost Sensoren insbesondere auch im Vergleich mit eignungsgeprüften teuren Analysatoren der Umweltämter einschätzen Sie kennen Aufbau, Funktionsweise und Bedeutung von Sensoren, die bei Automobilen bei der Luftschadstoffreduktion eingesetzt werden.
2	**Inhalte (Contents)** Overview of low-cost sensors in ambient air 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 the measurement of particles. Networks of low-cost sensors and visualization of measurement results in Google Maps and Google Earth. Limitations of low-cost sensors and comparison with certified expensive analytical instruments. Formation and emission of air pollutants at automobiles and use of sensors for air pollution control in automobiles. Requirements for sensors at automobiles and short overview of sensors at automobiles. Übersicht über low-cost Sensoren in der Luftreinhaltung. Funktionsweise und Aufbau von low-cost Sensoren für gasförmige Luftschadstoffe, insbesondere von elektrochemischen Sensoren. Funktionsweise und Aufbau von verschiedenen low-cost Sensoren in der Partikelmesstechnik. Vernetzung von low-cost Sensoren und Darstellung der Ergebnisse in Google Maps oder Google Earth. Grenzen der Leistungsfähigkeit von low-cost Sensoren. Vergleich von low-cost Sensoren mit eignungsgeprüften teuren Analysatoren in der Luftreinhaltung. Grundlagen der Schadstoffentstehung bei Automobilen und Einsatz von Sensoren bei der Luftschadstoffreduktion. Anforderungen an Sensoren bei Automobilen je nach Einsatzweck und Überblick für den Einsatz von Sensoren bei Automobilen.
3	**Lehrformen (Teaching Forms)** Impulse lecture, Seminar, Discussion. Course in English, on special demand in English / German. Einführende Vorlesung, seminaristischer Unterricht, Veranstaltung in Englisch, auf Wunsch Englisch-Deutsch.
4	**Empfohlene Voraussetzungen (Recommended prerequisites)** Basics of physics, electrical engineering, electronics. Grundlagen der Physik, Elektrotechnik, Elektronik.
5	**Prüfungsformen (Examination forms)** Oral examination or term paper, to be announced at the beginning of the course Mündliche Prüfung oder schriftliche Hausarbeit, wird zu Beginn der Lehrveranstaltung bekanntgegeben.

6	**Voraussetzungen für die Vergabe von Leistungspunkten (Requirements for awarding credits)** Passed examination (100%)
7	**Modulverantwortliche(r) (Responsible person for the module)** Lecturer/Dozent: Prof. Dr. Weber
8	**Sprache (Language)** English or German
9	**Sonstige Informationen / Literaturempfehlungen (other information and references)** 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 Internetquellen wie: http://alphasense.com; http://www.citi-sense.eu/ www.luftdaten.info; http://www.ch.cam.ac.uk/files/aw534/RLJ%20AAMG%20 More literature will be announced at the beginning of the course. Weitere Literatur wird aktuell am Beginn der Veranstaltung angegeben.