Faculty of Technology and Bionics

HOCHSCHULE RHEIN-WAAL
Rhine-Waal University of Applied Sciences

Module Description

of the study course

„Mechanical Engineering M.Sc.“

Revision 1.1

16.01.2014

Contents

Module M_ME_01 "Advanced Engineering Mathematics"

Module name:	Advanced Engineering Mathematics
Module code:	Master Mechanical Engineering: M_ME_01
Courses (where applicable):	
Semester:	1st semester
Module coordinator:	Prof. Dr. Achim Kehrein
Lecturer:	Prof. Dr. Achim Kehrein
Language:	English
Place in curriculum:	Core subject
Timetabled hours:	Advanced Engineering Mathematics Lectures: 2 HPW Tutorials: 1 HPW
Workload:	45 h attendance 45 h preparation and review 30 h exam preparation
Credits:	4
Recommended prerequisites:	Algebra, trigonometry, differential and integral calculus, systems of linear equations, vector algebra, analytic geometry of lines and planes, Taylor series, introduction to ordinary differential equations at undergraduate level
Module objectives:	The students learn a variety of more advanced mathematical concepts and methods in an engineering context. They are able to make connections between different areas of mathematics and to understand the concepts from a more abstract point of view.
Content:	• Vector Analysis - divergence and curl - line, surface, and volume integrals - Green's Theorem (context: e.g., fluid mechanics or electrodynamics) • Fourier Analysis - Fourier Series, - Fourier integral, - discrete Fourier transform (context: e.g., digital signal processing or differential equations) • Linear Algebra - linear independence, bases, orthogonality, function spaces, linear transformations, eigenfunctions, complex matrices (context: e.g., Fourier analysis or finite element methods)
Assessment:	Exam

Forms of media:	Whiteboard, Beamer
Literature:	O'Neil, Peter: Advanced Engineering Mathematics. 7th International edition. Cengage Learning 2012. 00/TLK 47 Strang, Gilbert. *18.085 Computational Science and Engineering I, Fall 2008*. (MIT OpenCourseWare: Massachusetts Institute of Technology), http://ocw.mit.edu/courses/mathematics/18-085-computational-science-and-engineering-i-fall-2008 (Accessed 16 Dec, 2013). License: Creative Commons BY-NC-SA. Textbook in Library 00/TKX 3 Feynman, Richard; Leighton, Robert, Sands, Matthew: The Feynman Lectures on Physics. Basic Books 2011.

Module M_ME_02 “Principles of Software Development”

Module name:	Principles of Software Development
Module code:	Master Mechanical Engineering: M_ME_02
Courses (where applicable):	
Semester:	1st semester
Module coordinator:	Prof. Dr. Matthias Krauledat
Lecturer:	Prof. Dr. Matthias Krauledat
Language:	English
Place in curriculum:	Core subject
Timetabled hours:	Principles of Software Development Lectures: 1 HPW Tutorials: 1 HPW Practicals: 1 HPW
Workload:	45 h attendance 25 h preparation and review 20 h exam preparation
Credits:	3
Recommended prerequisites:	Basic Courses in IT Programming at undergraduate level; knowledge of at least one higher level programming language (C, C++, Java or similar)
Module objectives:	• Students are familiar with different software process models. • Students are able to classify different aspects of software-related process activities and can recognize the importance of the roles of the parties involved into these processes. • Students are able to derive the software specifications from the requirements of a software project. • Students can develop test procedures for software projects.
Content:	• Software processes - Software process models (Waterfall model, incremental model, reuse-oriented software design) - Process activities (Specification, Design and implementation, Verification, Software evolution) - Coping with change • Agile Development • Requirements Engineering - Functional and non-functional requirements - Requirements specification

	- Requirements management - Formalisms and concepts • Design and Implementation • Software testing • Software Evolution and Configuration Management • Project Management
Assessment:	Written exam
Forms of media:	Whiteboard, PowerPoint, Projector, PC-Pool
Literature:	I. Somerville: Software Engineering. Pearson 2011. H. Partsch: Requirements Engineering systematisch. Springer 2010. E. Gamma, R. Helm, R. Johnson, J. Vlissides: Design Patterns: Elements of Reusable Object-Oriented Software. Addison-Wesley 1995. J. A. Whittaker: How to break software: a practical guide to testing. Addison-Wesley 2002.

Module M_ME_03 “Fluid Mechanics”

Module name:	Fluid Mechanics
Module code:	Master Mechanical Engineering: M_ME_03
Courses (where applicable):	
Semester:	1st semester
Module coordinator:	Prof. Dr.-Ing. Joachim Gebel
Lecturer:	Prof. Dr.-Ing. Joachim Gebel
Language:	English
Place in curriculum:	Core subject
Timetabled hours:	Lectures: 2 HPW Tutorials: 1 HPW
Workload:	45 h attendance 75 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequi-sites:	Advanced Engineering Mathematics in parallel
Module objectives:	On completion of this module the student is able to... • understand the principles of Fluid Mechanics, • identify the importance and role of Fluid Mechanics within the Mechanical Engineering profession. • understand how physical principles such as conserva-tion of mass, momentum, and energy determine fluid behaviour and lead to mathematical descriptions of key features; • understand the advantages and limitations of Fluid Me-chanics models, equations and formulae; • use the principles of Fluid Mechanics to solve engineer-ing problems involving such quantities as velocity, pres-sure, forces (e.g. friction, drag, lift), power require-ments, and efficiency.
Content:	• Fluid Properties - Density, viscosity, compressibility - Pressure and temperature - Thermodynamic properties • Fluids at rest (Hydrostatics) - Pressure in liquids at rest - Stability of submerged and floating objects - Rotating containers • Fluids in motion - Langrangian and Eulerian description of motion - Pathlines, streaklines and streamlines - Viscous and inviscid flows

	- Laminar and turbulent flows - Incompressible and compressible flows - The Bernoulli equation • Integral forms of the fundamental laws - Equation of continuity - Energy equation - Momentum equation • Differential forms of the fundamental laws - Differential continuity equation - Differential momentum equation - Euler's equation - Navier stokes equations - Vorticity equations - Differential energy equation • Dimensional analysis and similitude • Internal flows - Laminar and turbulent flow in a pipe - Laminar and turbulent flow between plates - Flow in piping systems • External flows - Flow around immersed bodies - Lift and drag on airfoils - Potential-flow theory - Boundary-layer theory • Compressible flow - Speed of sound and Mach number - Normal shock wave - Isentropic nozzle flow • Flow in open channels - Significance of Froude number - Hydraulic jump • Introduction to Computational Fluid Dynamics CFD
Assessment:	Written exam
Forms of media:	Whiteboard, PowerPoint, Projector, Tablet
Literature:	Merle C. Potter, David C. Wiggert, Bassem H. Ramadan: Mechanics of fluids. Fourth edition, ISBN 978-1-4390-6203-6 K.S.N. Raju: Fluid Mechanics, Heat Transfer, and Mass Transfer. Chemical Engineering Practice. John Wiley & Sons, 2011. ISBN 978-0-470-63774-6 Pijush K. Kundu, Ira M. Cohen. Fluid Mechanics. Elsevier, 2008. Fourth Edition, ISBN 978-0-12-381-399-2 Herbert Oertel jr., Sebastian Ruck. Bioströmungsmechanik. Vieweg+Teubner Verlag, 2012. 2. Auflage, ISBN 978-3-8348-1765-5.

Module M_ME_04 “Structural Analysis”

Module name:	Structural Analysis
Module code:	Master Mechanical Engineering: M_ME_04
Courses (where applicable):	
Semester:	1st semester
Module coordinator:	Prof. Dr.-Ing. Henning Schütte
Lecturer:	Prof. Dr.-Ing. Henning Schütte
Language:	English
Place in curriculum:	Core subject
Timetabled hours:	Lectures: 2 HPW Tutorials: 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequi-sites:	Advanced Engineering Mathematics in parallel Basic Courses in Statics, Mechanics of Materials and Dy-namics at undergraduate level
Module objectives:	After completing the course the students are able to: • reduce the basic set of fundamental equations of con-tinuum mechanics to one and two-dimensional prob-lems • reduce static engineering problems to models of beams, plates and shells with their corresponding boundary conditions and solve them • reduce dynamics engineering problems to vibrations of lumped mass systems and assess their modes, eigen-frequencies and answers to excitations • understand and use the basic concepts of fatigue and fracture mechanics
Content:	• Energy methods in continuum mechanics (Virtual Work, Stability, Menabrea, Castigliano, Method of Virtual Forces) • Modal analysis and forced excitation analysis of lumped mass systems of springs, rods and beams. • Vibrations of continuum systems (e.g. beams, circular plates etc.) • Fatigue Analysis using the FKM code • Fundamentals of fracture Mechanics using the FKM code

Assessment:	Exam
Forms of media:	Whiteboard, PowerPoint, Projector
Literature:	Lecture notes Bruhns: Advanced Mechanics of Solids, Springer 2002 Dresig,Holzweißig: Dynamics of Machinery: Theory and Applications, Springer 2010 Radaj, Vormwald: Advanced Methods of Fatigue Assessment, Springer 2013 Gross, Selig: Fracture Mechanics, 2011 FKM Guideline “Analytical Strength Assessment” FKM Guideline “Fracture Mechanics Proof of Strength for Engineering Components”

Module M_ME_05 “Quality and Intellectual Property Management”

Module name:	Quality and Intellectual Property Management
Module code:	Master Mechanical Engineering: M_ME_05
Courses (where applicable):	*Applied QM Methods* *Patenting and Intellectual Property Management*
Semester:	2^{nd} semester
Module coordinator:	Prof. Dr.-Ing. Alexander Klein
Lecturer:	
Language:	English
Place in curriculum:	Core subject
Timetabled hours:	*Applied QM Methods* Lectures: 1 HPW Tutorials: 1 HPW *Patenting and Intellectual Property Management* Lectures: 1 HPW Project: 1 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequi-sites:	Integrated Management Systems or Quality Management Basics at undergraduate level
Module objectives:	Students are able to apply important quality management methodologies. They can choose the right QM tools to solve miscellaneous problems that occur in business. The students are sensitive for the need of total quality management and comprehend the high impact of the right use of methods and toolkits. They realize that total quality management (TQM) is more than quality assurance (QA) can and should be applied in all functional areas of business, including core processes, auxiliary processes as well as management processes. Additionally students know how to use patents during the product development process, in order to further improve the quality of the product.
Content:	*Applied QM Methods* • Product development perspective - Design for six sigma (DFSS, IDOV, DMADV) - Quality gates - TRIZ - Design review and DR based on failure modes (DRBFM)

	- Advanced product quality planning (APQP) - Perceived quality evaluation • Service development perspective - Service blueprinting - Service quality function deployment (QFD) - Service FMEA • Production perspective - Six sigma in production (SIPOC, DMAIC) - Process structure matrix (PSM) - Ishikawa analysis - Design of experiments (DoE) - 5W method - Process capability analysis and improvement • After sales and field perspective - Weibull analysis - Benchmarking - Quality backward chain implementation • Management perspective - Audits and performance measurement - Business process analysis and engineering - Computer aided quality management (CAQ) - Continuous improvement process (CIP) - Implementation and adaption of a (T)QM system *Patenting and Intellectual Property Management* • Prerequisites for patenting • Inventor's concept • Worker as inventor – legal aspects • Biotechnology patents • Patent process • Infringing on a patent - consequences • European and international patent law
Assessment:	Exam
Forms of media:	Flipchart, whiteboard, projector, metaplan cards
Literature:	*Applied QM Methods* Dhillon, Balbir S.: Applied reliability and quality, Springer, 2007 Schmitt, Robert: Qualitätsmanagement, Hanser, 2010 Sanders, Donald A., Scott, C. Frank: Passing Your ISO 9000/QS-9000 Audit, CRC Press LLC, 1997

	May, Constantin, Schimek, Peter: TPM Total Productive Management, 2nd edition, CETPM Publishing, 2009 Hoyle, David: ISO 9000 Quality Systems Handbook, 6th edition, Routledge, 2009 DIN ISO EN 9000ff, raw documents BS OHSAS 18001; DIN ISO EN 14000 f, raw documents *Patenting and Intellectual Property Management* Georg Weber, Gerd A. Hedemann, Helge B. Cohausz: Patentstrategien. Heymanns-Verlag. ISBN 978-3452254429. Avery N. Goldstein: Patent Law for Scientists and Engineers. CRC Press. ISBN 978-0824723835. Howard B. Rockman: Intellectual property law for engineers and scientists. John Wiley & Sons. ISBN 978-0471449980.

Module M_ME_06 “Field Data Processing”

Module name:	Field Data Processing
Module code:	Master Mechanical Engineering: M_ME_06
Courses (where applicable):	
Semester:	2nd semester
Module coordinator:	Prof. Dr.-Ing. Peter Kisters
Lecturer:	Prof. Dr.-Ing. Peter Kisters
Language:	English
Place in curriculum:	Core subject
Timetabled hours:	Lectures: 2 HPW Tutorials: 1 HPW
Workload:	45 h attendance 50 h preparation and review 25 h exam preparation
Credits:	4
Recommended prerequi-sites:	
Module objectives:	The students understand the need for a holistic approach to product design and development. They detect potentials for improvement in economic and technical issues by investigating field data collected during operation. After the course students use fault detection methods such as limit analysis, trend checking and plausibility checks to design appropriate condition monitoring systems. They differentiate between signal-based and process-model-based fault detection. The students are well versed in generating a data flow structure for the supervision of a given system or process. Their knowledge enables them to develop not only the monitoring concepts but also fault tolerant machines and redundant systems to improve reliability and availability of the product. The students understand how to use field data for future developments and deduce appropriate after sales and service concepts.
Content:	• Introduction: - Product life cycles and fault management - Process automation and process supervision - Technical and economic potentials of field data processing • Technical part: - Basic tasks of supervision - Terminology - Reliability and availability - Methods for monitoring and fault detection - Knowledge-based fault detection and diagnosis

	- Signal-based fault detection and diagnosis - Process-model-based fault detection and diagnosis - Closed loop fault detection - Condition monitoring - Data flow structure for supervision - Design of fault-tolerant systems - Design of redundant systems • Business part: - preconditions for the development of business models - launch concepts - transfer of technical service into business case - determination of economic potentials
Assessment:	Exam
Forms of media:	Lecture slides, Power Point, Tablet
Literature:	Isermann: Fault Diagnosis Application, Model based Condition Monitoring: Actuators, drives machinery, plants, sensors, and fault tolerant systems, ISBN 978-3-642-12767-0, Springer Verlag, Berlin Heidelberg, 2011 R.A. Collacott: Mechanical Fault Diagnosis and condition monitoring, ISBN 978-94-009-5725-1, Chapman and Hall, London, 1976

Module M_ME_11 "Tribology in Design Engineering"

Module name:	Tribology in Design Engineering
Module code:	Master Mechanical Engineering: M_ME_11
Courses (where applicable):	
Semester:	1st semester
Module coordinator:	Prof. Dr.-Ing. Peter Kisters
Lecturer:	Prof. Dr.-Ing. Peter Kisters
Language:	English
Place in curriculum:	Compulsory optional subject: Advanced Product Engineering
Timetabled hours:	Lectures: 2 HPW Tutorials: 1 HPW Practicals: 1 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	
Module objectives:	After passing the course the students are able to communicate about tribological phenomena. They identify different kinds of problems and understand basic wear mechanisms. The students differentiate between different types of friction and wear. They are aware of the importance of lubrication for the tribological system and distinguish between different kinds of lubricants and their properties. The students know different options for surface modification and their influence on the tribological system. After description of a given tribologically stressed system the students are able to analyse it and know how they can find root causes for existing wear problems. Based on that they develop and evaluate countermeasures against wear and tear by surface modification. Besides, the students are able to analyse the influence of wear and tear on the function of a product as well as ecological impacts.
Content:	• Introduction - The term tribology - Importance of tribology - The tribological system - Surfaces, contact and loading of tribological systems • Friction - Static and kinematic friction - Sliding and rolling friction - Friction and lubrication conditions

	- Types of friction • Wear - Wear mechanisms - Types of wear • Lubricants - Lubrication systems and their application - Types and properties of lubricants - The selection of lubricants - Temperature influence - Ageing • Tribology and materials - Basic Principles - Metallic materials - Non-metallic inorganic materials - Composite materials • Basics of Surface Engineering • Wear testing methods
Assessment:	Exam
Forms of media:	Presentation, Board, Tablet, Lecture Slides
Literature:	Mang, Bobzin, Bartels: Industrial Tribology: Tribosystems, Friction, Wear and Surface Engineering, Lubrication, ISBN 978-3-52732057-8, Wiley, 2011 Menezes, Ingole, Nosonovsky, Kailas, Lovell: Tribology for Scientists and Engineers - From Basics to Advanced Concepts, ISBN 978-1-4614-1944-0, Springer, 2013 Lyubimov, Dolgapolov, Pinchuk: Micromechanisms of Friction and Wear, ISBN 978-3642351471, Springer-Verlag, 2010 Czichos, Habig: Tribologie-Handbuch: Tribometrie, Tribomaterialien, Tribotechnik: Reibung und Verschleiß, ISBN 978-3834800176, Vieweg-Teubner, 2010

Module M_ME_12 “Methods for Structural Analysis”

Module name:	Methods for Structural Analysis
Module code:	Master Mechanical Engineering: M_ME_12
Courses (where applicable):	
Semester:	1st semester
Module coordinator:	Prof. Dr.-Ing. Henning Schütte
Lecturer:	Prof. Dr.-Ing. Henning Schütte
Language:	English
Place in curriculum:	Compulsory optional subject: Advanced Product Engineering
Timetabled hours:	Practicals: 2 HPW
Workload:	30 h attendance 70 h preparation and review 20 h exam preparation
Credits:	4
Recommended prerequisites:	Structural Analysis in parallel, Knowledge of linear static analysis using a commercial FEM code, Knowledge of basic lab work.
Module objectives:	After completing the course the students are able to: • set up simulation models for linear, geometrically non-linear static and dynamic analysis in the commercial FEM code ANSYS WORKBENCH • reduce models according to engineering demands and results sought • judge the accuracy and validity of simulation results including predictions of fatigue life • set up, conduct and analyse the results of fatigue experiments using a rotating bending fatigue testing machine • set up, conduct and analyse the results of mechanical experiments for non-linear elasticity, dynamics, friction, bolted connections etc. • compare the results of lab experiments and simulations and use them to validate and if necessary improve the setting of both lab and simulation respectively
Content:	Most of the topic presented are analysed using experiment and simulation: • fatigue lifetime of metallic engineering parts • bolted connections • modal analysis, forced vibrations • problems of non-linear material and/or large defor-

	mations (e.g. rubber, metal plasticity) • fracture analysis, crack growth
Assessment:	Lab and calculation reports (graded) with hand-in interview
Forms of media:	Powerpoint, Whiteboard, Hands-on Laboratory Experiments, Computer Lab using ANSYS Workbench
Literature:	H. Lee: Finite Element Simulations With ANSYS Workbench 14, SDC Publication, 2012 Dresig,Holzweißig: Dynamics of Machinery: Theory and Applications, Springer, 2010 Radaj, Vormwald: Advanced Methods of Fatigue Assessment, Springer 2013 Gross, Selig: Fracture Mechanics, Springer, 2011 FKM Guideline "Analytical Strength Assessment" FKM Guideline "Fracture Mechanics Proof of Strength for Engineering Components"

Module M_ME_13 "Design of Experimental Validation"

Module name:	Design of Experimental Validation
Module code:	Master Mechanical Engineering: M_ME_13
Courses (where applicable):	
Semester:	1st semester
Module coordinator:	Prof. Dr.-Ing. Peter Kisters
Lecturer:	Prof. Dr.-Ing. Peter Kisters
Language:	English
Place in curriculum:	Compulsory optional subject: Advanced Product Engineering
Timetabled hours:	Lectures: 2 HPW Tutorials: 1 HPW
Workload:	45 h attendance 50 h preparation and review 25 h exam preparation
Credits:	4
Recommended prerequisites:	None
Module objectives:	After having the course the students understand the need for a holistic approach in developing test equipment. They recognize that the development of test systems is an interdisciplinary challenge. They are able to discuss the need for tests, their purpose and the engineering of the required equipment with customers and technicians of different fields. The students are able to abstract from real operation conditions, derive required mechanical, electrical and thermal loads and transfer them to lab conditions. They know how they can evaluate the limited validity of test. Based on their analysis of real operation conditions the students develop required test equipment and choose appropriate measurements. They plan tests under consideration of static/dynamic loading and time limits. The students analyse the lab results and check the reliability of obtained data. They gain knowledge to project the results on the operation.
Content:	Analysis of real operation conditions • Description of operation conditions • Influences on the operation conditions • Static /dynamic mechanical loads • Thermal loads • Chemical loads Abstraction of real operation loads • Definition of the important influences

	• Determination of test loads and conditions • Specification of the test system boundaries • Evaluation of the test validity • Design of the experiments • Definition of turn-off criteria Development of test equipment • Determination of mechanical and thermal constraint for the tested product • Selection and positioning of required measurements • Evaluation of the influence of constraints and measurement equipment on test results • Design of the mechanical equipment including load application • Design of the control systems Analysis of test results • Statistical evaluation of the results • Conclusions on the experimental validation • Discussion of limitations and their influence on the test results
Assessment:	Attestation
Forms of media:	Presentation, Board, Tablet, Lecture Slides
Literature:	Patrick O'Connor: Test Engineering: A Concise Guide to Cost-Effective Design, Development and Manufacture (Quality and Reliability Engineering), ISBN 978-0471498827, John Wiley & Sons, 1. Edition, 2001 Evans, Evans: Product Integrity and Reliability in Design, ISBN 978-1447110651, Springer; Edition: Softcover reprint of the original 1st ed. 2001 (2012) Reynolds, Reynolds: Test and Evaluation of Complex Systems (Wiley Series in Measurement Science and Technology), ISBN 978-0471967194, John Wiley & Sons, 1997

Module M_ME_21 “Thermodynamics of Gas and Vapour Power Systems”

Module name:	Thermodynamics of Gas and Vapour Power Systems
Module code:	Master Mechanical Engineering: M_ME_21
Courses (where applicable):	
Semester:	1^{st} semester
Module coordinator:	Prof. Dr.-Ing. Joachim Gebel
Lecturer:	Prof. Dr.-Ing. Joachim Gebel
Language:	English
Place in curriculum:	Compulsory optional subject: Energy and Process Engineering
Timetabled hours:	Lectures: 2 HPW Tutorials: 1 HPW Practicals: 1 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	Thermodynamics from Bachelor Fluid Mechanics in parallel Advanced Engineering Mathematics in parallel
Module objectives:	On completion of this module the student is able to... • evaluate the performance of gas power cycles for which the working fluid remains a gas throughout the entire cycle • analyse vapour power cycles in which the fluid is alternately vaporized and condensed • review the operation of reciprocating engines • solve problems based on the Otto, Diesel, Ericsson and Stirling cycle • solve problems based on the Brayton cycle • investigate ways to modify the basic Rankine vapour power cycle to increase the thermal efficiency • analyse power cycles that consist of two separate cycles known as combined cycles (GUD) • analyse jet-propulsion cycles • perform exergy analysis of vapour and gas power cycles
Content:	1 Review of basics - First law of thermodynamics - Second law of thermodynamics - The Carnot Cycle

	- Anergy and exergy 2 Vapour power systems - Modeling and analysing vapour power systems - The Rankine Cycle - Improving performance - Cycle exergy analysis 3 Gas power systems 3.1 Internal combustion engines - Fuels and combustion equations - Reciprocating engines - The Otto Cycle - The Diesel Cycle 3.2 Gas turbine power plants - The Brayton Cycle - The Ericsson Cyclce - The Stirling Cycle 3.3 Gas and steam turbine power plants (GuD) 3.4 Gas turbines for aircraft propulsion 3.5 Practicals - Practical training on Steam engine - Practical training on Stirling motor - Field trip to coal-fired steam power plant
Assessment	Written exam
Forms of media:	Whiteboard, PowerPoint, Projector, Tablet
Literature:	Michael J. Moran, Howard Shapiro: Fundamentals of Engineering Thermodynamics. SI-Version, ISBN 978-0-470-54019-0 Robert Balmer: Modern Engineering Thermodynamics. ISBN 978-0-12-374996-3 Yunus A. Cengel, Michael A. Boles: Thermodynamics An Engineering Approach: 7thedition in SI-Units, ISBN 978-007-131111-3 Claus Borgnakke, Robert E. Sonntag: Fundamentals of Thermodynamics, International Student Version, 7thedition, ISBN 978-0-470-17157-8

Module M_ME_22 “Thermal Process Engineering”

Module name:	Thermal Process Engineering
Module code:	Master Mechanical Engineering: M_ME_22
Courses (where applicable):	
Semester:	1st semester
Module coordinator:	Prof. Dr.-Ing. Joachim Gebel
Lecturer:	Prof. Dr.-Ing. Joachim Gebel
Language:	English
Place in curriculum:	Compulsory optional subject: Energy and Process Engineering
Timetabled hours:	Lectures: 2 HPW Tutorials: 1 HPW
Workload:	45 h attendance 75 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	Thermodynamics from Bachelor Fluid Mechanics in parallel Advanced Engineering Mathematics in parallel
Module objectives:	On completion of this module the student is able to... • know all thermal separation processes and their functionality • make up balances for all separation processes on the basis of thermodynamic equilibrium models • know the most important equipment and internals, their advantages and disadvantages as well as their fields of application • select a suitable process for a given separation problem and to design it on the basis of equilibrium models.
Content:	1 Review of basics - Fluid Mechanics - Heat transfer - Mass transfer - Thermodynamic phase equilibrium 2 Thermal unit operations - Distillation and rectification - Evaporation and condensation - Extraction - Gas absorption and stripping - Adsorption and ion-exchange - Crystallisation - Drying of solids 3 Process Design on the basis of examples

	- Thermal seawater desalination - Stripping ammonia from sludge water - Hybrid processes
Assessment:	Written exam
Forms of media:	Whiteboard, PowerPoint, Projector, Tablet
Literature:	Alfons Mersmann, Matthias Kind, Johann Stichlmair: Thermal Separation Technology: Principles, Methods, Process Design. ISBN 978-3-642-12524-6 Warren L. McCabe, Julian C. Smith, Peter Harriott: Unit Operations of Chemical Engineering. McGraw-Hill Higher Education, 7e, 2005. ISBN: 978-0-07-284823-6 K.S.N. Raju: Fluid Mechanics, Heat Transfer, and Mass Transfer. Chemical Engineering Practice. John Wiley & Sons, 2011. ISBN 978-0-470-63774-6

Module M_ME_23 "Heating, Ventilation, and Air-Conditioning (HVAC)"

Module name:	Heating, Ventilation, and Air-Conditioning (HVAC)
Module code:	Master Mechanical Engineering: M_ME_23
Courses (where applicable):	
Semester:	1st semester
Module coordinator:	Prof. Dr.-Ing. Joachim Gebel
Lecturer:	Prof. Dr.-Ing. Joachim Gebel
Language:	English
Place in curriculum:	Compulsory optional subject: Energy and Process Engineering
Timetabled hours:	Lectures: 1 HPW Tutorials: 1 HPW
Workload:	30 h attendance 40 h preparation and review 20 h exam preparation
Credits:	3
Recommended prerequisites:	Thermodynamics from Bachelor Fluid Mechanics in parallel
Module objectives:	On completion of this module the student is able to... • know the fundamentals of heat transfer, refrigeration and air-conditioning regarding the design of an HVAC – system • analyse ideal and actual vapour-compression refrigerator cycles • select the right refrigerant for an application • analyse absorption-refrigeration systems • understand what human comfort means in terms of heating, ventilation and air-conditioning • know the essential components of an air-conditioning system • select the right HVAC- process for an application
Content:	1 Review on heat transfer - Thermal conduction in static material - Forced convection - Free convection - Boiling and condensation - Thermal radiation - Heat exchangers - Heat exchanger networks / Pinch Point 2 Fundamentals of refrigeration - Refrigerators and heat pumps - The Reversed Carnot Cycle

	- The Ideal Vapour-Compression Refrigerator Cycle - Actual Vapour-Compression Refrigerator Cycle - Selecting the right refrigerant - Heat pump systems - Gas refrigeration cycles - Absorption refrigeration systems 3 Fundamentals of air-conditioning - Dry and atmospheric air - Specific and relative humidity of air - Dew-point temperature - Adiabatic saturation and wet-bulb temperature - The Psychrometric Chart / Mollier h-x diagram 4 Human comfort and air-conditioning 5 HVAC - processes - Simple heating and cooling - Heating with humidification - Cooling with dehumidification - Evaporative cooling - Adiabatic mixing of airstreams
Assessment:	Exam
Forms of media:	Whiteboard, PowerPoint, Projector, Tablet
Literature:	W. Larsen Angel: HVAC Design Sourcebook. McGraw-Hill, 2012. ISBN 978-0-07-175303-6 H. Recknagel, E. Sprenger, E.-R. Schramek: Taschenbuch für Heizung + Klimatechnik 13/14. Div Deutscher Industrie-verlag, 76. Auflage, 2012. ISBN 978-3835633018 Yunus A. Cengel, Michael A. Boles: Thermodynamics - An Engineering Approach. 7th Edition in SI-Units. ISBN 978-007-131111-3 Michael J. Moran, Howard Shapiro: Fundamentals of Engineering Thermodynamics. SI-Version, ISBN 978-0-470-54019-0 Peter von Böckh, Thomas Wetzel: Heat Transfer – Basics and Practice. Chemical Engineering Practice. Springer, 2012. ISBN 978-3-642-19182-4 Robin Smith: Chemical Process – Design and Integration. John Wiley & Sons, 2005. ISBN 978-0-471-48680-0

Module M_ME_31 “Application of Gas Power Systems”

Module name:	Application of Gas Power Systems
Module code:	Master Mechanical Engineering: M_ME_31
Courses (where applicable):	
Semester:	1st semester
Module coordinator:	Prof. Dr.-Ing. Roland Schmetz
Lecturer:	Prof. Dr.-Ing. Roland Schmetz
Language:	English
Place in curriculum:	Compulsory optional subject: Power Transmission Systems
Timetabled hours:	Lectures: 1 HPW Tutorials: 1 HPW
Workload:	30 h attendance 45 h preparation and review 15 h exam preparation
Credits:	3
Recommended prerequisites:	Advanced Engineering Mathematics and Fluid Mechanics in parallel
Module objectives:	After completion of the module students are able to • describe a wide range of gas power systems • perform calculations and specifications of the most important gas power systems • analyse and to compose basic gas power systems • evaluate the usability of basic gas power systems
Content:	• Internal Combustion Engines - Types - Designs - Typical Characteristics and their Adjustment - Common Engine Peripherals - Emission Standards - Biofuels - Energy Efficiency - Advanced Engine Peripherals • Gas Turbines • Advanced Power Sources - Fuel Cells - Batteries and Stores - Solar Panels - Wind Turbines - Hydropower Systems - External Supplies
Assessment:	Exam

Forms of media:	Presentation, media board, practical demonstrations
Literature:	New Bosch Automotive Handbook - Extended and Revised 27th Edition, 2011 Course Materials from the Lecturer Exercises from the Lecturer

Module M_ME_32 "Advanced Drives"

Module name:	Advanced Drives
Module code:	Master Mechanical Engineering: M_ME_32
Courses (where applicable):	
Semester:	1st semester
Module coordinator:	Prof. Dr.-Ing. Roland Schmetz
Lecturer:	Prof. Dr.-Ing. Roland Schmetz
Language:	English
Place in curriculum:	Compulsory optional subject: Power Transmission Systems
Timetabled hours:	Lectures: 2 HPW Tutorials: 1 HPW
Workload:	45 h attendance 45 h preparation and review 30 h exam preparation
Credits:	4
Recommended prerequisites:	Advanced Engineering Mathematics and Fluid Mechanics in parallel
Module objectives:	After completion of the module students are able to • describe the most important control technologies for electric motors and select them due to application • classify, analyse and evaluate hybrid and distributed drives • compose simple hybrid and distributed drives • describe the most important types of advanced electric drives
Content:	• Advanced Control of Electric Motors - Repetition of u/f-Control - Voltage Flux Control - Current Flux Control - Advanced Control Technologies • Hybrid Drives - serial - parallel - with power-split and power-merging • Distributed Drives • Advanced Electric Drives - Stepper Motors

	- Direct Drive Machines - Linear Motors - Switched Reluctance Motors - Synchronous Reluctance Motors - Trans Flux Motors
Assessment:	Exam
Forms of media:	Presentation, media board, practical demonstrations
Literature:	Pollevliet, J.: Electronic Power Control, Volume 2: Electronic Motor Control, Academia Press, 2012 De Doncker, R.W., Pulle, D.W.J., Veltman, A.: Advanced Electrical Drives, Springer Netherlands, 2011 Course Materials from the Lecturer Exercises from the Lecturer

Module M_ME_33 "Engineering of Power Transmission Systems"

Module name:	Engineering of Power Transmission Systems
Module code:	Master Mechanical Engineering: M_ME_33
Courses (where applicable):	*M_ME_33.1: Design and Evaluation of Power Transmission Systems* *M_ME_33.2: Simulation of Power Transmission Systems*
Semester:	1st semester
Module coordinator:	Prof. Dr.-Ing. Roland Schmetz
Lecturer:	Prof. Dr.-Ing. Roland Schmetz Prof. Dr.-Ing. Dirk Nissing
Language:	English
Place in curriculum:	Compulsory optional subject: Power Transmission Systems
Timetabled hours:	*Design and Evaluation of Power Transmission Systems* Lectures: 1 HPW Tutorials: 1 HPW *Simulation of Power Transmission Systems* Lectures: 1 HPW Practicals: 1 HPW
Workload:	60 h attendance 90 h preparation and review 30 h exam preparation
Credits:	6
Recommended prerequisites:	Advanced Engineering Mathematics and Fluid Mechanics in parallel
Module objectives:	After completion of the module students are able to mention, explain and recommend a suitable number of features to increase the energy efficiency of power transmission systems with regard to different applications. They are able to sketch basic power transmission systems for different applications and to perform basic life cycle analysis of some components of power transmission systems. Students have the ability to compare and evaluate different power transmission systems and can execute computer based simulations of main components of power transmission systems and simple power transmission systems. Students can use the method of decomposition for complex system structures into sub-modules. Ultimately, students are able to interpret, evaluate and assess the simulation results and they have the experience and knowledge to identify and develop required changes of the model.

<table>
<tr><td>Content:</td><td>Design and Evaluation of Power Transmission Systems

Design for Energy Efficiency
Design for Application
- Stationary
- Handheld
- Onroad light
- Onroad heavy
- Offroad
- Rail-guided Transportation Systems
Life Cycle Analysis
- Production
- Operating Cycle Analysis
- Recycling and Disposal
Comparison of
- Life Cycle Cost
- Strategic Aspects
- Life Cycle Energy Efficiency
- Life Cycle Environmental Impacts

Simulation of Power Transmission Systems

Review/Repetition
- Simulation and modelling
Principles of decomposition of a complex system / problem (V-model)
- Decomposition into sub-modules
- Interface definition
- Assignment of simulation tasks
- Integration of simulation modules
- Synthesis of simulated system
Simulation of electric power transmission drive
- Electric motor
- Parameterization
- Investigation of disturbances
- Model verification
- Extension of the model
Simulation of fluidic power transmission system
- Comparison simulation vs. measurement
- Calculation of pump requirements
</td></tr>
<tr><td>Assessment:</td><td>Design and Evaluation of Power Transmission Systems: Exam
Simulation of Power Transmission Systems: Attestation</td></tr>
<tr><td>Forms of media:</td><td>Presentation/PowerPoint, Media board, practical demonstrations, computer laboratory, controls laboratory</td></tr>
<tr><td>Literature:</td><td>Mohan, N.: Advanced Electrical Drives, Analysis, Control and Modeling using Simulink. Mnpere, Minneapolis, 2001.

Veltman, A, Pulle, D.W.J., De Doncker, R.W.: Fundamentals of Electrical Drives. Springer Netherlands, 2011.

James B. Dabney, Thomas L. Harman: Mastering Simulink®. Pearson Education 2004. ISBN 0-13-142477-7.</td></tr>
</table>

	Mohieddine Jelali, Andreas Kroll: Hydraulic Servo-systems. Springer 2003. ISBN 1-85233-692-7. Course Materials from the Lecturers Exercises from the Lecturers

Module M_ME_41 “Computational Multibody Dynamics”

Module name:	Computational Multibody Dynamics
Module code:	Master Mechanical Engineering: M_ME_41
Courses (where applicable):	
Semester:	2nd semester
Module coordinator:	Prof. Dr.-Ing. Thorsten Brandt
Lecturer:	Prof. Dr.-Ing. Thorsten Brandt
Language:	English
Place in curriculum:	Compulsory optional subject: Mechatronics
Timetabled hours:	Lectures: 2 HPW Practicals: 2 HPW
Workload:	60 h attendance 80 h preparation and review 40 h exam preparation
Credits:	6
Recommended prerequisites:	Fundamentals of Mechanics, Multibody Dynamics, and Engineering Mathematics at the undergraduate level
Module objectives:	After successfully finishing the module, students are familiar with the fundamentals of spatial multibody dynamics. They are able to apply concepts from linear algebra such as vectors and matrices to mechanical systems. The kinematics of technical joints such as revolute joints can be modeled by algebraic constraints by the student. The student is also able to model the dynamics of constraint multibody dynamic systems. Furthermore, the student is able to develop basic programming code and to simulate multibody dynamic systems and to interpret the simulation results.
Content:	The course focuses on the modelling and numerical simulation of dynamic multibody systems. Main subjects are: • Definitions: bodies, joints, and coordinates • Kinematics: rotation, translation • Kinematic constraints • Dynamics • Development of multibody dynamics simulation code • Application of multibody simulation software • Analysis of multibody dynamic systems
Assessment:	Written or oral examination
Forms of media:	Whiteboard, PowerPoint, Projector
Literature:	P. E. Nikravesh: Planar Multibody Dynamics - Formulation, Programming, and Application. CRC press 2008 Lecture Notes

Module M_ME_42 “Mobile Robotics”

Module name:	Mobile Robotics
Module code:	Master Mechanical Engineering: M_ME_42
Courses (where applicable):	
Semester:	2nd semester
Module coordinator:	Prof. Dr.-Ing. Thorsten Brandt
Lecturer:	Prof. Dr.-Ing. Thorsten Brandt Prof. Dr. William M. Megill
Language:	English
Place in curriculum:	Compulsory optional subject: Mechatronics
Timetabled hours:	Lectures: 2 HPW
Workload:	30 h attendance 40 h preparation and review 20 h exam preparation
Credits:	3
Recommended prerequi-sites:	Mechanics background at undergraduate level
Module objectives:	After successfully finishing the module, students are famil-iar with different concepts of mobile robots. Different loco-motion concepts for ground-based robots (wheeled and un-wheeled), aerial robots and naval systems are known. Advantages and drawbacks of different concepts can be distinguished.
Content:	Concepts for • Design, • Locomotion, • Actuation, • Sensorics, • Controls, and • Self-localization of mobile robots.
Assessment:	Written or oral examination
Forms of media:	Whiteboard, PowerPoint, Projector
Literature:	R. Siegwart, I.R. Nourbakhsh: Introduction to Autonomous Mobile Robots. MIT Press 2004 Class notes

Module M_ME_43 “System Identification and Optimal Controls”

Module name:	System Identification and Optimal Controls
Module code:	Master Mechanical Engineering: M_ME_43
Courses (where applicable):	
Semester:	2nd semester
Module coordinator:	Prof. Dr.-Ing. Dirk Nissing
Lecturer:	Prof. Dr.-Ing. Dirk Nissing
Language:	English
Place in curriculum:	Compulsory optional subject: Mechatronics
Timetabled hours:	Lectures: 1 HPW Tutorials: 1 HPW Practicals: 1 HPW
Workload:	45 h attendance 60 h preparation and review 15 h test preparation
Credits:	4
Recommended prerequisites:	Advanced Engineering Mathematics in parallel Control Engineering at undergraduate level
Module objectives:	The students are able to understand the principles, approaches and methods of “system Identification” and “Optimal Control”. They have the knowledge of using and implementing the “System Identification” method by considering a practical example. The results can be analysed and assessed by the students. Additionally the students gain their knowledge with respect to design, implementation, analysis and evaluation of an optimal controller dependent on the requirements and use cases.
Content:	• Modelling - Theoretical modelling - Experimental modelling • Repetition: Mathematical models • Identification with parametric models - Least square parameter estimation - Implementation of a real problem: Measurement of data, system identification, system validation • Estimation of system states using the Kalman Filter • Definition Control criterion - Principle of cost functions - Integrated criterion - Application of a real problem scenario • Lead/lag compensator • Linear quadratic regulator (LQR)
Assessment:	Attestation

Forms of media:	Presentation/PowerPoint, Media board, computer laborato-ry, controls laboratory
Literature:	Rolf Isermann, Marco Münchhoff: Identification of Dynamic Systems. Springer 2011. ISBN 978-3-540-78878-2. Lennart Ljung: System Identification. Prentice Hall 2009. ISBN 0-13-656695-2. Frank L. Lewis: Applied Optimal Control & Estimation. Prentice Hall 1992. ISBN: 0-13-040361-x. Frank L. Lewis, D. Vrabie, V. Syrmos: Optimal Control. John Wiley & Sons 2012. ISBN 978-0-470-63349-6.

Module M_ME_51 “Machine Tools”

Module name:	Machine Tools
Module code:	Master Mechanical Engineering: M_ME_51
Courses (where applicable):	
Semester:	2nd semester
Module coordinator:	Prof. Dr.-Ing. Alexander Klein
Lecturer:	
Language:	English
Place in curriculum:	Compulsory optional subject: Production
Timetabled hours:	Lectures: 2 HPW Practicals: 1 HPW
Workload:	45 h attendance 50 h preparation and review 25 h exam preparation
Credits:	4
Recommended prerequisites:	Manufacturing technology, controls, mechanics (elastostatics), technical design at undergraduate level
Module objectives:	The students know different types of machine tools for diverse fields of application (deforming, machining, thermal cutting etc.) as well as their sub functions. They understand the parameters of machine tool design and the evaluation criteria for machine tool performance. They are capable of selecting and dimensioning of machine tool components with analytical and numerical methods. Furthermore, they comprehend means of experimental machine evaluation.
Content:	• Machine tool types and concepts - machining, deforming, thermal cutting, hybrid etc. - different concepts (position of axes, kinematics) • Machine components - structure (bed, guideways, housings, headstock, tailstock etc.) - feed drives - spindle drives - tool - sensors and encoders (e.g. position and speed) • Machine tool stiffness - static stiffness - dynamic stiffness, eigenfrequencies and eigenmodes - regenerative chatter • Thermal behaviour - thermal growth and resulting inaccuracy - Thermal compensation and thermally neutral design • Accuracy

	- repeat accuracy - structural influences (guideways, spindles, backlash bearings etc.) - controls influence (axis lag) • Controls - NC - PLC - safety concept and components - control loops (position, speed, acceleration, jolt control) - adaptive process control • Automation - tool changer - workpiece changer - pallet changer - workpiece conveyor (linking of machines)
Assessment:	Exam
Forms of media:	Flipchart, whiteboard, projector, metaplan cards
Literature:	Makhanov, Stanislav S., Anotaipaiboon, Weerachai: Advanced numerical methods to optimize cutting operations of five axis milling machines, Springer, 2007 Kibbe, Richard R.: Machine tool practices, Pearson 2010 Schmitz, Tony L., Smith, Kevin S.: Mechanical vibrations - modeling and measurement, Springer 2012 Cheng, Kai: Machining dynamics - fundamentals, applications and practices, Springer, 2009 Weck, Manfred; Brecher, Christian: Werkzeugmaschinen – Fertigungssysteme (1-5), Springer, 2006 Wang, Lihui: Dynamic thermal analysis of machines in running state, Springer 2014

Module M_ME_52 “Advanced Manufacturing Technology”

Module name:	Advanced Manufacturing Technology
Module code:	Master Mechanical Engineering: M_ME_52
Courses (where applicable):	
Semester:	2nd semester
Module coordinator:	Prof. Dr.-Ing. Alexander Klein
Lecturer:	Prof. Dr.-Ing. Alexander Klein
Language:	English
Place in curriculum:	Compulsory optional subject: Production
Timetabled hours:	Lectures: 1 HPW Tutorials: 1 HPW
Workload:	30 h attendance 40 h preparation and review 20 h exam preparation
Credits:	3
Recommended prerequi-sites:	Manufacturing technology and basic internship in manufac-turing (or manufacturing laboratory)
Module objectives:	The students have detailed knowledge about all six main groups of manufacturing technologies (shaping, cutting (dissection), deforming, joining, coating, and changing of material properties. They are able to design value chains and consider technical interdependencies between differ-ent links of the value chain. The students are aware of technical systems and their requirements, e. g die manu-facturing for casting and deforming processes. Moreover, they understand the benefits and challenges of integrated (hybrid) processes. The students have the skill to analyse manufacturing processes in detail and apply means of systematic process development and optimiza-tion. In addition to universal technologies they have gained insight in special (exotic) manufacturing technologies.
Content:	• Value chains and technical systems in manufacturing, e.g. - deforming, casting and injection moulding including die and mould making - tailored-blanks welding and deforming (sheet metal) - interdependencies between processes in a value chain - value chain planning • Integrated processes, e.g. - mill-turning and turn-milling - burnishing and turning in one machine - additive manufacturing (laser deposition welding + milling) - Hybrid processes, e.g.

	- laser-assisted machining - ultrasound-assisted machining - laser hybrid welding • Manufacturing technology development and process optimization - Process simulation (incl. numerical methods) e.g. FEM simulation of deforming process, tool life calculation model - Model experiments (analogy process) - Experimental studies (hypothesis-driven narrowing of DoE) • Special applications and dedicated processes: (deep dive to 6 main groups of manufacturing technologies acc. to DIN 8580) - e.g. helical gear grinding - continuous dressing - camshaft milling and grinding - bevel gear lapping - laser deforming - incremental sheet metal forming - three-dimensional printing of sand moulds & cores - selective laser melting and SL sintering (rapid technologies) - electron-beam welding - friction welding • Computer aided manufacturing - CAD CAM chain & process strategy
Assessment:	Exam
Forms of media:	Flipchart, whiteboard, projector, metaplan cards
Literature:	Kalpakjian & Schmid: Manufacturing Processes for Engineering Materials. 5th edition. ISBN 978-0132272711. Prentice Hall 2008 Brecher, Christian: Integrative production technology for high-wage countries. Springer 2012 ***Further Readings:*** Klocke, F. (Autor); Kuchle, A. (Übersetzer): Manufacturing Processes 1: Cutting: Lathing, Milling, Drilling; Springer Berlin Heidelberg; 1st edition, 2011 Klocke, F. (Autor); Kuchle, A. (Übersetzer): Manufacturing Processes 2: Grinding, Honing, Lapping; Springer Berlin Heidelberg; 1st edition, 2009 Fischer, Ulrich; Gomeringer, Roland; Heinzler, Max; Kilgus, Roland; Näher, Friedrich: Mechanical and Metal Trades Handbook. Europa-Verlag 2013 International Institution for Production Engineering Research: Wörterbuch der Fertigungstechnik. Springer 2012 Crowson, Richard: The handbook of manufacturing engineering. CRC, Taylor & Francis, 2006

Module M_ME_53 “Factory Design and Operations Management”

Module name:	Factory Design and Operations Management
Module code:	Master Mechanical Engineering: M_ME_53
Courses (where applicable):	
Semester:	2nd semester
Module coordinator:	Prof. Dr.-Ing. Alexander Klein
Lecturer:	Prof. Dr.-Ing. Alexander Klein
Language:	English
Place in curriculum:	Compulsory optional subject: Production
Timetabled hours:	Lectures: 2 HPW Tutorials: 1 HPW Practicals: 1 HPW
Workload:	60 h attendance 90 h preparation and review 30 h exam preparation
Credits:	6
Recommended prerequi-sites:	Production management or manufacturing systems
Module objectives:	After completion of the module, students are able to design a factory for a given product spectrum and production quantity. They have in-depth knowledge of the parameters in factory layout, production control and choice of technologies as well as the appropriate degree of automation. They under-stand the involved IT systems and business processes, the typical problems of operations and methods to reduce or abolish them. The students know how to apply means of lean production and optimization of throughput velocity. They can define and interpret performance indicators and forecast produc-tion costs in a differentiated manner.
Content:	• Factory design - Factory layout (green field and brown field planning) - Factory sub functions (including warehouses) - Capacity calculation - Flexible and versatile factories - Factory design project management - Building technology - Conveying technology - Value streams and material flows (& value stream design) - Cost forecasting and investment planning - Technology selection - Ergonomics and workplace design

	- factory role in supply network (supply chain management) • Operations management - order management - ERP enterprise resource planning - work planning - throughput time, critical chain and funnel model - work planning and scheduling - production logistics and priority rules - parts manufacturing and assembly - performance metrics (KPI) • Lean production - waste in production (muda) - production systems (and Toyota production system) - Kaizen, Heijunka, Kanban, FIFO - value stream mapping & value stream design • Complexity management - impact of product design on complexity in production - complexity trap - postponement, customer decoupling point and variant creation point - internal and external complexity • Dilemmas in production - polylemma of production (economies of scale vs. economies of scope & planning orientation vs. value orientation) - approaches to reduce dilemmas
Assessment:	Exam
Forms of media:	Flipchart, whiteboard, projector, metaplan cards
Literature:	Stevenson, W. J.: Operations Management. 11th revised edition. McGraw-Hill 2011 Schenk, Michael, Wirth, Siegfried, Müller, Egon: Factory planning manual. Springer 2010 Hopp, Wallace J.; Spearman, Mark L.: Factory Physics. 3rd edition. McGraw-Hill 2011 ***Recommended Further reading:*** Brecher, Christian: Integrative production technology for high-wage countries. Springer 2012 Nyhuis, Peter; Wiendahl, Hans-Peter: Fundamentals of Production Logistics. Springer 2008 Serope Kalpakjian, Steven Schmid: Manufacturing Engineering & Technology. 6th edition. ISBN 978-0136081685. Prentice Hall 2010 Wright: 21st Century Manufacturing. 1st edition. ISBN 978-0130956019. Prentice Hall 2001 Lödding, Hermann: Handbook of Manufacturing Control. Springer 2013

Module M_ME_61 “Surface Engineering and Coating”

Module name:	Surface Engineering and Coating
Module code:	Master Mechanical Engineering: M_ME_61
Courses (where applicable):	
Semester:	2nd semester
Module coordinator:	Prof. Dr. Amir Fahmi
Lecturer:	Prof. Dr. Amir Fahmi
Language:	English
Place in curriculum:	Compulsory optional subject: Materials
Timetabled hours:	Lectures: 1 HPW Tutorials: 1 HPW
Workload:	30 h attendance 40 h preparation and review 20 h exam preparation
Credits:	3
Recommended prerequisites:	
Module objectives:	After the course students are able to: • understand the need for surface modification technologies and demonstrate comprehensive knowledge of surface technologies. • classify and use surface technology processes to design and control surface properties via surface modification techniques • identify significant problems concerned with interactions between the coating materials and the underline substrates • introduce suitable analytical techniques used to evaluate and characterise surfaces and thin films. • specify surface technology solutions for complex problems such as corrosion, wear, solderability, friction and fatigue of engineering components.
Content:	• Fundamentals of surface modification: classification, definition, scope and general principles of surface dependent properties, importance and scope of surface modification. • Conventional surface modification and surfaces treatments: chemical and physical methods to engineering surfaces by material removal principle and its application with examples such as cleaning, etching, grinding, polishing, estimate of surface roughness. Surface engineering by material addition principle and its application with example in gaseous medium such as oxidation, ni-

	triding and carburizing. • Surface engineering by energy beams: general classification, scope and principles, types and intensity/energy deposition profile such UV, electron beam, laser, ion beam. • Surface engineering by spray techniques and plasma coating: principle and scope of applications • Surface coating by thermal and sputtering techniques in thin film such chemical vapor deposition and physical vapor deposition. • Characterization techniques of modified surfaces: principle and scope of measurements film thickness (monolayers and multilayers), hydrophobicity, porosity, adhesion, spectroscopic analysis and surfaces microscopy. • Design surfaces structures and properties for tailored functions via surfaces medication in different dimensions and length scales such as design nanostructured films for applications in photovoltaics, sensors, electronic and optoelectronic devices.
Assessment:	Exam (written examination)
Forms of media:	Whiteboard, power points and projector
Literature:	Surface Engineering of Metals: Principles, Equipment, Technologies. Series: Materials Science & Technology. 1998 by CRC Press Tadeusz Burakowski, Tadeusz Wierzchon. Surface Engineering for Corrosion and Wear Resistance. ASM International, 2001 J. R. Davis. Surface Modification and Mechanisms: Friction, Stress, and Reaction Engineering. Published: 2004 by CRC Press, George E. Totten, Hong Liang. Surface Engineering: Surface Modification of Materials. R. Kossowsky, S.C. Singha.

Module M_ME_62 “Material Selection”

Module name:	Material Selection
Module code:	Master Mechanical Engineering: M_ME_62
Courses (where applicable):	*Advanced Materials Science (metallic and non-metallic)* *Material Simulation and Selection*
Semester:	2nd semester
Module coordinator:	Prof. Sicking
Lecturer:	Prof. Sicking tbd
Language:	English
Place in curriculum:	Compulsory optional subject: Materials
Timetabled hours:	*Advanced Materials Science (metallic and non-metallic)* Lectures: 1 HPW Practicals: 1 HPW *Material Simulation and Selection* Lectures: 1 HPW Practicals: 2 HPW
Workload:	75 h attendance 95 h preparation and review 40 h exam preparation
Credits:	7
Recommended prerequisites:	
Module objectives:	After successful completion of the module, students can/have • advanced understanding of materials microstructures, and properties • knowledge how to use classical, modern and novel materials in engineering design • classify materials according to specific applications • understand tools and keys for proper selection of materials for specific applications • detect limits of materials and present proper alternative selection • identify standard procedures and benchmarks for materials classification and selection • apply basic materials property calculations • identify and apply proper simulation models and tools
Content:	*Advanced Materials Science (metallic and non-metallic)* • Metal and ceramic structures • Phase diagrams • Structural changes

	• Heat treatment • Case studies on steel and light metals • Review on polymers, fibre reinforced plastics and hard metals • Production aspects • Exemplary value chain considerations *Material Simulation and Selection* • General ideas of materials selection • Methods and procedures • Determination of requirements • Information sources and databases • Evaluation, validation and decision • Risk evaluation and control • Overview and application of modeling approaches simulation methods, e.g. target-/penalty functions, FEM-based evaluation, risk and failure models • Error analysis and control
Assessment:	*Advanced Materials Science (metallic and non-metallic)*: Exam *Material Simulation and Selection*: Attestation
Forms of media:	Whiteboard, Powerpoint, Projector, Materials laboratory, Microscopy laboratory, Computer labs
Literature:	Michael F. Ashby, David R. H. Jones: Engineering Materials 2 – An Introduction to Microstructures, Processing and Design, 3rd edition, 2006, ISBN-13 978-0-7506-6381-6 C. Barry Carter, M. Grant Norton: Ceramic Materials, 2nd edition, 2013, ISBN 978-1-4614-3522-8, Springer Donald R. Askeland: Materialwissenschaften, 1st edition, 1996, ISBN 978-3-8274-2741-0, Spektrum ASM International, Harry Chandler (Editor): Heat Treater´s Guide – Practices and Procedures for Irons and Steels, 2nd edition, 2010, ISBN-13 978-0-87170-520-4 Michael Ashby: Materials Selection in Mechanical Design. Butterworth Heinemann; 4th revised edition 2010

Module M_ME_63 "Joining Technology"

Module name:	Joining Technology
Module code:	Master Mechanical Engineering: M_ME_63
Courses (where applicable):	
Semester:	2nd semester
Module coordinator:	Prof. Dr.-Ing. Raimund Sicking
Lecturer:	Prof. Dr.-Ing. Raimund Sicking
Language:	English
Place in curriculum:	Compulsory optional subject: Materials
Timetabled hours:	Lectures: 1 HPW Practicals: 1 HPW
Workload:	30 h attendance 35 h preparation and review 25 h exam preparation
Credits:	3
Recommended prerequi-sites:	
Module objectives:	Students will understand traditional engineering joining technologies used for different conventional materials, and how materials grow and resorb in response to stress and other forces.
Content:	• Welding, soldering, brazing of metals • Combination of joining and heat treatment processes • Glueing, bonding of plastics and composites • Mechanical joining techniques • Stress concentrations • Load transfer across joints • Corrosion hotspots
Assessment:	Exam
Forms of media:	Whiteboard, PowerPoint, Materials laboratory, Microscopy laboratory, Computer labs.
Literature:	M. F. Ashby, D. R. H. Jones: Engineering Materials 2 – An Introduction to Microstructures, Processing and Design, 3rd edition, 2006, ISBN-13 978-0-7506-6381-6 H. J. Fahrenwaldt, V. Schuler: Praxiswissen Schweißtech-nik – Werkstoffe, Prozesse, Fertigung; 4th edition, 2011, ISBN 978-3-8348-1523-1, Vieweg+Teuber AWS C3 Committee on Brazing and Soldering: Brazing Handbook, 5th edition, 2012, ISBN 978-0-87171-046-8, AWS H. Schoer: Schweißen und Hartlöten von Aluminiumwerk-stoffen, 2nd edition, 2002, ISBN 3-87155-190-2, DVS-

	Verlag Current conference proceedings

Module M_ME_07 “Applied Research Project”

Module name:	Applied Research Project
Module code:	Master Mechanical Engineering: M_ME_07
Courses (where applicable):	
Semester:	2^{nd} semester
Module coordinator:	Prof. Dr.-Ing. Dirk Nissing Prof. Dr.-Ing. Alexander Klein
Lecturer:	Project dependent
Language:	English
Place in curriculum:	Core
Timetabled hours:	none
Workload:	240 h
Credits:	8
Recommended Prerequisites:	
Module objectives:	The students demonstrate their capability to work independently on an applied research subject in alignment with their course of study, meeting all topical and scientific requirements in a limited period of time. They have the ability to self-analyze and assess the results and make recommendations for improvements. They are able to organize their workflow in order to meet the demands of the problems formulated in their project, as well as to monitor progress and make necessary amendments. Additionally students are able to improve their documentation skills, thus documenting their approach and their results to meet the requirements of a scientific publication.
Content:	The project content depends on the chosen topic and is agreed upon with the supervisor. Documentation is granted by an adequately sized description of the topic/problem, the chosen approach, used methods and results.
Assessment:	Written documentation, research results, proceeded data and charts, prototypes, software code, blueprints where applicable
Forms of media:	Raw data, slide deck, written documentation
Literature:	

Module M_ME_08 “General Management”

Module name:	General Management
Module code:	Master Mechanical Engineering: M_ME_08
Courses (where applicable):	
Semester:	3rd semester
Module coordinator:	Prof. Dr.-Ing. Dirk Untiedt
Lecturer:	Prof. Dr.-Ing. Dirk Untiedt
Language:	English
Place in curriculum:	Core subject
Timetabled hours:	Lectures: 1 HPW Seminar: 3 HPW
Workload:	60 h attendance 80 h preparation and review 40 h exam preparation
Credits:	6
Recommended prerequi-sites:	
Module objectives:	In addition to the corporate management mostly three management functions for any kind of company can be distinguished with respect to general Management: • Marketing Management • Finance Management and • Production management. Students know the main tools, methods and instruments of general management. They have the ability to use them effectively. They are able to formulate strategies and implementation plans on all strategy levels and in specific contexts.
Content:	• Fundamentals of General Management • Strategy • Finance and Controlling • Organisation and Management • Human Resource Management • Change Management • Marketing
Assessment:	Exam
Forms of media:	Powerpoint Slides; Business Simulation Game
Literature:	

Module M_ME_09 “Master Thesis”

Module name:	Master Thesis
Module code:	Master Mechanical Engineering: M_ME_09
Courses (where applicable):	
Semester:	3rd semester
Module coordinator:	Prof. Dr.-Ing. Dirk Nissing Prof. Dr.-Ing. Alexander Klein
Lecturer:	Project dependent
Language:	English
Place in curriculum:	Core
Timetabled hours:	none
Workload:	630 h
Credits:	21
Prerequisites:	At least 50 credit points in the respective courses. Successfully passed “Applied Research Project”.
Module objectives:	The students demonstrate their capability to work independently on a scientific subject in alignment with their course of study, meeting all topical and scientific requirements in a limited period of time. Scientific methods and approaches are used in order to work on the subject and they have the ability to analyze and assess the results. They are able to organize their workflow in order to meet the demands of the problems formulated in their theses, as well as to monitor progress and make necessary amendments. Additionally students are able to improve their documentation skills, thus documenting their approach and their results to meet the requirements of a scientific publication.
Content:	The Thesis content depends on the chosen topic and is agreed upon with the supervisor. Documentation is granted by an adequately sized description of the topic/problem, the chosen approach, used methods and results.
Assessment:	Written Thesis
Forms of media:	Written Thesis
Literature:	

Module M_ME_10 “Colloquium”

Module name:	Colloquium
Module code:	Master Mechanical Engineering: M_ME_10
Courses (where applicable):	
Semester:	3rd semester
Module coordinator:	Prof. Dr.-Ing. Dirk Nissing Prof. Dr.-Ing. Alexander Klein
Lecturer:	Supervisor of the Master Thesis
Language:	English
Place in curriculum:	Core
Timetabled hours:	none
Workload:	90 h
Credits:	3
Prerequisites:	At least 87 credits
Module objectives:	The students are able to defend the results of the Master Thesis place their work in a context of scientific applications and present their results in a proper form for the audience. They motivate their approach and make estimations, how assumptions and simplifications may affect the validity of their results. Additionally, students are able to analyze questions concerning their thesis and results and answer them properly in the context of professional and extra-professional reference.
Content:	The content is aligned with the content of the Master Thesis, in addition methodological discussions.
Assessment:	Oral examination
Forms of media:	Whiteboard, PowerPoint, Projector
Literature:	