Mechanical Engineering
Module Handbook

- Courses in English* -

- Finite Elements
- Industry Design Team Project (aerospace)
- Machine Cutting Technology
- Systematic Product Development
- Technical Thermodynamics
- Thermal Energy Systems

* courses are offered in the summer semester (March – July) only
Faculty of Engineering & Computer Science. Exchange students may also be able to take classes from other programmes in this faculty (aeronautical engineering, automotive engineering, information engineering) if lecture schedules and capacity allow.

Department of Mechanical Engineering & Production Management (September 2019)

Course Name: Finite Elements

Degree programme: **Mechanical Engineering** (Bachelor)	Responsible Lecturer: Prof. Dr.-Ing. Thomas Grätsch	
Work load: 180 hours	**Lecture hours per week:** 4	**ECTS Credits:** 6

Course objectives:

Technical and methodology skills: The aim is to enable the students/participants to work independently with finite element standard software and to critically evaluate the calculated results. In the lectures, basic mechanical principles of the finite element method and its programming implementation will be taught. According to the specifics of mechanical engineering, in the lectures it will be focused on mechanics of materials, thermal elasticity, modeling aspects and dynamic analysis. In seminar discussions, foundations of engineering mechanics and numerical methods will be repeated and enhanced. Selected topics of advanced engineering mechanics are taught. Laboratory assignments are divided into two parts. In the first part, simple finite element models need to be programmed with a suitable software (e.g. in Matlab, Mathcad). In the second part, more advanced finite element analysis tasks will be carried out using commercial finite element systems (e.g. Ansys, Adina or MSC/Nastran).

Social skills: In seminar discussions, the students/participants will be motivated to discuss technical problems. In the laboratory work, the students/participants will be encouraged and enabled to work self-dependently and autonomously through special training materials as well as the introduction to the documentation of the used program tools. For the completion of their laboratory and homework assignments, the students are encouraged to cooperate within small groups.
Selected topics will be provided for assignments and the results will be presented during the lecture.

Content:

1. Introduction and motivation: Industrial applications of the finite element method, three steps of an analysis: pre-processing, solution, post-processing

2. Truss elements: basic differential equations, strong and weak form of differential equations, local stiffness matrix and matrix assembly, principle of virtual displacements, shape functions, higher-order elements, local-global transformations, finite element analysis of trusses

3. Beam elements: basic differential equations, stresses and strains, principle of virtual displacements, local stiffness matrix and matrix assembly, three- dimensional beam elements, local coordinate systems, local-global transformations, equivalent load vector

4. Modeling aspects: modeling of supports and hinges (single point and multiple point constraints, rigid body elements), assessment of finite element solutions, practical guideline to assess and assure model and mesh quality, treatment of singularities

5. Shell, plate, and slab elements (thin-walled structures): approximation on two-dimensional element domains, linear shape functions, higher-order shape functions, isoparametric elements, local-global coordinate transformations, classification and analytical treatment of thin-walled structures, plane stress state, plane strain state, kinematics of plate bending elements, local stiffness matrix and matrix assembly, non-conforming plate bending elements, mixed methods for shell elements

6. Three-dimensional elements: approximation on three-dimensional element domains, linear shape functions, higher-order shape functions, displacements and strains, three-dimensional stress state and equilibrium, linear elasticity, brick elements and tetrahedrals

7. Finite elements in structural dynamics: vibrations of mass-spring-systems, stiffness matrix and mass matrix, eigenmodes and eigenfrequencies, forced vibrations, mass matrices for trusses and beams

8. Summary and outlook: linear and nonlinear analysis, super-elements, thermo-elastic analysis, fluid-structure-interactions and multi-physics, error analysis

About didactics and work load distribution:

Seminars, computer simulation . 2.5 hours lecture + 1.5 hour lab. 72 hours lectures/lab and 108 hours self-study

Requirements for participation: Engineering mechanics, mathematics, physics	**Course language:** English

Type of exam:
Written exam

Requirements for credit point allocation:
successful completion of written exam and laboratory work

Literature:

- Bathe, Finite-Elemente-Methoden, Springer-Verlag 2002
- Bathe, Finite Element Procedures, 2nd edition, 2015
- Fish und Belytschko, A first course in FEM, J. Wiley 2007
- Steinke, Finite-Elemente-Methode, Springer-Verlag 2010
- Gross et al., Technische Mechanik 4, Springer-Verlag 2007

Course Name: Machine Cutting Technology

Degree programme: **Mechanical Engineering** (Bachelor)	Responsible Lecturer: Prof. Dr.-Ing. Dietmar Pähler	
Work load: 150 hours	**Lecture hours per week:** 3 (plus 1 hr lab)	**ECTS Credits:** 5

Course objectives:

Building on the basic knowledge regarding the various manufacturing technologies classified within the DIN 8580 and previously acquired by the students during their foundation studies, the focus is set on the most important machining technologies with geometrically defined as well as undefined cutting edges. Most relevant cutting tool materials, geometries and process parameters are discussed regarding their influence on part quality, process times as well as economical aspects. Application related pros and cons are discussed. Resulting there from, the students will be enabled to evaluate in a more profound manner the applicability of the discussed machining technologies and to select an appropriate technology for a given task.

Contents:

1. Cutting with geometrically defined cutting edges

- Tool engagement situation; cutting angles; machining criteria: chip formation, surface generation, mechanical loads, tool wear; cutting tool materials; methods for calculation of process forces, tool life and machining cost with focus on turning operations; basic process optimisation measures
- Technology overview: Turning, drilling, milling, reaming, broaching, sawing; particular features of drilling and milling processes

2. Cutting with geometrically undefined cutting edges (grinding)

- Grinding basics: Process overview and nomenclature, grinding principles
- Grinding tools: Specification of conventional and super abrasive grinding wheels (e.g. grit type, size, concentration; bond; wheel geometry)
- Grinding technology: Influence of tool and process parameters on process results for important cylindrical and surface grinding processes
- Dressing of grinding wheels: Techniques, tools, parameters, calculations

About didactics and work load distribution:

Machining Technology lecture in seminar form (3 hrs/week) and Machining Technology lab (1 hr/week); self-study 84 hrs

Requirements for participation:

Practical company placements with focus on machining technology, basics in manufacturing engineering

Course language:

English

Type of exam:

Written or oral exam

Requirements for credit point allocation:

Successful completion of exam

Literature:

- Fritz Klocke and Wilfried König; Manufacturing Technology in 5 volumes; Publishers Springer Vieweg (in German) Volume 1: Turning, milling, drilling; ISBN 978-3-540-23458-6 Volume 2: Grinding, honing, lapping; ISBN 978-3-540-23496-9
- Eberhard Paucksch e.a.; Machining Technology; 12. edition, 2008; Publishers Vieweg+Teubner (in German); ISBN 978-3-8348-0279-8
- J. Paulo Davim; Modern machining technology - a practical guide Woodhead Pub, 2011 (in English)

Course Name: Systematic Product Development

Degree programme: **Mechanical Engineering** (Bachelor)	Responsible Lecturer: Prof. Dr.-Ing. Meyer-Eschenbach

Work load: 150 hours	**Lecture hours per week:** 4	**ECTS Credits:** 5

Course objectives:
The students will be able to understand the product development process including typical process stages and milestones. Then the students will know the most important methods and they will be able to use these methods in different stages of engineering design. These knowledges will be applied and discussed in different exercises in tutorials.
The students know the tasks of a design engineer in industry and the most important strategies of collaboration in project teams. In this context different targets of departments in international companies can be found, discussed and analysed.

Content:

- Product development process in industry:
  general problem solving, workflow during the development phase
- Product planning
- Clarification and definition of the task:
  finding and setting up requirements
- Methods for conceptual design:
  steps of conceptual design, abstracting to identify the essential problems, establishing function structures, developing of working structures, search for solution principles, developing concepts
- Methods for selection and evaluation
- Methods for embodiment design:
  checklist for embodiment design, basic rules of embodiment design, principles of embodiment design, guidelines for embodiment design
- Design for quality
  fault-tree analysis (FTA), failure mode and analysis (FMEA)
- Developing size rages and modular products
- Distributed development

About didactics and work load distribution:
Seminar (72 hours lecture, 78 hours self-study)

Requirements for participation: Technical drawing, engineering design including machine elements (KonA,B)	**Course language:** English
Type of exam: Written exam	

Requirements for credit point allocation:
Successful completion of the written exam; active participation in class

Literature:

- lecture notes & worksheet
- Pahl, G.; Beitz, W; Feldhusen, J.; Grote, K.-H.: Engineering Design: A Systematic Approach. Third Edition. Springer Verlag, Berlin, Heidelberg, 2007
- Pahl, G.; Beitz, W; Feldhusen, J.; Grote, K.-H.: Konstruktionslehre: Grundlagen erfolgreicher Produktentwicklung; Methoden und Anwendung, 7. Aufl., Springer Verlag. Berlin, Heidelberg, 2007
- Pahl, G.; Beitz, W; Feldhusen, J.; Grote, K.-H.: Konstruktionslehre: Grundlagen erfolgreicher Produktentwicklung; Methoden und Anwendung, 8. Aufl., Springer Verlag. Berlin, Heidelberg, 2013
- Ehrlenspiel, K.: Integrierte Produktentwicklung: Denkabläufe, Methodeneinsatz, Zusammenarbeit, 3. Aufl., München, 2007

Course Name: Technical Thermodynamics 1

Degree programme: **Mechanical Engineering** (Bachelor)	Responsible Lecturer: Prof. Dr.-Ing. Achim Schmidt

Work load: 150 hours	**Lecture hours per week:** 4	**ECTS Credits:** 5

Course objectives:

The students will be qualified to perform thermodynamic balances of machines and facilities within the project stages planning, calculation, design and operation. They shall understand the meaning of energy conversion and the quality of different forms of energy. Furthermore, they will have a consolidated knowledge of thermodynamic properties of different working fluids. The module's task is to mediate expertise as well as methodical competence. Methods for thermodynamical calculations will be developed by using practical examples. In order to transfer thermodynamic knowledge into technical applications, the focus on the essentials is sharpened.

Contents:

- Introduction
- Task of thermodynamic
- Energy and work
- System and state: system boundary, state values, fluid phases, homogeneous/heterogeneous systems, ideal gas vs. real fluid
- Thermodynamic equilibrium
- Equations of state
- Thermal equation of state, changes of state, thermodynamic processes, quasi-static changes of state, reversible/irreversible processes
- First law of thermodynamic (closed systems, steady/unsteady open systems, thermodynamic cycles
- caloric equation of state: enthalpy, entropy, Internal energy
- Second law of thermodynamic (Entropy, entropy balances for open and closed systems, irreversibility of transient balancing processes, heat transfer phenomena, dissipation, thermal engine, T,s-diagram)
- Energy/exergy loaa
- Components and thermodynamic cycles (thermal engines, heat pumps, cooling machines, carnot-cycle, Seliger process, Stirlingmachine, Joule process)

About didactics and work load distribution:

Seminar

Requirements for participation:

Mathematics 1 and 2

Course language:

English

Type of exam:

Written exam

Requirements for credit point allocation:

Successful completion of written exam

Literature:

- Schmidt, A.: Technical Thermodynamics for Engineers, Springer Verlag, ISBN 978-3-030-20396-2
- Baehr, H. D.; Kabelac, S.: Thermodynamik. Grundlagen und technische Anwendungen. 13. Auflage. Berlin, Heidelberg: Springer-Verlag 2006.
- Cerbe, G.; Wilhelms, G.: Einführung in die Thermodynamik. Von den Grundlagen zur technischen Anwendung. 14. Auflage. München, Wien: Carl Hanser Verlag 2005.
- Doering, E.; Schedwill, H.; Dehli, M.: Grundlagen der Technischen Thermodynamik. 5. Auflage. Stuttgart, Leipzig, Wiesbaden: B. G. Teubner Verlag 2005.

Course Name: Thermal Energy Systems

Degree programme: **Mechanical Engineering** (Bachelor)		Responsible Lecturer: Prof. Dr. Thomas Flower
Work load: 150 hours	**Lecture hours per week:** 4	**ECTS Credits:** 5

Course objectives:

Appreciation of state of the art energy conversion systems for central and distributed heat and electrical power supply. Students learn to apply thermodynamic, numerical and economic techniques to evaluate the merits of modern power systems.

Students are enabled to skillfully apply carefully chosen plant and component balances to analyze potential energy supply options and check the plausibility of complex computational tools.

Contents:

1. Thermodynamic and chemical fundamentals of energy conversion
   - Energy conversion in thermal power plants
   - Simplified thermodynamic comparative models and their application
   - Analysis of losses during energy conversion
   - Combustion processes (heating value, absolute enthalpy and entropy, air ratio)
   - Calculation of exhaust composition
   - Calculation of adiabatic combustion temperature
   - Electrochemical analysis of fuel cells
2. Economic evaluation
   - Calculation of cost-of-energy and its individual components
   - Comparison of different economic evaluation options
3. Component design principles and analysis for power plants
   - Steam and gas turbines
   - Micro-turbines
   - Stationary reciprocating engines (Diesel, Stirling)
   - Fuel cells (PEMFC, SOFC)
   - Steam generators
4. Operation of energy systems
   - Environmental impact
   - Part load operation
   - Flexibility of dispatch
   - Combined heat and electrical power supply
5. Numerical analysis
   - Material properties of water/steam and gases
   - MatLab simulation of compressors, turbines, regenerative preheating, combustion processes
   - MatLab simulation of power systems
   - Starting values and solving strategies

About didactics and work load distribution:

Seminars, computer simulation using MatLab, e-Learning with EMIL. Attendance 4h per week (72h), self study (78h)

Requirements for participation:

Good understanding of Mathematics, Thermodynamics and Matlab

Course language:

English

Type of exam:

Written or Oral exam

Requirements for credit point allocation:

Active participation in group work and lessons, successful completion of oral exam, use of MatLab

Literature:

- Kraftwerkstechnik zur Nutzung fossiler, nuklearer und regenerativen Energiequellen (auch als eBook), Karl Strauß, VDI Verlag
- Dezentrale Energiesysteme, Neue Technologien im liberalisierten Energiemarkt Jürgen Karl, Oldenbourg Verlag
- Technische Thermodynamik, Fran Bosnjakovic, K.F. Knoche, Steinkopff Verlag,1988
- Energietechnik, Systeme zur Energieumwandlung, Kompaktwissen für Studium und Beruf, Zahoransky, Allelein, Bollin, Oehler, Schelling, Vieweg + Teubner Verlag
- Stationäre Gasturbinen, Christof Lechner, Jörg Seume, Springer Verlag (eBook bei HIBS)
- Thermische Turbomaschinen, Walter Traupel, Springer Verlag
- Dampfturbinen, Fritz Dietzel, Carl Hanser Verlag, 1980
- Dampferzeugerpraxis, Grundlagen und Betrieb, Heinz Lehmann, 1994, Resch- Media Mail Verlag

- Microturbines, Application for Distributed Energy Systems, Claire Soares, 2007, Butterworth-Heinemann/Elsevier, (eBook bei HIBS)
- Blockheizkraftwerke – Ein Leitfaden für den Anwender, BINE- Informationspaket, Wolfgang Suttor, FIZ Karlsruhe, 2009 (HIBS)
- Essential MatLab for Engineers and Scientists, Brian H. Hahn, Daniel, T. Valentine, Elsevier, Academic Press, 2013