Mechanical Engineering
Module Handbook
- Courses in English* -

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

* courses are offered in the summer semester (March – July) only
Department of Mechanical Engineering & Production Management (March 2018)
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.
### Course Name: Energy Systems

**Degree programme:** Mechanical Engineering (Bachelor)  
**Responsibility Lecturer:** Prof. Dr. Thomas Flower

<table>
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<tr>
<th>Work load: 150 hours</th>
<th>Lecture hours per week: 4</th>
<th>ECTS Credits: 5</th>
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**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:**
- 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 regenerativer 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 Turbosysteme, Walter Traupel, Springer Verlag
- Dampfturbine, Fritz Dietzel, Carl Hanser Verlag, 1980
- Dampferzeugerpraxis, Grundlagen und Betrieb, Heinz Lehmann, 1994, Resch- Media Mail Verlag
• Blockheizkraftwerke – Ein Leitfaden für den Anwender, BINE- Informationspaket, Wolfgang Suttor, RIZ Karlsruhe, 2009 (HIBS)
**Course Name:** Finite Elements

<table>
<thead>
<tr>
<th>Degree programme:</th>
<th>Mechanical Engineering (Bachelor)</th>
<th>Responsible Lecturer: Prof. Dr.-Ing. Thomas Grätsch</th>
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<tr>
<td><strong>Work load:</strong></td>
<td>180 hours</td>
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<tr>
<td><strong>Lecture hours per week:</strong></td>
<td>4</td>
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<td><strong>ECTS Credits:</strong></td>
<td>6</td>
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**Course objectives:**
Technical and methodological 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
**Course Name:** Technical Thermodynamics 1  

**Degree programme:**  
Mechanical Engineering (Bachelor)  

**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 the thermodynamical knowledge into engineering applications the view for the essentials is sharpened.

**Contents:**  
- Introduction  
- Task of thermodynamic  
- System and state, system border, variables of state, fluid phases, equation of state  
- Temperature, thermal balance, ideal gas thermometer, thermal equation of state (ideal and real gases), standard volume  
- First law of thermodynamic (closed systems, Internal energy, caloric equation of state, energy balances, heat and work, volume change work, shaft work, heat and heat flux, heat transfer, open systems (unsteady processes, steady state systems), enthalpy  
- Second law of thermodynamic (Entropy, entropy balances for open and closed systems, irreversibility of heat transfer phenomena, cooling processes, thermal engine, entropy as state variable, T,s-diagram)  
- Limited conversion ability of energy (thermodynamic cycles, heat pumps, cooling machines, carno t-cycle, Clausius-Rankine process)

**About didactics and work load distribution:**  
Seminar

**Requirements for participation:**  
Mathematics 1 and 2

**Type of exam:**  
Written exam

**Requirements for credit point allocation:**  
Successful completion of written exam

**Literature:**  
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<tr>
<td>Written exam</td>
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**Requirements for credit point allocation:**
successful completion of written exam and laboratory work

**Literature:**
- Bathe, Finite-Element-METHODEN, Springer-Verlag 2002
- Fish und Belytschko, A first course in FEM, J. Wiley 2007
- Steinke, Finite-Element-Methode, Springer-Verlag 2010
- Gross et al., Technische Mechanik 4, Springer-Verlag 2007
**Course Name:** Industry Design Team Project

**Degree programme:**
*Aeronautical Engineering* (Bachelor)

**Responsible Lecturer:** Prof. Dr.-Ing. J. Abulawi

**Work load:** 150 hours

**Lecture hours per week:** –

**ECTS Credits:** 5

**Course objectives:**
In a team 3 - 5 students conceive and elaborate a mechanical design solution for an aeronautical engineering design task. They use a methodical approach to identify requirements and define and evaluate various creative concepts. With their knowledge in engineering mechanics, machine elements, materials science, and computer aided engineering (CAD), they elaborate the favorite concept into a detailed design solution. They present and discuss their concepts and their final solution, and document the whole project in a team portfolio. Students are usually given a task by a company such as Airbus. In this case students have the opportunity to present their design to Airbus management on site at the Hamburg plant.

**Contents:**
Brief introduction to project management and team work. Familiarization with methods for requirements elicitation, concept definition and evaluation. Each team obtains individual ongoing support in the concept and the design phase. On demand, support is offered for aspects of team work and organization.

**Team work includes:**
- (Self-)Organization and project management
- Identification of needs and requirements & functional analysis
- Development of at least three concepts with creativity methods & methodical concept evaluation
- Elaboration of one concept into a detailed engineering design solution
- Dimensioning of critical design elements & estimation of weight and cost
- 3D CAD modeling of the design solution with associated technical drawings & bill of materials
- Detailed documentation of the project work
- Interim and final presentation and discussion of concepts and design solutions

**About didactics and work load distribution:**
150 hours of individual study and project work. The course includes several optional lecture sessions, at least three individual team progress review meetings with the lecturer and two plenum presentation sessions.

**Requirements for participation:**
Successful completion of year 1 of an undergraduate degree programme in aeronautical or mechanical engineering.

**Course language:**
English

**Type of exam:**
Completion and presentation of the project as a team, submission of a team portfolio with specific documents (e.g. drawings, calculations) produced by individual students.

**Requirements for credit point allocation:**
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**Literature:**
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**Notes:**
This course is usually organized in cooperation with design engineers from the local aeronautical industry who offer additional technical support. The practical aspect of the course is supported by excursions to an aircraft manufacturer and to the Aircraft Interiors Expo.
Course Name: Machine Cutting Technology

Degree programme: Mechanical Engineering (Bachelor)

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

Type of exam:
Written or oral exam

Course language:
English

Requirements for credit point allocation:
Successful completion of exam

Literature:
- 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 ranges 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