TUHH
Hamburg
University of
Technology

Module Manual

Master of Science (M.Sc.)

Energy Systems
Dual study program

Cohort: Winter Term 2023

Updated: 20th April 2023

Table of Contents

Program description

Content

The research-oriented master’s study program in Energy Systems follows on from the bachelor’s in Mechanical Engineering, specializing in Energy Systems resp. the bachelor's in General Engineering Science, specializing in Mechanical Engineering and Energy Systems. The program deals in greater depth with the math, scientific and engineering contents of the bachelor’s degree course and teaches further methods to solve complex energy systems problems systematically and scientifically.

As a part of this master’s program students must opt to specialize in either energy systems or marine engineering. A ship’s engine room is a complex floating energy plant. The TUHH is the only German university to offer a study program in energy systems that includes marine engineering.

The content of the study program consists of basic and method-oriented knowledge about the physical description of classical energy systems, regenerative energy systems, and marine engineering.

In addition to the foundational curriculum taught at TUHH, seminars on developing personal skills are integrated into the dual study programme, in the context of transfer between theory and practice. These seminars correspond to the modern professional requirements expected of an engineer, as well as promoting the link between the two places of learning.

The intensive dual courses at TUHH integrating practical experience consist of an academic-oriented and a practice-oriented element, which are completed at two places of learning. The academic-oriented element comprises study at TUHH. The practice-oriented element is coordinated with the study programme in terms of content and time, and consists of practical modules and phases spent in an affiliate company during periods when there are no lectures.

Career prospects

The study program covers a wide range of math and physics basics and prepares students for senior roles in industry and science in selected energy systems and/or marine engineering modules.

The program’s wide-ranging scope facilitates challenging scientific work in very different areas of energy systems and marine engineering and also in general mechanical engineering, automotive and aviation engineering.

In addition, students acquire basic professional and personal skills as part of the dual study programme that enable them to enter professional practice at an early stage and to go on to further study. Students also gain practical work experience through the integrated practical modules. Graduates of the dual course have broad foundational knowledge, fundamental skills for academic work and relevant personal competences.

Learning target

The aim of the master’s program in Energy Systems is to familiarize students with the different energy conversion, distribution, and application technologies. It must be borne in mind that Energy Systems is a cross-sectional subject that touches upon practically all areas of technology. Leading to a M.Sc., the program is therefore designed to teach the skills required to recognize relationships in complex systems.

Graduates of the master’s program in Energy Systems are able to apply the specialized knowledge that they have acquired to complex energy systems problems. They can work their way independently into new issues. They can analyze, abstract, and model processes using scientific methods and can also document them. They can assess data and results and develop from them strategies for devising innovative solutions. They are capable of discussing problems as members of a team and, if need be, of optimizing them.

By continually switching places of learnings throughout the dual study programme, it is possible for theory and practice to be interlinked. Students reflect theoretically on their individual professional practical experience, and apply the results of their reflection to new forms of practice. They also test theoretical elements of the course in a practical setting, and use their findings as a stimulus for theoretical debate.

Program structure

The structure of the master’s program in Energy Systems consists of the core qualification, a specialization (Energy Systems or Marine Engineering), and the thesis.

As a part of the core qualification students must study, along with the compulsory modules Operation and Management and Non-technical Supplementary Modules, the two modules Energy Systems Lab and Energy Systems Project Work. In addition, they can choose three from a range of 14 modules that are on offer.

Within the specialization "Energy Systems", 2 compulsory modules ("Thermal Energy Systems" and "Design and Assessment of Renewable Energy Systems") and 5 compulsory elective modules (out of 16 offered) have to be taken. The elective catalog also includes two Open Modules "Selected Topics in Energy Systems, Option A (or Option B)", from which courses with 6 LP (or 12 LP) can be selected from a range of 27 LP.

Within the specialization "Marine Engineering", students have to take 2 compulsory modules ("Energy Technology on Ships", "Marine Engine Systems") and 5 compulsory elective modules (out of 11 offered). The elective catalog also includes two Open Modules "Selected Topics in Marine Mechanical Engineering, Option A (or Option B)", from which courses with 6 LP (or 12 LP) can be taken from a range of 26 LP.

In their master’s thesis students work independently on research-oriented problems, structuring the task into different sub-aspects and apply systematically the specialized competences they have acquired in the course of the study program.

The contents of the compulsory modules that form a part of the core qualification and those of the modules that form a part of the specializations are, together with the tasks set for the master’s thesis, closely connected to the research areas at the university departments with an energy systems orientation.

The structural model of the dual study programme follows a module-differentiating approach. Given the practice-oriented element, the curriculum of the dual study programme is different compared to a standard Bachelor’s course. Five practical modules are completed at the dual students’ partner company as part of corresponding practical terms during lecture-free periods.

Core Qualification

In-depth physics, math, and engineering contents of energy systems and marine engineering are taught in the core qualification area. In addition, research- and application-oriented experiments are undertaken in the Energy Systems Lab compulsory module and research-oriented problems are dealt with in the Energy Systems Project Work module.

Students are able to model and to analyze energy systems in terms of physics and mathematics. Furthermore, in the Energy Systems Lab module they are taught competences relating to the critical analysis and evaluation of measurement data and experimental results. In the Project Work module they are encouraged to work independently on problems, on the structuring of solution approaches, and on their written documentation. The Energy Systems Lab works in small groups and the Project Work can be undertaken as group work, thereby strengthening teamwork skills.

Module M0508: Fluid Mechanics and Ocean Energy

Courses

Title	Typ	Hrs/wk	CP
Energy from the Ocean (L0002)	Lecture	2	2
Fluid Mechanics II (L0001)	Lecture	2	4

Module Responsible	Prof. Michael Schlüter
Admission Requirements	None
Recommended Previous Knowledge	Technische Thermodynamik I-II Wärme- und Stoffübertragung
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe different applications of fluid mechanics for the field of Renewable Energies. They are able to use the fundamentals of fluid mechanics for calculations of certain engineering problems in the field of ocean energy. The students are able to estimate if a problem can be solved with an analytical solution and what kind of alternative possibilities are available (e.g. self-similarity, empirical solutions, numerical methods).
Skills	Students are able to use the governing equations of Fluid Dynamics for the design of technical processes. Especially they are able to formulate momentum and mass balances to optimize the hydrodynamics of technical processes. They are able to transform a verbal formulated message into an abstract formal procedure.
Personal Competence	
Social Competence	The students are able to discuss a given problem in small groups and to develop an approach. They are able to solve a problem within a team, to prepare a poster with the results and to present the poster.
Autonomy	Students are able to define independently tasks for problems related to fluid mechanics. They are able to work out the knowledge that is necessary to solve the problem by themselves on the basis of the existing knowledge from the lecture.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	Compulsory: No; Bonus: 10 %; Form: Group discussion; Description:
Examination	Written exam
Examination duration and scale	3h
Assignment for the Following Curricula	Energy Systems: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory

Course L0002: Energy from the Ocean	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE
Cycle	WiSe

Content	1. Introduction to ocean energy conversion
	2. Wave properties
	  ◦ Linear wave theory
	  ◦ Nonlinear wave theory
	  ◦ Irregular waves
	  ◦ Wave energy
	  ◦ Refraction, reflection and diffraction of waves
	3. Wave energy converters
	  ◦ Overview of the different technologies
	  ◦ Methods for design and calculation
	4. Ocean current turbine

Literature	• Cruz, J., Ocean wave energy, Springer Series in Green Energy and Technology, UK, 2008. • Brooke, J., Wave energy conversion, Elsevier, 2003. • McCormick, M.E., Ocean wave energy conversion, Courier Dover Publications, USA, 2013. • Falnes, J., Ocean waves and oscillating systems, Cambridge University Press,UK, 2002. • Charlier, R. H., Charles, W. F., Ocean energy. Tide and tidal Power. Berlin, Heidelberg, 2009. • Clauss, G. F., Lehmann, E., Östergaard, C., Offshore Structures. Volume 1, Conceptual Design. Springer-Verlag, Berlin 1992

Course L0001: Fluid Mechanics II	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	• Differential equations for momentum-, heat and mass transfer • Examples for simplifications of the Navier-Stokes Equations • Unsteady momentum transfer • Free shear layer, turbulence and free jets • Flow around particles - Solids Process Engineering • Coupling of momentum and heat transfer - Thermal Process Engineering • Rheology – Bioprocess Engineering • Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering • Flow threw porous structures - heterogeneous catalysis • Pumps and turbines - Energy- and Environmental Process Engineering • Wind- and Wave-Turbines - Renewable Energy • Introduction into Computational Fluid Dynamics
Literature	1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971. 2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972. 3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009. 4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. 5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994. 6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006. 7. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008. 8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007 9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009. 10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007. 11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008. 12. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006. 13. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.

Module M0523: Business & Management	
Module Responsible	Prof. Matthias Meyer
Admission Requirements	None
Recommended Previous Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge*	• Students are able to find their way around selected special areas of management within the scope of business management. • Students are able to explain basic theories, categories, and models in selected special areas of business management. • Students are able to interrelate technical and management knowledge.
Skills	• Students are able to apply basic methods in selected areas of business management. • Students are able to explain and give reasons for decision proposals on practical issues in areas of business management.
Personal Competence *Social Competence*	• Students are able to communicate in small interdisciplinary groups and to jointly develop solutions for complex problems
Autonomy	• Students are capable of acquiring necessary knowledge independently by means of research and preparation of material.
Workload in Hours	Depends on choice of courses
Credit points	6

Courses
Information regarding lectures and courses can be found in the corresponding module handbook published separately.

Module M1909: System Simulation

Courses

Title	Typ	Hrs/wk	CP
System Simulation Modul (L3150)	Lecture	2	3
System Simulation Modul (L3151)	Recitation Section (large)	2	3

Module Responsible	Prof. Arne Speerforck
Admission Requirements	None
Recommended Previous Knowledge	Mathematics I-III, Computer Sciense, Engineering Thermodynamics I, II, Fluid Dynamics, Heat Transfer, Control Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Energy Systems: Core Qualification: Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Aeronautics: Core Qualification: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Renewable Energies: Specialisation Solar Energy Systems: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory

Course L3150: System Simulation Modul	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Arne Speerforck, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica 1.17.0. • Instruction and modelling of physical processes • Modelling and limits of model • Time constant, stiffness, stability, step size • Terms of object orientated programming • Differential equations of simple systems • Introduction into Modelica • Introduction into simulation tool • Example:Hydraulic systems and heat transfer • Example: System with different subsystems
Literature	[1] Modelica Association: "Modelica Language Specification - Version 3.5", Linköping, Sweden, 2021. [2] OpenModelica: OpenModelica 1.17.0, https://www.openmodelica.org (siehe Download), 2021. [3] M. Tiller: “Modelica by Example", https://book.xogeny.com, 2014. [4] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000. [5] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015. [6] P. Fritzson: “Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica”, Wiley, New York, 2011.

Course L3151: System Simulation Modul	
Typ	Recitation Section (large)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Arne Speerforck, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0808: Finite Elements Methods

Courses

Title	Typ	Hrs/wk	CP
Finite Element Methods (L0291)	Lecture	2	3
Finite Element Methods (L0804)	Recitation Section (large)	2	3

Module Responsible	Prof. Benedikt Kriegesmann
Admission Requirements	None
Recommended Previous Knowledge	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students possess an in-depth knowledge regarding the derivation of the finite element method and are able to give an overview of the theoretical and methodical basis of the method.
Skills	The students are capable to handle engineering problems by formulating suitable finite elements, assembling the corresponding system matrices, and solving the resulting system of equations.
Personal Competence	
Social Competence	Students can work in small groups on specific problems to arrive at joint solutions.
Autonomy	The students are able to independently solve challenging computational problems and develop own finite element routines. Problems can be identified and the results are critically scrutinized.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	Compulsory: No; Bonus: 20 %; Form: Midterm; Description:
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Aeronautics: Core Qualification: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory

Course L0291: Finite Element Methods	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Benedikt Kriegesmann
Language	EN
Cycle	WiSe
Content	- General overview on modern engineering - Displacement method - Hybrid formulation - Isoparametric elements - Numerical integration - Solving systems of equations (statics, dynamics) - Eigenvalue problems - Non-linear systems - Applications - Programming of elements (Matlab, hands-on sessions) - Applications
Literature	Bathe, K.-J. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin

Course L0804: Finite Element Methods	
Typ	Recitation Section (large)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Benedikt Kriegesmann
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0846: Control Systems Theory and Design

Courses

Title	Typ	Hrs/wk	CP
Control Systems Theory and Design (L0656)	Lecture	2	4
Control Systems Theory and Design (L0657)	Recitation Section (small)	2	2

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	Introduction to Control Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can explain how linear dynamic systems are represented as state space models; they can interpret the system response to initial states or external excitation as trajectories in state space • They can explain the system properties controllability and observability, and their relationship to state feedback and state estimation, respectively • They can explain the significance of a minimal realisation • They can explain observer-based state feedback and how it can be used to achieve tracking and disturbance rejection • They can extend all of the above to multi-input multi-output systems • They can explain the z-transform and its relationship with the Laplace Transform • They can explain state space models and transfer function models of discrete-time systems • They can explain the experimental identification of ARX models of dynamic systems, and how the identification problem can be solved by solving a normal equation • They can explain how a state space model can be constructed from a discrete-time impulse response
Skills	• Students can transform transfer function models into state space models and vice versa • They can assess controllability and observability and construct minimal realisations • They can design LQG controllers for multivariable plants • They can carry out a controller design both in continuous-time and discrete-time domain, and decide which is appropriate for a given sampling rate • They can identify transfer function models and state space models of dynamic systems from experimental data • They can carry out all these tasks using standard software tools (Matlab Control Toolbox, System Identification Toolbox, Simulink)
Personal Competence	
Social Competence	Students can work in small groups on specific problems to arrive at joint solutions.
Autonomy	Students can obtain information from provided sources (lecture notes, software documentation, experiment guides) and use it when solving given problems. They can assess their knowledge in weekly on-line tests and thereby control their learning progress.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Aeronautics: Core Qualification: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory

Course L0656: Control Systems Theory and Design	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	NN
Language	EN
Cycle	WiSe
Content	State space methods (single-input single-output) • State space models and transfer functions, state feedback • Coordinate basis, similarity transformations • Solutions of state equations, matrix exponentials, Caley-Hamilton Theorem • Controllability and pole placement • State estimation, observability, Kalman decomposition • Observer-based state feedback control, reference tracking • Transmission zeros • Optimal pole placement, symmetric root locus Multi-input multi-output systems • Transfer function matrices, state space models of multivariable systems, Gilbert realization • Poles and zeros of multivariable systems, minimal realization • Closed-loop stability • Pole placement for multivariable systems, LQR design, Kalman filter Digital Control • Discrete-time systems: difference equations and z-transform • Discrete-time state space models, sampled data systems, poles and zeros • Frequency response of sampled data systems, choice of sampling rate System identification and model order reduction • Least squares estimation, ARX models, persistent excitation • Identification of state space models, subspace identification • Balanced realization and model order reduction Case study • Modelling and multivariable control of a process evaporator using Matlab and Simulink Software tools • Matlab/Simulink
Literature	• Werner, H., Lecture Notes „Control Systems Theory and Design“ • T. Kailath "Linear Systems", Prentice Hall, 1980 • K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997 • L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999

Course L0657: Control Systems Theory and Design	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	NN
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1503: Technical Complementary Course Core Studies for ENTMS (according to Subject Specific Regulations)	
Courses	
Title	**Typ** **Hrs/wk** **CP**
Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	See selected module according to FSPO
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	See selected module according to FSPO
Skills	See selected module according to FSPO
Personal Competence	
Social Competence	See selected module according to FSPO
Autonomy	See selected module according to FSPO
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Energy Systems: Core Qualification: Elective Compulsory

Module M1759: Linking theory and practice (dual study program, Master's degree)	
Module Responsible	Dr. Henning Haschke
Admission Requirements	None
Recommended Previous Knowledge	• Successful completion of practical modules as part of the dual Bachelor’s course • Module "interlinking theory and practice as part of the dual Master’s course"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Dual students ... ... can describe and classify selected classic and current theories, concepts and methods • related to project management and • change and transformation management ... and apply them to specific situations, processes and plans in a personal, professional context.
Skills	Dual students ... • ... anticipate typical difficulties, positive and negative effects, as well as success and failure factors in the engineering sector, evaluate them and consider promising strategies and courses of action. • ... develop specialised technical and conceptual skills to solve complex tasks and problems in their professional field of activity/work.
Personal Competence	
Social Competence	Dual students ... • ... can responsibly lead interdisciplinary teams within the framework of complex tasks and problems. • ... engage in sector-specific and cross-sectoral discussions with experts, stakeholders and staff, representing their approaches, points of view and work results.
Autonomy	Dual students ... • ... define, reflect and evaluate goals and measures for complex application-oriented projects and change processes. • ... shape their professional area of responsibility independently and sustainably. • ... take responsibility for their actions and for the results of their work.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Studienbegleitende und semesterübergreifende Dokumentation: Die Leistungspunkte für das Modul werden durch die Anfertigung eines digitalen Lern- und Entwicklungsberichtes (E-Portfolio) erworben. Dabei handelt es sich um eine fortlaufende Dokumentation und Reflexion der Lernerfahrungen und der Kompetenzentwicklung im Bereich der Personalen Kompetenz.

Course L2890: Responsible Project Management in Engineering (for Dual Study Program)	
Typ	Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Henning Haschke, Heiko Sieben
Language	DE
Cycle	WiSe/SoSe
Content	• Theories and methods of project management • Innovation management • Agile project management • Fundamentals of classic and agile methods • Hybrid use of classic and agile methods • Roles, perspectives and stakeholders throughout the project • Initiating and coordinating complex engineering projects • Principles of moderation, team management, team leadership, conflict management • Communication structures: in-house, cross-company • Public information policy • Promoting commitment and empowerment • Sharing experience with specialists and managers from the engineering sector • Documenting and reflecting on learning experiences
Literature	Seminarapparat

Course L2891: Responsible Change and Transformation Management in Engineering (for Dual Study Program)	
Typ	Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Henning Haschke, Heiko Sieben
Language	DE
Cycle	WiSe/SoSe
Content	• Basic concepts, opportunities and limits of organisational change • Models and methods of organisational design and development • Strategic orientation and change, and their short-, medium- and long-term consequences for individuals, organisations and society as a whole • Roles, perspectives and stakeholders in change processes • Initiating and coordinating change measures in engineering • Phase models of organisational change (Lewin, Kotter, etc.) • Change-oriented information policy and dealing with resistance and uncertainty • Promoting commitment and empowerment • Successfully handling change and transformation: personally, as an employee, as a manager (personal, professional, organisational) • Company-level and globally (systemic) • Sharing experience with specialists and managers from the engineering sector • Documenting and reflecting on learning experiences
Literature	Seminarapparat

Module M1504: Technical Complementary Course for ENTMS, Option B (according to Subject Specific Regulations)

Courses

Title	Typ	Hrs/wk	CP

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	See selected module according to FSPO
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	See selected module according to FSPO
Skills	See selected module according to FSPO
Personal Competence	
Social Competence	See selected module according to FSPO
Autonomy	See selected module according to FSPO
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Energy Systems: Core Qualification: Elective Compulsory

Module M0751: Vibration Theory

Courses

Title	Typ	Hrs/wk	CP
Vibration Theory (L0701)	Integrated Lecture	4	6

Module Responsible	Prof. Norbert Hoffmann
Admission Requirements	None
Recommended Previous Knowledge	• Calculus • Linear Algebra • Engineering Mechanics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to denote terms and concepts of Vibration Theory and develop them further. • Students know methods of modeling and simulation for free, driven, self-excited and parameter driven vibrations. • Students know about concepts of linear and nonlinear vibration problems. • Students know basic tasks of vibration problems of discrete and continuous systems.
Skills	• Students are able to denote methods of Vibration Theory and develop them further. • Students are able to apply and expand methods of modeling and simulation for free, forced, self-excited and parameter driven vibrations. • Students are able to solve linear and nonlinear vibration problems.
Personal Competence	
Social Competence	• Students can analyze vibration problems, work on them, and reach working results also in teams or groups. • Students are able to document the results of vibration studies also in groups.
Autonomy	• Students are able to individually analyze and solve vibration problems. • Students are able to approach individually research tasks in Vibration Theory.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	2 Hours
Assignment for the Following Curricula	Energy Systems: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory

Course L0701: Vibration Theory	
Typ	Integrated Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Norbert Hoffmann
Language	DE/EN
Cycle	WiSe
Content	Linear and Nonlinear Single and Multiple Degree of Freedom Vibrations • Free vibration • Self-excited vibration • Parameter driven vibration • Forced vibration • Multi degree of freedom vibration • Continuum vibration • Irregular vibration
Literature	German - K. Magnus, K. Popp, W. Sextro: Schwingungen. Physikalische Grundlagen und mathematische Behandlung von Schwingungen. English - K. Magnus: Vibrations.

Module M1756: Practical module 1 (dual study program, Master's degree)

Courses

Title	Typ	Hrs/wk	CP
Practical term 1 (dual study program, Master's degree) (L2887)		0	10

Module Responsible	Dr. Henning Haschke
Admission Requirements	None
Recommended Previous Knowledge	• Successful completion of a compatible dual B.Sc. at TU Hamburg or comparable practical work experience and competences in the area of interlinking theory and practice • Course D from the module on interlinking theory and practice as part of the dual Master's course
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Dual students ... • ... combine their knowledge of facts, principles, theories and methods gained from previous study content with acquired practical knowledge - in particular their knowledge of practical professional procedures and approaches, in the current field of activity in engineering. • ... have a critical understanding of the practical applications of their engineering subject.
Skills	Dual students ... • ... apply technical theoretical knowledge to complex, interdisciplinary problems within the company, and evaluate the associated work processes and results, taking into account different possible courses of action. • ... implement the university's application recommendations with regard to their current tasks. • ... develop solutions as well as procedures and approaches in their field of activity and area of responsibility.
Personal Competence	
Social Competence	Dual students ... • ... work responsibly in project teams within their working area and proactively deal with problems within their team. • ... represent complex engineering viewpoints, facts, problems and solution approaches in discussions with internal and external stakeholders.
Autonomy	Dual students ... • ... define goals for their own learning and working processes as engineers. • ... reflect on learning and work processes in their area of responsibility. • ... reflect on the relevance of subject modules specialisations and specialisation for work as an engineer, and also implement the university's application recommendations and the associated challenges to positively transfer knowledge between theory and practice.
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Credit points	10
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the dual@TUHH Coordination Office that the dual student has completed the practical phase.
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Computer Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Compulsory Environmental Engineering: Core Qualification: Compulsory Aircraft Systems Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Information and Communication Systems: Core Qualification: Compulsory International Management and Engineering: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Core Qualification: Compulsory Aeronautics: Core Qualification: Compulsory Materials Science and Engineering: Core Qualification: Compulsory Materials Science: Core Qualification: Compulsory Mechanical Engineering and Management: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Core Qualification: Compulsory Microelectronics and Microsystems: Core Qualification: Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Renewable Energies: Core Qualification: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Compulsory

	Theoretical Mechanical Engineering: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Water and Environmental Engineering: Core Qualification: Compulsory

Course L2887: Practical term 1 (dual study program, Master's degree)	
Typ	
Hrs/wk	0
CP	10
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Lecturer	Dr. Henning Haschke
Language	DE
Cycle	WiSe/SoSe
Content	**Company onboarding process** • Assigning a professional field of activity as an engineer (B.Sc.) and associated fields of work • Establishing responsibilities and authorisation of the dual student within the company as an engineer (B.Sc.) • Working independently in a team and on selected projects - across departments and, if applicable, across companies • Scheduling the current practical module with a clear correlation to work structures • Scheduling the examination phase/subsequent study semester **Operational knowledge and skills** • Company-specific: Responsibility as an engineer (B.Sc.) in their own area of work, coordinating team and project work, dealing with complex contexts and unsolved problems, developing and implementing innovative solutions • Subject specialisation (corresponding to the chosen course [M.Sc.]) in the field of activity • Systemic skills • Implementing the university’s application recommendations (theory-practice transfer) in corresponding work and task areas across the company **Sharing/reflecting on learning** • Creating an e-portfolio • Importance of course contents (M.Sc.) when working as an engineer • Importance of development and innovation when working as an engineer
Literature	• Studierendenhandbuch • Betriebliche Dokumente • Hochschulseitige Handlungsempfehlungen zum Theorie-Praxis-Transfer

Module M0657: Computational Fluid Dynamics II

Courses

Title	Typ	Hrs/wk	CP
Computational Fluid Dynamics II (L0237)	Lecture	2	3
Computational Fluid Dynamics II (L0421)	Recitation Section (large)	2	3

Module Responsible	Prof. Thomas Rung
Admission Requirements	None
Recommended Previous Knowledge	Students should have sound knowledge of engineering mathematics (series expansions, internal & vector calculus), and be familiar with the foundations of partial/ordinary differential equations. They should also be familiar with engineering fluid mechanics and thermodynamics. Basic knowledge of numerical analysis or computational fluid dynamics is of advantage but not necessary.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will acquire a deeper knowledge of computational fluid dynamics (CFD) and can translate general principles of thermo-/fluid engineering into discrete algorithms on the basis of finite volume methods. They are familiar with the similarities and differences between different discretisation and approximation concepts for investigating coupled systems of non-linear, convective partial differential equations (PDE) on structured and unstructured grids. Students have the required background knowledge to develop, code and apply modelling concepts to numerically describe turbulent and multiphase flow. They establish a thorough understanding of details of the theoretical background of complex CFD algorithms and the parameters used to control and adjust the execution of CFD procedures.
Skills	The students are able choose and apply appropriate finite volume (FV) approximation concepts and flow physics models that integrate the governing thermofluid dynamic PDEs in space and time. They can apply/optimise FV concepts to/for fluid dynamic applications. They acquire the ability to code computational algorithms dedicated to unstructured grid arrangements, apply these codes for parameter investigations and supplement interfaces to extract simulation data for an engineering analysis. They are able to judge different solution strategies.
Personal Competence	
Social Competence	The students are able to discuss problems, present the results of their own analysis, and jointly develop, implement and report on solution strategies that address given technical reference problems in a team.
Autonomy	The students can independently analyse numerical methods to solving fluid engineering problems. They are able to critically analyse own results as well as external data with regards to the plausibility and reliability.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	0.5h-0.75h
Assignment for the Following Curricula	Energy Systems: Core Qualification: Elective Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0237: Computational Fluid Dynamics II

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Thomas Rung
Language	DE/EN
Cycle	SoSe
Content	Computational Modelling of complex single- and multiphase flows using higher-order approximations for unstructured grids and mehsless particle-based methods.
Literature	1) Vorlesungsmanuskript und Übungsunterlagen 2) J.H. Ferziger, M. Peric: Computational Methods for Fluid Dynamics, Springer

Course L0421: Computational Fluid Dynamics II	
Typ	Recitation Section (large)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Thomas Rung
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0840: Optimal and Robust Control

Courses

Title	Typ	Hrs/wk	CP
Optimal and Robust Control (L0658)	Lecture	2	3
Optimal and Robust Control (L0659)	Recitation Section (small)	2	3

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	• Classical control (frequency response, root locus) • State space methods • Linear algebra, singular value decomposition
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can explain the significance of the matrix Riccati equation for the solution of LQ problems. • They can explain the duality between optimal state feedback and optimal state estimation. • They can explain how the H2 and H-infinity norms are used to represent stability and performance constraints. • They can explain how an LQG design problem can be formulated as special case of an H2 design problem. • They can explain how model uncertainty can be represented in a way that lends itself to robust controller design • They can explain how - based on the small gain theorem - a robust controller can guarantee stability and performance for an uncertain plant. • They understand how analysis and synthesis conditions on feedback loops can be represented as linear matrix inequalities.
Skills	• Students are capable of designing and tuning LQG controllers for multivariable plant models. • They are capable of representing a H2 or H-infinity design problem in the form of a generalized plant, and of using standard software tools for solving it. • They are capable of translating time and frequency domain specifications for control loops into constraints on closed-loop sensitivity functions, and of carrying out a mixed-sensitivity design. • They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective robust controller. • They are capable of formulating analysis and synthesis conditions as linear matrix inequalities (LMI), and of using standard LMI-solvers for solving them. • They can carry out all of the above using standard software tools (Matlab robust control toolbox).
Personal Competence	
Social Competence	Students can work in small groups on specific problems to arrive at joint solutions.
Autonomy	Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Aeronautics: Core Qualification: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory

Course L0658: Optimal and Robust Control	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
Language	EN
Cycle	SoSe
Content	• Optimal regulator problem with finite time horizon, Riccati differential equation • Time-varying and steady state solutions, algebraic Riccati equation, Hamiltonian system • Kalman’s identity, phase margin of LQR controllers, spectral factorization • Optimal state estimation, Kalman filter, LQG control • Generalized plant, review of LQG control • Signal and system norms, computing H2 and H∞ norms • Singular value plots, input and output directions • Mixed sensitivity design, H∞ loop shaping, choice of weighting filters • Case study: design example flight control • Linear matrix inequalities, design specifications as LMI constraints (H2, H∞ and pole region) • Controller synthesis by solving LMI problems, multi-objective design • Robust control of uncertain systems, small gain theorem, representation of parameter uncertainty
Literature	• Werner, H., Lecture Notes: "Optimale und Robuste Regelung" • Boyd, S., L. El Ghaoui, E. Feron and V. Balakrishnan "Linear Matrix Inequalities in Systems and Control", SIAM, Philadelphia, PA, 1994 • Skogestad, S. and I. Postlewhaite "Multivariable Feedback Control", John Wiley, Chichester, England, 1996 • Strang, G. "Linear Algebra and its Applications", Harcourt Brace Jovanovic, Orlando, FA, 1988 • Zhou, K. and J. Doyle "Essentials of Robust Control", Prentice Hall International, Upper Saddle River, NJ, 1998

Course L0659: Optimal and Robust Control	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1201: Practical Course Energy Systems

Courses

Title	Typ	Hrs/wk	CP
Practical Course Energy Systems (L1629)	Practical Course	6	6

Module Responsible	Prof. Arne Speerforck
Admission Requirements	None
Recommended Previous Knowledge	Heat Transfer, Gas and Steam Power Plants, Reciprocating Machinery
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The participating students can • explain complex energy systems, • describe the function of modern measurement devices for energy systems, • give critical comments to the whole measurement chain (sensor, installation situation, converting, display).
Skills	Students are able to • set sensors in relevant positions, • plan experiments and identify the relevant paramters, • generate test charts, • write a test report including sources of errors and literature comparison.
Personal Competence	
Social Competence	Students can • design experimental setups and perform experiments in small teams, • develop solutions in teams and represent solutions to other students, • work together in teams and evaluate the own part, • can coordinate the tasks of other teams, • write test reports and guide the discussions to the experiments.
Autonomy	Students are able to • familiarize with the measurment documents, • apply measurement methods, • plan the test procedure and operate the experiments autonomous, • give short presentations to selected topis, • estimate own asset and weakness.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	90 minutes
Assignment for the Following Curricula	Energy Systems: Core Qualification: Compulsory

Course L1629: Practical Course Energy Systems	
Typ	Practical Course
Hrs/wk	6
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Arne Speerforck, Dr. Kristin Abel-Günther
Language	DE
Cycle	SoSe
Content	In the Practical Course on Energy Systems experiments will be planned and carried out at selected test facilities. Measurement methods should be applied and the results should be conclused in a test report and critically analysed. Following experiments are offered: • Operational characteristics of a diesel engine • Combined heat, power and chill production in the district heating plant of the TUHH • Acceptance test of a steam turbine plant • Heat transfer on radial impinging jets • Measurement in an sorption based air conditioning plant • Energy balance of a condensation boiler
Literature	Versuchsmanuskripte werden zu den einzelnen Versuchen zur Verfügung gestellt. Pfeifer, T.; Profos, P.: Handbuch der industriellen Messtechnik, 6. Auflage, 1994, Oldenbourg Verlag München

Module M1757: Practical module 2 (dual study program, Master's degree)

Courses

Title	Typ	Hrs/wk	CP
Practical term 2 (dual study program, Master's degree) (L2888)		0	10

Module Responsible	Dr. Henning Haschke
Admission Requirements	None
Recommended Previous Knowledge	• Successful completion of practical module 1 as part of the dual Master's course • course D from the module on interlinking theory and practice as part of the dual Master's course
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Dual students ... • ... combine their knowledge of facts, principles, theories and methods gained from previous study content with acquired practical knowledge - in particular their knowledge of practical professional procedures and approaches, in the current field of activity in engineering. • ... have a critical understanding of the practical applications of their engineering subject.
Skills	Dual students ... • ... apply technical theoretical knowledge to complex, interdisciplinary problems within the company, and evaluate the associated work processes and results, taking into account different possible courses of action. • ... implement the university's application recommendations with regard to their current tasks. • ... develop (new) solutions as well as procedures and approaches in their field of activity and area of responsibility - including in the case of frequently changing requirements (systemic skills).
Personal Competence	
Social Competence	Dual students ... • ... work responsibly in cross-departmental and interdisciplinary project teams and proactively deal with problems within their team. • ... represent complex engineering viewpoints, facts, problems and solution approaches in discussions with internal and external stakeholders and develop these further together.
Autonomy	Dual students ... • ... define goals for their own learning and working processes as engineers. • ... reflect on learning and work processes in their area of responsibility. • ... reflect on the relevance of subject modules specialisations and specialisation for work as an engineer, and also implement the university's application recommendations and the associated challenges to positively transfer knowledge between theory and practice.
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Credit points	10
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the dual@TUHH Coordination Office that the dual student has completed the practical phase.
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Computer Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Compulsory Environmental Engineering: Core Qualification: Compulsory Aircraft Systems Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Information and Communication Systems: Core Qualification: Compulsory International Management and Engineering: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Core Qualification: Compulsory Aeronautics: Core Qualification: Compulsory Materials Science and Engineering: Core Qualification: Compulsory Materials Science: Core Qualification: Compulsory Mechanical Engineering and Management: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Core Qualification: Compulsory Microelectronics and Microsystems: Core Qualification: Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Renewable Energies: Core Qualification: Compulsory

	Naval Architecture and Ocean Engineering: Core Qualification: Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Water and Environmental Engineering: Core Qualification: Compulsory

Course L2888: Practical term 2 (dual study program, Master's degree)	
Typ	
Hrs/wk	0
CP	10
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Lecturer	Dr. Henning Haschke
Language	DE
Cycle	WiSe/SoSe
Content	**Company onboarding process** • Assigning a professional field of activity as an engineer (B.Sc.) and associated fields of work • Establishing responsibilities and authorisation of the dual student within the company as an engineer (B.Sc.) • Taking personal responsibility within a team and on selected projects - across departments and, if applicable, across companies • Scheduling the current practical module with a clear correlation to work structures • Scheduling the examination phase/subsequent study semester **Operational knowledge and skills** • Company-specific: Responsibility as an engineer (B.Sc.) in their own area of work, coordinating team and project work, dealing with complex contexts and unsolved problems, developing and implementing innovative solutions • Subject specialisation (corresponding to the chosen course [M.Sc.]) in the field of activity • Systemic skills • Implementing the university’s application recommendations (theory-practice transfer) in corresponding work and task areas across the company **Sharing/reflecting on learning** • Updating their e-portfolio • Importance of course contents (M.Sc.) when working as an engineer • Importance of development and innovation when working as an engineer
Literature	• Studierendenhandbuch • Betriebliche Dokumente • Hochschulseitige Anwendungsempfehlungen zum Theorie-Praxis-Transfer

Module M0714: Numerical Methods for Ordinary Differential Equations

Courses

Title	Typ	Hrs/wk	CP
Numerical Treatment of Ordinary Differential Equations (L0576)	Lecture	2	3
Numerical Treatment of Ordinary Differential Equations (L0582)	Recitation Section (small)	2	3

Module Responsible	Prof. Daniel Ruprecht
Admission Requirements	None
Recommended Previous Knowledge	• Mathematik I, II, III for Engineers (German or English) or Analysis & Linear Algebra I + II plus Analysis III for Technomathematiker. • Basic knowledge of MATLAB, Python or a similar programming language.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to • name numerical methods for the solution of ordinary differential equations and explain their core ideas, • formulate convergence statements for the taught numerical methods (including the necessary assumptions about the solved problem), • explain aspects regarding the practical realisation of a method, • select the appropriate numerical method for specific problems, implement the numerical algorithms efficiently and interpret the numerical results.
Skills	Students are able to • implement, apply and compare numerical methods for the solution of ordinary differential equations, • explain the convergence behaviour of numerical methods, taking into consideration the solved problem and selected algorithm, • develop a suitable solution approach for a given problem, if necessary by combining multiple algorithms, realise this approach and critically evaluate results.
Personal Competence	
Social Competence	Students are able to • work together in heterogeneous teams (i.e., teams from different study programs and with different background knowledge), explain theoretical foundations and support each other with practical aspects regarding the implementation of algorithms.
Autonomy	Students are capable • to assess whether the provided theoretical and practical excercises are better solved individually or in a team and • to assess their individual progress and, if necessary, to ask questions and seek help.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Computer Science: Specialisation III. Mathematics: Elective Compulsory Data Science: Specialisation I. Mathematics: Elective Compulsory Data Science: Specialisation IV. Special Focus Area: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Interdisciplinary Mathematics: Specialisation II. Numerical - Modelling Training: Compulsory Aeronautics: Core Qualification: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0576: Numerical Treatment of Ordinary Differential Equations	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Daniel Ruprecht
Language	DE/EN
Cycle	SoSe
Content	Numerical methods for Initial Value Problems • single step methods • multistep methods • stiff problems • differential algebraic equations (DAE) of index 1 Numerical methods for Boundary Value Problems • multiple shooting method • difference methods
Literature	• E. Hairer, S. Noersett, G. Wanner: Solving Ordinary Differential Equations I: Nonstiff Problems. • E. Hairer, G. Wanner: Solving Ordinary Differential Equations II: Stiff and Differential-Algebraic Problems. • D. Griffiths, D. Higham: Numerical Methods for Ordinary Differential Equations.

Course L0582: Numerical Treatment of Ordinary Differential Equations	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Daniel Ruprecht
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1208: Project Work Energy Systems

Courses

Title	Typ	Hrs/wk	CP

Module Responsible	Prof. Arne Speerforck
Admission Requirements	None
Recommended Previous Knowledge	Basic moduls of mechanical engineering, energy systems and marine technologies
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can • explain the selected research project and correlate it into current topics of energy systems and/or marine systems, • work with scientific methods, • document the research project in a written form, • summarise the research project in a short presentation.
Skills	The students are able to • work on a particular project of a current research project, • structure and motivate the approach to solve the problem, • involve alternative solution concepts, • analyse and reason the results in a critical way.
Personal Competence	
Social Competence	The students can • discuss selected aspects of the work with the technical and scientific staff, • present intermediate and final results adapted to the addressee.
Autonomy	Students are able to • define on the base of their specific knowledge reasonable tasks in an autonomous way, • select appropriate solution methods, • approach to a neccessary additional knowledge for handling the task, • plan and manage experiments and simulations.
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0
Credit points	12
Course achievement	None
Examination	Study work
Examination duration and scale	depending on task
Assignment for the Following Curricula	Energy Systems: Core Qualification: Compulsory

Module M1159: Seminar Energy Systems

Courses

Title	Typ	Hrs/wk	CP
Seminar Energy Systems (L1560)	Seminar	6	6

Module Responsible	Prof. Arne Speerforck
Admission Requirements	None
Recommended Previous Knowledge	Basic moduls of mechanical engineering, energy systems and marine technologies
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can • explain a new topic in the field of energy systems and/or marine systems, • describe complex issues, • present different views and evaluate in a critical way.
Skills	The students can • familiarize in a new topic of energy systems and/or marine systems in limited time, • realise a literature survey on a specific topic and cite in a correct way, • elaborate a presentation and give a lecture to a selected audience, • concluse a presentation in 10-15 lines, • coordinate in a group and represent common theses, • pose and answer a question in the final discussion.
Personal Competence	
Social Competence	The students can • elaborate and introduce a topic for a certain audience, • discuss the topic, content and structure of the presentation with the instructor, • discuss with other students within the group and formulate and represent solution approaches, • discuss certain aspects with the audience, • (as the lecturer) listen and response questions from the audience, • (as the audience) pose questions to the topic.
Autonomy	The students can • define the task in an autonomous way, • develop the necessary knowledge, • use appropriate work equipment, • coordinate with other students, • - guided by an instructor - critically check the working status.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Presentation
Examination duration and scale	45 min
Assignment for the Following Curricula	Energy Systems: Core Qualification: Elective Compulsory

Course L1560: Seminar Energy Systems	
Typ	Seminar
Hrs/wk	6
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Arne Speerforck
Language	DE
Cycle	WiSe
Content	The Seminar Energy Systems is a module in which students in a group (3 to 4 students) work intensively with a current topic in energy systems. In the introductory lecture (-> compulsory course) at the beginning of the term the conditions will be explained, a rhetoric lecture will be presented and the general topics will be awarded. The students should in cooperation with the supervising scientific staff first divide the general topic into individual topics in consultation and then work on them. After a reasonable preparation time, the students of the respective group should present the individual topics in 30-minutes. Afterwards the supervising scientific staff give a task to the general topic, which must be prepared by the group within one week and then also presented. After this presentation a podium discussion follows, in which individual questions are treated.
Literature	Allg. Literatur zu Rhetorik und Präsentationstechniken

Module M1758: Practical module 3 (dual study program, Master's degree)

Courses

Title	Typ	Hrs/wk	CP
Practical term 3 (dual study program, Master's degree) (L2889)		0	10

Module Responsible	Dr. Henning Haschke
Admission Requirements	None
Recommended Previous Knowledge	• Successful completion of practical module 2 as part of the dual Master's course • course E from the module on interlinking theory and practice as part of the dual Master's course
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Dual students ... • ... combine their comprehensive and specialised engineering knowledge acquired from previous study contents with the strategy-oriented practical knowledge gained from their current field of work and area of responsibility. • ... have a critical understanding of the practical applications of their engineering subject, as well as related fields when implementing innovations.
Skills	Dual students ... • ... apply specialised and conceptual skills to solve complex, sometimes interdisciplinary problems within the company, and evaluate the associated work processes and results, taking into account different possible courses of action. • ... implement the university's application recommendations with regard to their current tasks. • ... develop new solutions as well as procedures and approaches to implement operational projects and assignments - even when facing frequently changing requirements and unpredictable changes (systemic skills). • ... can use academic methods to develop new ideas and procedures for operational problems and issues, and to assess these with regard to their usability.
Personal Competence	
Social Competence	Dual students ... • ... work responsibly in cross-departmental and interdisciplinary project teams and proactively deal with problems within their team. • ... can promote the professional development of others in a targeted manner. • ... represent complex and interdisciplinary engineering viewpoints, facts, problems and solution approaches in discussions with internal and external stakeholders and develop these further together.
Autonomy	Dual students ... • ... reflect on learning and work processes in their area of responsibility. • ... define goals for new application-oriented tasks, projects and innovation plans while reflecting on potential effects on the company and the public. • ... reflect on the relevance of areas of specialisation and research for work as an engineer, and also implement the university's application recommendations and the associated challenges to positively transfer knowledge between theory and practice.
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Credit points	10
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the dual@TUHH Coordination Office that the dual student has completed the practical phase.
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Computer Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Compulsory Environmental Engineering: Core Qualification: Compulsory Aircraft Systems Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Information and Communication Systems: Core Qualification: Compulsory International Management and Engineering: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Core Qualification: Compulsory Aeronautics: Core Qualification: Compulsory Materials Science and Engineering: Core Qualification: Compulsory Materials Science: Core Qualification: Compulsory

	Mechanical Engineering and Management: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Core Qualification: Compulsory Microelectronics and Microsystems: Core Qualification: Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Renewable Energies: Core Qualification: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Water and Environmental Engineering: Core Qualification: Compulsory

Course L2889: Practical term 3 (dual study program, Master's degree)	
Typ	
Hrs/wk	0
CP	10
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Lecturer	Dr. Henning Haschke
Language	DE
Cycle	WiSe/SoSe
Content	**Company onboarding process** • Assigning a future professional field of activity as an engineer (M.Sc.) and associated fields of work • Extending responsibilities and authorisation of the dual student within the company up to the intended first assignment after completing their studies • Working responsibly in a team; project responsibility within own area - as well as across divisions and companies if necessary • Scheduling the final practical module with a clear correlation to work structures • Internal agreement on a potential topic or innovation project for the Master's dissertation • Planning the Master's dissertation within the company in cooperation with TU Hamburg • Scheduling the examination phase/subsequent study semester **Operational knowledge and skills** • Company-specific: dealing with change, project and team development, responsibility as an engineer in their future field of work (M.Sc.), dealing with complex contexts, frequent and unpredictable changes, developing and implementing innovative solutions • Specialising in one field of work (final dissertation) • Systemic skills • Implementing the university's application recommendations (theory-practice transfer) in corresponding work and task areas across the company **Sharing/reflecting on learning** • E-portfolio • Relevance of study content and personal specialisation when working as an engineer • Relevance of research and innovation when working as an engineer
Literature	• Studierendenhandbuch • betriebliche Dokumente • Hochschulseitige Anwendungsempfehlungen zum Theorie-Praxis-Transfer

Module M0658: Innovative CFD Approaches

Courses

Title	Typ	Hrs/wk	CP
Application of Innovative CFD Methods in Research and Development (L0239)	Lecture	2	3
Application of Innovative CFD Methods in Research and Development (L1685)	Recitation Section (small)	2	3

Module Responsible	Prof. Thomas Rung
Admission Requirements	None
Recommended Previous Knowledge	Students should have sound knowledge of engineering mathematics (series expansions, internal & vector calculus), and be familiar with the foundations of partial/ordinary differential equations. They are expected to be familiar with engineering fluid mechanics. Basic knowledge of numerical analysis or computational fluid dynamics, e.g. acquired in previous CFD courses, is of advantage but not necessary.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will acquire a deeper knowledge of recent trends in computational fluid dynamics (CFD), i.e. finite volume, smoothed particle hydrodynamics and lattice Boltzmann approaches, and can relate recent innovations with present challenges in computational fluid mechanics. They are familiar with the similarities and differences between different Eulerian and Lagrangian discretisation and approximation concepts for investigating on the basis of continuum and kinetic theories. Students have the required knowledge to develop, explain, code and apply numerical models concepts to approximate multiphase and multifield problems with grid and particle based methods, respectively. Students know the fundamentals of simulation based PDE constraint optimisation.
Skills	The students are able choose and apply appropriate discretisation concepts and flow physics models. They acquire the ability to code computational algorithms dedicated to finite volumes on unstructured grids & particle-based discretisations & structured lattice Boltzmann arrangements, apply these codes for parameter investigations and supplement interfaces to extract simulation data for an engineering analysis. They are able to sophisticatedly judge different solution strategies.
Personal Competence	
Social Competence	The students are able to discuss problems, present the results of their own analysis, and jointly develop, implement and report on solution strategies that address given technical reference problems in a team. They to lead team sessions and present solutions to experts.
Autonomy	The students can independently analyse innovative methods to solving fluid engineering problems. They are able to critically analyse own results as well as external data with regards to the plausibility and reliability. Students are able to structure and perform a simulation-based investigation.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description**: Yes / 20 % / Written elaboration
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Energy Systems: Core Qualification: Elective Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Ship and Offshore Technology: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0239: Application of Innovative CFD Methods in Research and Development

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Thomas Rung
Language	DE/EN
Cycle	WiSe
Content	Computational Optimisation, Parallel Computing, Efficient CFD-Procedures for GPU Archtiectures, Alternative Approximations (Lattice-Boltzmann Methods, Particle Methods), Fluid/Structure-Interaction, Modelling of Hybrid Continua
Literature	Vorlesungsmaterialien /lecture notes

Course L1685: Application of Innovative CFD Methods in Research and Development	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Thomas Rung
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Specialization Energy Systems

The Energy Systems specialization covers the mechanical engineering-oriented area of energy systems. Attention is paid to covering examples from the entire energy chain as far as possible, from small energy conversion units (Thermal Engineering) to large-scale facilities (Steam Generators). The modules offered cover both classical (Turbomachines) and regenerative energy systems (Wind Farms). A number of modules deal with energy systems in the mobile sector, such as for cars, airplanes and ships (Air Conditioning). The focus is on teaching the system concept because only by considering a system as a whole can useful energy be provided efficiently by means of conversion from conventional and renewable energy sources.

Students learn to understand complex energy systems, to describe them physically, and to model them mathematically. They are able to analyze and assess complex energy systems issues in the context of current energy policy. These skills can be put to practical use in all areas of engineering.

Module M0742: Thermal Energy Systems

Courses

Title	Typ	Hrs/wk	CP
Thermal Engergy Systems (L0023)	Lecture	3	5
Thermal Engergy Systems (L0024)	Recitation Section (large)	1	1

Module Responsible	Prof. Arne Speerforck
Admission Requirements	None
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students know the different energy conversion stages and the difference between efficiency and annual efficiency. They have increased knowledge in heat and mass transfer, especially in regard to buildings and mobile applications. They are familiar with German energy saving code and other technical relevant rules. They know to differ different heating systems in the domestic and industrial area and how to control such heating systems. They are able to model a furnace and to calculate the transient temperatures in a furnace. They have the basic knowledge of emission formations in the flames of small burners and how to conduct the flue gases into the atmosphere. They are able to model thermodynamic systems with object oriented languages.
Skills	Students are able to calculate the heating demand for different heating systems and to choose the suitable components. They are able to calculate a pipeline network and have the ability to perform simple planning tasks, regarding solar energy. They can write Modelica programs and can transfer research knowledge into practice. They are able to perform scientific work in the field of thermal engineering.
Personal Competence	
Social Competence	In lectures and exercises, the students can use many examples and experiments to discuss in small groups in a goal-oriented manner, develop a solution and present it. Within the exercises, the students can independently develop further questions and work out targeted solutions.
Autonomy	Students are able to define tasks independently, to develop the necessary knowledge themselves based on the knowledge they have received, and to use suitable means for implementation. In the exercises, the students discuss the methods taught in the lectures using complex tasks and critically analyze the results.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	60 min
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0023: Thermal Engergy Systems	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Arne Speerforck
Language	DE
Cycle	WiSe
Content	1. Introduction 2. Fundamentals of Thermal Engineering 2.1 Heat Conduction 2.2 Convection 2.3 Radiation 2.4 Heat transition 2.5 Combustion parameters 2.6 Electrical heating 2.7 Water vapor transport 3. Heating Systems 3.1 Warm water heating systems 3.2 Warm water supply 3.3 piping calculation 3.4 boilers, heat pumps, solar collectors 3.5 Air heating systems 3.6 radiative heating systems 4. Thermal traetment systems 4.1 Industrial furnaces 4.2 Melting furnaces 4.3 Drying plants 4.4 Emission control 4.5 Chimney calculation 4.6 Energy measuring 5. Laws and standards 5.1 Buildings 5.2 Industrial plants
Literature	• Schmitz, G.: Klimaanlagen, Skript zur Vorlesung • VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013 • Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009 • Recknagel, H.; Sprenger, E.; Schrammek, E.-R.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013

Course L0024: Thermal Engergy Systems	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Arne Speerforck
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0763: Aircraft Energy Systems

Courses

Title	Typ	Hrs/wk	CP
Aircraft Energy Systems (L0735)	Lecture	3	4
Aircraft Energy Systems (L0739)	Recitation Section (large)	2	2

Module Responsible	Prof. Frank Thielecke
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Fluid mechanics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • Assess challenges during the design of aircraft energy systems • Describe essential components and design points of hydraulic and electrical supply systems • Give an overview of the functionality of air conditioning systems • Describe different system concepts for de-icing • Identify constraints for the electrification of aircraft systems, and evaluate possible concepts and limitations • Describe architectures for fuel supply systems and illustrate design examples • Explain possible approaches for the integration of fuel cell systems and evaluate zero-emission concepts
Skills	Students are able to: • Design hydraulic and electric supply systems of aircrafts • Analyze the thermodynamic behavior of air conditioning systems • Design ice protection systems • Apply possible electrification concepts to existing aircraft systems • Design fuel supply systems • Perform the design of a fuel cell system
Personal Competence	
Social Competence	Students are able to: • Perform system design in groups and present and discuss results • Present systems engineering problems and discuss solutions with experts
Autonomy	Students are able to: • Reflect on the content of lectures autonomously • Apply methods learned in the course of exercises to more advanced problems • Identify complex system dependencies autonomously and abstract simplified models and design processes
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	165 Minutes
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Aeronautics: Core Qualification: Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory

Course L0735: Aircraft Energy Systems	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Frank Thielecke
Language	DE
Cycle	WiSe
Content	• Hydraulic Energy Systems (Fluids; pressure loss in valves and pipes; components of hydraulic systems like pumps, valves, etc.; pressure/flow characteristics; actuators; tanks; power and heat balances; emergency power) • Electric Energy Systems (Generators; constant-speed-drives; DC and AC converters; electrical power distribution; bus systems; monitoring; load analysis) • High Lift Systems (Principles; investigation of loads and system actuation power; principles and sizing of actuation and positioning systems; safety requirements and devices) • Environmental Control Systems (Thermodynamic analysis; expansion and compression cooling systems; control strategies; cabin pressure control systems)
Literature	• Moir, Seabridge: Aircraft Systems • Green: Aircraft Hydraulic Systems • Torenbek: Synthesis of Subsonic Airplane Design • SAE1991: ARP; Air Conditioning Systems for Subsonic Airplanes

Course L0739: Aircraft Energy Systems	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Frank Thielecke
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1149: Marine Power Engineering

Courses

Title	Typ	Hrs/wk	CP
Electrical Installation on Ships (L1531)	Lecture	2	2
Electrical Installation on Ships (L1532)	Recitation Section (large)	1	1
Marine Engineering (L1569)	Lecture	2	2
Marine Engineering (L1570)	Recitation Section (large)	1	1

Module Responsible	Prof. Christopher Friedrich Wirz
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the state-of-the-art regarding the wide range of propulsion components on ships and apply their knowledge. They further know how to analyze and optimize the interaction of the components of the propulsion system and how to describe complex correlations with the specific technical terms in German and English. The students are able to name the operating behaviour of consumers, describe special requirements on the design of supply networks and to the electrical equipment in isolated networks, as e.g. onboard ships, offshore units, factories and emergency power supply systems, explain power generation and distribution in isolated grids, wave generator systems on ships, and name requirements for network protection, selectivity and operational monitoring.
Skills	The students are skilled to employ basic and detail knowledge regarding reciprocating machinery, their selection and operation on board ships. They are further able to assess, analyse and solve technical and operational problems with propulsion and auxiliary plants and to design propulsion systems. The students have the skills to describe complex correlations and bring them into context with related disciplines. Students are able to calculate short-circuit currents, switchgear, and design electrical propulsion systems for ships.
Personal Competence	
Social Competence	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.
Autonomy	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 minutes plus 20 minutes oral exam
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory

Course L1531: Electrical Installation on Ships	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	WiSe
Content	• performance in service of electrical consumers. • special requirements for power supply systems and for electrical equipment in isolated systems/networks e. g. aboard ships, offshore installations, factory systems and emergency power supply systems. • power generation and distribution in isolated networks, shaft generators for ships • calculation of short circuits and behaviour of switching devices • protective devices, selectivity monitoring • electrical Propulsion plants for ships
Literature	H. Meier-Peter, F. Bernhardt u. a.: Handbuch der Schiffsbetriebstechnik, Seehafen Verlag (engl. Version: "Compendium Marine Engineering") Gleß, Thamm: Schiffselektrotechnik, VEB Verlag Technik Berlin

Course L1532: Electrical Installation on Ships	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1569: Marine Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	WiSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1570: Marine Engineering	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1518: Technical Complementary Course for ENTMS, Option A (according to Subject Specific Regulations)

Courses

Title	Typ	Hrs/wk	CP

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	See selected module according to FSPO
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	See selected module according to FSPO
Skills	See selected module according to FSPO
Personal Competence	
Social Competence	See selected module according to FSPO
Autonomy	See selected module according to FSPO
Workload in Hours	Depends on choice of courses
Credit points	12
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory

Module M1504: Technical Complementary Course for ENTMS, Option B (according to Subject Specific Regulations)

Courses

Title	Typ	Hrs/wk	CP

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	See selected module according to FSPO
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	See selected module according to FSPO
Skills	See selected module according to FSPO
Personal Competence	
Social Competence	See selected module according to FSPO
Autonomy	See selected module according to FSPO
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Energy Systems: Core Qualification: Elective Compulsory

Module M1235: Electrical Power Systems I: Introduction to Electrical Power Systems

Courses

Title	Typ	Hrs/wk	CP
Electrical Power Systems I: Introduction to Electrical Power Systems (L1670)	Lecture	3	4
Electrical Power Systems I: Introduction to Electrical Power Systems (L1671)	Recitation Section (small)	2	2

Module Responsible	Prof. Christian Becker
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of Electrical Engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to give an overview of conventional and modern electric power systems. They can explain in detail and critically evaluate technologies of electric power generation, transmission, storage, and distribution as well as integration of equipment into electric power systems.
Skills	With completion of this module the students are able to apply the acquired skills in applications of the design, integration, development of electric power systems and to assess the results.
Personal Competence	
Social Competence	The students can participate in specialized and interdisciplinary discussions, advance ideas and represent their own work results in front of others.
Autonomy	Students can independently tap knowledge of the emphasis of the lectures.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 - 150 minutes
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory Data Science: Core Qualification: Elective Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Engineering Science: Specialisation Electrical Engineering: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Integrated Building Technology: Core Qualification: Compulsory Mechatronics: Specialisation Electrical Systems: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory

Course L1670: Electrical Power Systems I: Introduction to Electrical Power Systems	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe

Content	• fundamentals and current development trends in electric power engineering
	• tasks and history of electric power systems
	• symmetric three-phase systems
	• fundamentals and modelling of eletric power systems
	  ◦ lines
	  ◦ transformers
	  ◦ synchronous machines
	  ◦ induction machines
	  ◦ loads and compensation
	  ◦ grid structures and substations
	• fundamentals of energy conversion
	  ◦ electro-mechanical energy conversion
	  ◦ thermodynamics
	  ◦ power station technology
	  ◦ renewable energy conversion systems
	• steady-state network calculation
	  ◦ network modelling
	  ◦ load flow calculation
	  ◦ (n-1)-criterion
	• symmetric failure calculations, short-circuit power
	• control in networks and power stations
	• grid protection
	• grid planning
	• power economy fundamentals

Literature	K. Heuck, K.-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013 A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017 R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008

Course L1671: Electrical Power Systems I: Introduction to Electrical Power Systems	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe

Content	• fundamentals and current development trends in electric power engineering
	• tasks and history of electric power systems
	• symmetric three-phase systems
	• fundamentals and modelling of eletric power systems
	  ◦ lines
	  ◦ transformers
	  ◦ synchronous machines
	  ◦ induction machines
	  ◦ loads and compensation
	  ◦ grid structures and substations
	• fundamentals of energy conversion
	  ◦ electro-mechanical energy conversion
	  ◦ thermodynamics
	  ◦ power station technology
	  ◦ renewable energy conversion systems
	• steady-state network calculation
	  ◦ network modelling
	  ◦ load flow calculation
	  ◦ (n-1)-criterion
	• symmetric failure calculations, short-circuit power
	• control in networks and power stations
	• grid protection
	• grid planning
	• power economy fundamentals

Literature	K. Heuck, K.-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013 A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017 R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008

Module M1309: Dimensioning and Assessment of Renewable Energy Systems

Courses

Title	Typ	Hrs/wk	CP
Environmental Technology and Energy Economics (L0137)	Project-/problem-based Learning	2	2
Electricity Generation from Renewable Sources of Energy (L0046)	Seminar	2	2
Heat Provision from Renewable Sources of Energy (L0045)	Seminar	2	2

Module Responsible	Prof. Martin Kaltschmitt
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can describe current issue and problems in the field of renewable energies. Furthermore, they can explain aspects in relation to the provision of heat or electricity through different renewable technologies, and explain and assess them in a technical, economical and environmental way.
Skills	Students are able to solve scientific problems in the context of heat and electricity supply using renewable energy systems by: • using module-comprehensive knowledge for different applications, • evaluating alternative input parameter regarding the solution of the task in the case of incomplete information (technical, economical and ecological parameter), • a systematic documentation of the work results in form of a written version, the presentation itself and the defense of contents.
Personal Competence	
Social Competence	Students can • respectfully work together as a team with around 2-3 members, • participate in subject-specific and interdisciplinary discussions in the area of dimensioning and analysis of potentials of heat and electricty supply using renewable energie, and can develop cooperated solutions, • defend their own work results in front of fellow students and • assess the performance of fellow students in comparison to their own performance. Furthermore, they can accept professional constructive criticism.
Autonomy	Students can independently tap knowledge regarding to the given task. They are capable, in consultation with supervisors, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	per course: 20 minutes presentation + written report
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Compulsory Renewable Energies: Core Qualification: Compulsory

Course L0137: Environmental Technology and Energy Economics

Typ	Project-/problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Martin Kaltschmitt
Language	DE
Cycle	WiSe
Content	• Preliminary discussion with the rules of the lecture • Issue of topics from the field of renewable energy technology in the form of a tender of engineering services to a group of students (depending on the number of participating students) • "Procurement" deal with aspects of the design, costing and environmental, economic and technical evaluation of various energy generation concepts (eg onshore wind power generation, commercial-scale photovoltaic power generation, biogas production, geothermal power and heat generation) under very special circumstances • Submission of a written solution of the task and distribution to the participants by the student / group of students • Presentation of the edited theme (20 min) with PPT presentation and subsequent discussion (20 minutes) • Attendance is mandatory for all seminars
Literature	Eigenständiges Literaturstudium in der Bibliothek und aus anderen Quellen.

Course L0046: Electricity Generation from Renewable Sources of Energy	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Martin Kaltschmitt
Language	DE
Cycle	WiSe
Content	• Preliminary discussion with the seminar rules • Distribution of the topics related to the subject of the seminar to individual students / groups of students (depending on the number of participating students) • Delivery of a five-page summary of the seminar topic and distribution to the participants by the student / group of students • Presentation of the processed topic (30 min) with PPT presentation and subsequent discussion (20 minutes) • Attendance is mandatory for all seminars
Literature	• Eigenständiges Literaturstudium in der Bibliothek und aus anderen Quellen.

Course L0045: Heat Provision from Renewable Sources of Energy	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Martin Kaltschmitt
Language	DE
Cycle	SoSe
Content	• Preliminary discussion with the seminar rules • Distribution of the topics related to the subject of the seminar to individual students / groups of students (depending on the number of participating students) • Delivery of a five-page summary of the seminar topic and distribution to the participants by the student / group of students • Presentation of the processed topic (30 min) with PPT presentation and subsequent discussion (20 minutes) • Attendance is mandatory for all seminars
Literature	Eigenständiges Literaturstudium in der Bibliothek und aus anderen Quellen.

Module M0721: Air Conditioning

Courses

Title	Typ	Hrs/wk	CP
Air Conditioning (L0594)	Lecture	3	5
Air Conditioning (L0595)	Recitation Section (large)	1	1

Module Responsible	Prof. Arne Speerforck
Admission Requirements	None
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students know the different kinds of air conditioning systems for buildings and mobile applications and how these systems are controlled. They are familiar with the change of state of humid air and are able to draw the state changes in a h1+x,x-diagram. They are able to calculate the minimum airflow needed for hygienic conditions in rooms and can choose suitable filters. They know the basic flow pattern in rooms and are able to calculate the air velocity in rooms with the help of simple methods. They know the principles to calculate an air duct network. They know the different possibilities to produce cold and are able to draw these processes into suitable thermodynamic diagrams. They know the criteria for the assessment of refrigerants.
Skills	Students are able to configure air condition systems for buildings and mobile applications. They are able to calculate an air duct network and have the ability to perform simple planning tasks, regarding natural heat sources and heat sinks. They can transfer research knowledge into practice. They are able to perform scientific work in the field of air conditioning.
Personal Competence	
Social Competence	In lectures and exercises, the students can use many examples and experiments to discuss in small groups in a goal-oriented manner, develop a solution and present it. Within the exercises, the students can independently develop further questions and work out targeted solutions.
Autonomy	Students are able to define tasks independently, to develop the necessary knowledge themselves based on the knowledge they have received, and to use suitable means for implementation. In the exercises, the students discuss the methods taught in the lectures using complex tasks and critically analyze the results.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	60 min
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0594: Air Conditioning	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Arne Speerforck, Prof. Gerhard Schmitz
Language	DE
Cycle	SoSe
Content	1. Overview 1.1 Kinds of air conditioning systems 1.2 Ventilating 1.3 Function of an air condition system 2. Thermodynamic processes 2.1 Psychrometric chart 2.2 Mixer preheater, heater 2.3 Cooler 2.4 Humidifier 2.5 Air conditioning process in a Psychrometric chart 2.6 Desiccant assisted air conditioning 3. Calculation of heating and cooling loads 3.1 Heating loads 3.2 Cooling loads 3.3 Calculation of inner cooling load 3.4 Calculation of outer cooling load 4. Ventilating systems 4.1 Fresh air demand 4.2 Air flow in rooms 4.3 Calculation of duct systems 4.4 Fans 4.5 Filters 5. Refrigeration systems 5.1. compression chillers 5.2Absorption chillers
Literature	• Schmitz, G.: Klimaanlagen, Skript zur Vorlesung • VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013 • Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009 • Recknagel, H.; Sprenger, E.; Schrammek, E.-R.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013

Course L0595: Air Conditioning	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Arne Speerforck, Prof. Gerhard Schmitz
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1021: Marine Diesel Engine Plants

Courses

Title	Typ	Hrs/wk	CP
Marine Diesel Engine Plants (L0637)	Lecture	3	4
Marine Diesel Engine Plants (L0638)	Recitation Section (large)	1	2

Module Responsible	Prof. Christopher Friedrich Wirz
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can • explain different types four / two-stroke engines and assign types to given engines, • name definitions and characteristics, as well as • elaborate on special features of the heavy oil operation, lubrication and cooling.
Skills	Students can • evaluate the interaction of ship, engine and propeller, • use relationships between gas exchange, flushing, air demand, charge injection and combustion for the design of systems, • design waste heat recovery, starting systems, controls, automation, foundation and design machinery spaces , and • apply evaluation methods for excited motor noise and vibration.
Personal Competence	
Social Competence	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.
Autonomy	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	20 min
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory

Course L0637: Marine Diesel Engine Plants	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	SoSe
Content	• Historischer Überblick • Bauarten von Vier- und Zweitaktmotoren als Schiffsmotoren • Vergleichsprozesse, Definitionen, Kenndaten • Zusammenwirken von Schiff, Motor und Propeller • Ausgeführte Schiffsdieselmotoren • Gaswechsel, Spülverfahren, Luftbedarf • Aufladung von Schiffsdieselmotoren • Einspritzung und Verbrennung • Schweröl betrieb • Schmierung • Kühlung • Wärmebilanz • Abwärmenutzung • Anlassen und Umsteuern • Regelung, Automatisierung, Überwachung • Motorerregte Geräusche und Schwingungen • Fundamentierung • Gestaltung von Maschinenräumen
Literature	• D. Woodyard: Pounder’s Marine Diesel Engines • H. Meyer-Peter, F. Bernhardt: Handbuch der Schiffsbetriebstechnik • K. Kuiken: Diesel Engines • Mollenhauer, Tschöke: Handbuch Dieselmotoren • Projektierungsunterlagen der Motorenhersteller

Course L0638: Marine Diesel Engine Plants	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1161: Turbomachinery

Courses

Title	Typ	Hrs/wk	CP
Turbomachines (L1562)	Lecture	3	4
Turbomachines (L1563)	Recitation Section (large)	1	2

Module Responsible	Prof. Markus Schatz
Admission Requirements	None
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can • distinguish the physical phenomena of conversion of energy, • understand the different mathematic modelling of turbomachinery, • calculate and evaluate turbomachinery.
Skills	The students are able to - understand the physics of Turbomachinery, - solve excersises self-consistent.
Personal Competence	
Social Competence	The students are able to • discuss in small groups and develop an approach.
Autonomy	The students are able to • develop a complex problem self-consistent, • analyse the results in a critical way, • have an qualified exchange with other students.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory

Course L1562: Turbomachines	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Markus Schatz
Language	DE
Cycle	SoSe
Content	Topics to be covered will include: • Application cases of turbomachinery • Fundamentals of thermodynamics and fluid mechanics • Design fundamentals of turbomachinery • Introduction to the theory of turbine stage • Design and operation of the turbocompressor • Design and operation of the steam turbine • Design and operation of the gas turbine • Physical limits of the turbomachines
Literature	• Traupel: Thermische Turbomaschinen, Springer. Berlin, Heidelberg, New York • Bräunling: Flugzeuggasturbinen, Springer., Berlin, Heidelberg, New York • Seume: Stationäre Gasturbinen, Springer., Berlin, Heidelberg, New York • Menny: Strömungsmaschinen, Teubner., Stuttgart

Course L1563: Turbomachines	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Markus Schatz
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0512: Use of Solar Energy

Courses

Title	Typ	Hrs/wk	CP
Energy Meteorology (L0016)	Lecture	1	1
Energy Meteorology (L0017)	Recitation Section (small)	1	1
Collector Technology (L0018)	Lecture	2	2
Solar Power Generation (L0015)	Lecture	2	2

Module Responsible	Prof. Martin Kaltschmitt
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	With the completion of this module, students will be able to deal with technical foundations and current issues and problems in the field of solar energy and explain and evaulate these critically in consideration of the prior curriculum and current subject specific issues. In particular they can professionally describe the processes within a solar cell and explain the specific features of application of solar modules. Furthermore, they can provide an overview of the collector technology in solar thermal systems.
Skills	Students can apply the acquired theoretical foundations of exemplary energy systems using solar radiation. In this context, for example they can assess and evaluate potential and constraints of solar energy systems with respect to different geographical assumptions. They are able to dimension solar energy systems in consideration of technical aspects and given assumptions. Using module-comprehensive knowledge students can evalute the economic and ecologic conditions of these systems. They can select calculation methods within the radiation theory for these topics.
Personal Competence	
Social Competence	Students are able to discuss issues in the thematic fields in the renewable energy sector addressed within the module.
Autonomy	Students can independently exploit sources and acquire the particular knowledge about the subject area with respect to emphasis fo the lectures. Furthermore, with the assistance of lecturers, they can discrete use calculation methods for analysing and dimensioning solar energy systems. Based on this procedure they can concrete assess their specific learning level and can consequently define the further workflow.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6

Course achievement

Compulsory	Bonus	Form	Description
Yes	20 %	Written elaboration	Ausarbeitung Kollektortechnik

Examination	Written exam
Examination duration and scale	180 min
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory

Course L0016: Energy Meteorology	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Volker Matthias, Dr. Beate Geyer
Language	DE
Cycle	SoSe

Content	• Introduction: radiation source Sun, Astronomical Foundations, Fundamentals of radiation
	• Structure of the atmosphere
	• Properties and laws of radiation
	  ◦ Polarization
	  ◦ Radiation quantities
	  ◦ Planck's radiation law
	  ◦ Wien's displacement law
	  ◦ Stefan-Boltzmann law
	  ◦ Kirchhoff's law
	  ◦ Brightness temperature
	  ◦ Absorption, reflection, transmission
	• Radiation balance, global radiation, energy balance
	• Atmospheric extinction
	• Mie and Rayleigh scattering
	• Radiative transfer
	• Optical effects in the atmosphere
	• Calculation of the sun and calculate radiation on inclined surfaces

Literature	• Helmut Kraus: Die Atmosphäre der Erde • Hans Häckel: Meteorologie • Grant W. Petty: A First Course in Atmosheric Radiation • Martin Kaltschmitt, Wolfgang Streicher, Andreas Wiese: Renewable Energy • Alexander Löw, Volker Matthias: Skript Optik Strahlung Fernerkundung

Course L0017: Energy Meteorology	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Beate Geyer
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0018: Collector Technology	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Agis Papadopoulos
Language	DE
Cycle	SoSe
Content	• Introduction: Energy demand and application of solar energy. • Heat transfer in the solar thermal energy: conduction, convection, radiation. • Collectors: Types, structure, efficiency, dimensioning, concentrated systems. • Energy storage: Requirements, types. • Passive solar energy: components and systems. • Solar thermal low temperature systems: collector variants, construction, calculation. • Solar thermal high temperature systems: Classification of solar power plants construction. • Solar air conditioning.
Literature	• Vorlesungsskript. • Kaltschmitt, Streicher und Wiese (Hrsg.). Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, 5. Auflage, Springer, 2013. • Stieglitz und Heinzel .Thermische Solarenergie: Grundlagen, Technologie, Anwendungen. Springer, 2012. • Von Böckh und Wetzel. Wärmeübertragung: Grundlagen und Praxis, Springer, 2011. • Baehr und Stephan. Wärme- und Stoffübertragung. Springer, 2009. • de Vos. Thermodynamics of solar energy conversion. Wiley-VCH, 2008. • Mohr, Svoboda und Unger. Praxis solarthermischer Kraftwerke. Springer, 1999.

Course L0015: Solar Power Generation	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Martin Schlecht, Prof. Alf Mews, Roman Fritsches-Baguhl
Language	DE
Cycle	SoSe
Content	Photovoltaics: 1. Introduction 2. Primary energies and consumption, available solar energy 3. Physics of the ideal solar cell 4. Light absorption, PN transition, characteristic sizes of the solar cell, efficiency 5. Physics of the real solar cell 6. Charge carrier recombination, characteristic curves, barrier layer recombination, equivalent circuit diagram 7. Increasing efficiency 8. Methods for increasing the quantum yield and reducing recombination 9. Hetero- and tandem structures 10. Heterojunction, Schottky, electrochemical, MIS and SIS cell, tandem cell 11. Concentrator cells 12. Concentrator optics and tracking systems, concentrator cells 13. Technology and properties: solar cell types, manufacturing, monocrystalline silicon and gallium arsenide, polycrystalline silicon and silicon thin film cells, thin film cells on carriers (amorphous silicon, CIS, electrochemical cells) 14. Modules 15. Switches Concentrating solar power plants: 1. Introduction 2. Point focused technologies 3. Line focused technologies 4. Design of CSP projects
Literature	• A. Götzberger, B. Voß, J. Knobloch: Sonnenenergie: Photovoltaik, Teubner Studienskripten, Stuttgart, 1995 • A. Götzberger: Sonnenenergie: Photovoltaik : Physik und Technologie der Solarzelle, Teubner Stuttgart, 1994 • H.-J. Lewerenz, H. Jungblut: Photovoltaik, Springer, Berlin, Heidelberg, New York, 1995 • A. Götzberger: Photovoltaic solar energy generation, Springer, Berlin, 2005 • C. Hu, R. M. White: Solar Cells, Mc Graw Hill, New York, 1983 • H.-G. Wagemann: Grundlagen der photovoltaischen Energiewandlung: Solarstrahlung, Halbleitereigenschaften und Solarzellenkonzepte, Teubner, Stuttgart, 1994 • R. J. van Overstraeten, R.P. Mertens: Physics, technology and use of photovoltaics, Adam Hilger Ltd, Bristol and Boston, 1986 • B. O. Seraphin: Solar energy conversion Topics of applied physics V 01 31, Springer, Berlin, Heidelberg, New York, 1995 • P. Würfel: Physics of Solar cells, Principles and new concepts, Wiley-VCH, Weinheim 2005 • U. Rindelhardt: Photovoltaische Stromversorgung, Teubner-Reihe Umwelt, Stuttgart 2001 • V. Quaschning: Regenerative Energiesysteme, Hanser, München, 2003 • G. Schmitz: Regenerative Energien, Ringvorlesung TU Hamburg-Harburg 1994/95, Institut für Energietechnik

Module M1346: Selected Topics of Energy Systems - Option B

Courses

Title	Typ	Hrs/wk	CP
Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage (L0021)	Lecture	2	2
Auxiliary Systems on Board of Ships (L1249)	Lecture	2	2
Auxiliary Systems on Board of Ships (L1250)	Recitation Section (large)	1	1
Sustainable Industrial Production (L2863)	Lecture	2	4
Computational Fluid Dynamics - Exercises in OpenFoam (L1375)	Recitation Section (small)	1	1
Computational Fluid Dynamics in Process Engineering (L1052)	Lecture	2	2
Offshore Wind Parks (L0072)	Lecture	2	3
Selected Topics of Experimental and Theoretical Fluiddynamics (L0240)	Lecture	2	3
Turbines and Turbo Compressors (L1564)	Lecture	2	3
Turbines and Turbo Compressors (L1565)	Recitation Section (large)	1	1
Hydrogen Technology (L0060)	Lecture	2	2
Wind Turbine Plants (L0011)	Lecture	2	3

Module Responsible	Prof. Arne Speerforck
Admission Requirements	None
Recommended Previous Knowledge	Basic moduls of mechanical engineering, energy systems and marine technologies
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe selected energy systems and rank the interrrelation with other energy systems.
Skills	The students can analyse and evaluate tasks in the field of energy systems.
Personal Competence	
Social Competence	The students can discuss with other students and lecturers different aspects of energy systems.
Autonomy	The students can define tasks and become acquainted with neccessary knowledge.
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory

Course L0021: Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	
Lecturer	Prof. Michael Fröba
Language	DE
Cycle	SoSe

Content	1. Introduction to electrochemical energy conversion
	2. Function and structure of electrolyte
	3. Low-temperature fuel cell
	  ◦ Types
	  ◦ Thermodynamics of the PEM fuel cell
	  ◦ Cooling and humidification strategy
	4. High-temperature fuel cell
	  ◦ The MCFC
	  ◦ The SOFC
	  ◦ Integration Strategies and partial reforming
	5. Fuels
	  ◦ Supply of fuel
	  ◦ Reforming of natural gas and biogas
	  ◦ Reforming of liquid hydrocarbons
	6. Energetic Integration and control of fuel cell systems

Literature	• Hamann, C.; Vielstich, W.: Elektrochemie 3. Aufl.; Weinheim: Wiley - VCH, 2003

Course L1249: Auxiliary Systems on Board of Ships	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	20 min
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	SoSe
Content	• Vorschriften zur Schiffsausrüstung • Ausrüstungsanlagen auf Standard-Schiffen • Ausrüstungsanlagen auf Spezial-Schiffen • Grundlagen und Systemtechnik der Hydraulik • Auslegung und Betrieb von Ausrüstungsanlagen
Literature	• H. Meyer-Peter, F. Bernhardt: Handbuch der Schiffsbetriebstechnik • H. Watter: Hydraulik und Pneumatik

Course L1250: Auxiliary Systems on Board of Ships	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	20 min
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	SoSe
Content	
Literature	Siehe korrespondierende Vorlesung

Course L2863: Sustainable Industrial Production	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Dr. Simon Markus Kothe
Language	DE
Cycle	SoSe
Content	Industrial production deals with the manufacture of physical products to satisfy human needs using various manufacturing processes that change the form and physical properties of raw materials. Manufacturing is a central driver of economic development and has a major impact on the well-being of humanity. However, the scale of current manufacturing activities results in enormous global energy and material demands that are harmful to both the environment and people. Historically, industrial activities were mostly oriented towards economic constraints, while social and environmental consequences were only hardly considered. As a result, today's global consumption rates of many resources and associated emissions often exceed the natural regeneration rate of our planet. In this respect, current industrial production can mostly be described as unsustainable. This is emphasized each year by the Earth Overshoot Day, which marks the day when humanity's ecological footprint exceeds the Earth's annual regenerative capacity. This lecture aims to provide the motivation, analytical methods as well as approaches for sustainable industrial production and to clarify the influence of the production phase in relation to the raw material, use and recycling phases in the entire life cycle of products. For this, the following topics will be highlighted: - Motivation for sustainable production, the 17 Sustainable Development Goals (SDGs) of the UN and their relevance for tomorrow's manufacturing; - raw material vs. production phase vs. use phase vs. recycling/end-of-life phase: importance of the production phase for the environmental impact of manufactured products; - Typical energy- and resource-intensive processes in industrial production and innovative approaches to increase energy and resource efficiency; - Methodology for optimizing the energy and resource efficiency of industrial manufacturing chains with the three steps of modeling (1), evaluating (2) and improving (3); - Resource efficiency of industrial manufacturing value chains and its assessment using life cycle analysis (LCA); - Exercise: LCA analysis of a manufacturing process (thermoplastic joining of an aircraft fuselage segment) as part of a product life cycle assessment.
Literature	Literatur: - Stefan Alexander (2020): Resource efficiency in manufacturing value chains. Cham: Springer International Publishing. - Hauschild, Michael Z.; Rosenbaum, Ralph K.; Olsen, Stig Irving (Hg.) (2018): Life Cycle Assessment. Theory and Practice. Cham: Springer International Publishing. - Kishita, Yusuke; Matsumoto, Mitsutaka; Inoue, Masato; Fukushige, Shinichi (2021): EcoDesign and sustainability. Singapore: Springer. - Schebek, Liselotte; Herrmann, Christoph; Cerdas, Felipe (2019): Progress in Life Cycle Assessment. Cham: Springer International Publishing. - Thiede, Sebastian; Hermann, Christoph (2019): Eco-factories of the future. Cham: Springer Nature Switzerland AG. - Vorlesungsskript.

Course L1375: Computational Fluid Dynamics - Exercises in OpenFoam	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Michael Schlüter
Language	EN
Cycle	SoSe
Content	• generation of numerical grids with a common grid generator • selection of models and boundary conditions • basic numerical simulation with OpenFoam within the TUHH CIP-Pool
Literature	OpenFoam Tutorials (StudIP)

Course L1052: Computational Fluid Dynamics in Process Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Michael Schlüter
Language	EN
Cycle	SoSe
Content	• Introduction into partial differential equations • Basic equations • Boundary conditions and grids • Numerical methods • Finite difference method • Finite volume method • Time discretisation and stability • Population balance • Multiphase Systems • Modeling of Turbulent Flows • Exercises: Stability Analysis • Exercises: Example on CFD - analytically/numerically
Literature	Paschedag A.R.: CFD in der Verfahrenstechnik: Allgemeine Grundlagen und mehrphasige Anwendungen, Wiley-VCH, 2004 ISBN 3-527-30994-2. Ferziger, J.H.; Peric, M.: Numerische Strömungsmechanik. Springer-Verlag, Berlin, 2008, ISBN: 3540675868. Ferziger, J.H.; Peric, M.: Computational Methods for Fluid Dynamics. Springer, 2002, ISBN 3-540-42074-6

Course L0072: Offshore Wind Parks	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. Alexander Mitzlaff
Language	DE
Cycle	WiSe
Content	• Nonlinear Waves: Stability, pattern formation, solitary states • Bottom Boundary layers: wave boundary layers, scour, stability of marine slopes • Ice-structure interaction • Wave and tidal current energy conversion
Literature	• Chakrabarti, S., Handbook of Offshore Engineering, vol. I&II, Elsevier 2005. • Mc Cormick, M.E., Ocean Wave Energy Conversion, Dover 2007. • Infeld, E., Rowlands, G., Nonlinear Waves, Solitons and Chaos, Cambridge 2000. • Johnson, R.S., A Modern Introduction to the Mathematical Theory of Water Waves, Cambridge 1997. • Lykousis, V. et al., Submarine Mass Movements and Their Consequences, Springer 2007. • Nielsen, P., Coastal Bottom Boundary Layers and Sediment Transport, World Scientific 2005. • Research Articles.

Course L0240: Selected Topics of Experimental and Theoretical Fluiddynamics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Thomas Rung
Language	DE
Cycle	WiSe
Content	Will be announced at the beginning of the lecture. Exemplary topics are 1. methods and procedures from experimental fluid mechanics 2. rational Approaches towards flow physics modelling 3. selected topics of theoretical computation fluid dynamics 4. turbulent flows
Literature	Wird in der Veranstaltung bekannt gegeben. To be announced during the lecture.

Course L1564: Turbines and Turbo Compressors	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Markus Schatz
Language	DE
Cycle	WiSe
Content	Skript in Papierform im Sekretariat HSU H10 R 310 erhältlich Traupel Thermische Turbomaschinen Bde 1, 2, Springer Verlag Berlin Heidelberg New York 1988 Oertel, Laurien Numerische Strömungsmechanik Springer Verlag Berlin Heidelberg New York 2001
Literature	Topics: 1. Three dimensional flows in axial grids 2. secondary flows in axial turbomachines, 3. basics of computational fluid dynamics (CFD) 4. CFD of turbomachinary 5. basics of radial turbomachines 6. exhaust turbo charger 7. hydrodynamic gears

Course L1565: Turbines and Turbo Compressors	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Markus Schatz
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0060: Hydrogen Technology	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Jun.-Prof. Julian Jepsen
Language	DE
Cycle	SoSe
Content	1. Energy economy 2. Hydrogen economy 3. Occurrence and properties of hydrogen 4. Production of hydrogen (from hydrocarbons and by electrolysis) 5. Separation and purification Storage and transport of hydrogen 6. Security 7. Fuel cells 8. Projects
Literature	• Skriptum zur Vorlesung • Winter, Nitsch: Wasserstoff als Energieträger • Ullmann's Encyclopedia of Industrial Chemistry • Kirk, Othmer: Encyclopedia of Chemical Technology • Larminie, Dicks: Fuel cell systems explained

Course L0011: Wind Turbine Plants	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Dr. Rudolf Zellermann
Language	DE
Cycle	SoSe
Content	• Historical development • Wind: origins, geographic and temporal distribution, locations • Power coefficient, rotor thrust • Aerodynamics of the rotor • Operating performance • Power limitation, partial load, pitch and stall control • Plant selection, yield prediction, economy • Excursion
Literature	Gasch, R., Windkraftanlagen, 4. Auflage, Teubner-Verlag, 2005

Module M1709: Applied optimization in energy and process engineering

Courses

Title	Typ	Hrs/wk	CP
Applied optimization in energy and process engineering (L2693)	Integrated Lecture	2	3
Applied optimization in energy and process engineering (L2695)	Recitation Section (small)	2	3

Module Responsible	Prof. Mirko Skiborowski
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals in the field of mathematical modeling and numerical mathematics, as well as a basic understanding of process engineering processes. In particular the contents of the module Process and Plant Engineering II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The module provides a general introduction to the basics of applied mathematical optimization and deals with application areas on different scales from the identification of kinetic models, to the optimal design of unit operations and the optimization of entire (sub)processes, as well as production planning. In addition to the basic classification and formulation of optimization problems, different solution approaches are discussed and tested during the exercises. Besides deterministic gradient-based methods, metaheuristics such as evolutionary and genetic algorithms and their application are discussed as well. • Introduction to Applied Optimization • Formulation of optimization problems • Linear Optimization • Nonlinear Optimization • Mixed-integer (non)linear optimization • Multi-objective optimization • Global optimization
Skills	After successful participation in the module "Applied Optimization in Energy and Process Engineering", students are able to formulate the different types of optimization problems and to select appropriate solution methods in suitable software such as Matlab and GAMS and to develop improved solution strategies. Furthermore, students will be able to interpret and critically examine the results accordingly.
Personal Competence	
Social Competence	Students are capable of: •develop solutions in heterogeneous small groups
Autonomy	Students are capable of: •taping new knowledge on a special subject by literature research
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	35 min
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L2693: Applied optimization in energy and process engineering	
Typ	Integrated Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Mirko Skiborowski
Language	DE/EN
Cycle	SoSe
Content	The lecture offers a general introduction to the basics and possibilities of applied mathematical optimization and deals with application areas on different scales from kinetics identification, optimal design of unit operations to the optimization of entire (sub)processes, and production planning. In addition to the basic classification and formulation of optimization problems, different solution approaches are discussed. Besides deterministic gradient-based methods, metaheuristics such as evolutionary and genetic algorithms and their application are discussed as well. - Introduction to Applied Optimization - Formulation of optimization problems - Linear Optimization - Nonlinear Optimization - Mixed-integer (non)linear optimization - Multi-objective optimization - Global optimization
Literature	Weicker, K., Evolutionäre Algortihmen, Springer, 2015 Edgar, T. F., Himmelblau D. M., Lasdon, L. S., Optimization of Chemical Processes, McGraw Hill, 2001 Biegler, L. Nonlinear Programming - Concepts, Algorithms, and Applications to Chemical Processes, 2010 Kallrath, J. Gemischt-ganzzahlige Optimierung: Modellierung in der Praxis, Vieweg, 2002

Course L2695: Applied optimization in energy and process engineering	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Mirko Skiborowski
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1162: Selected Topics of Energy Systems - Option A

Courses

Title	Typ	Hrs/wk	CP
Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage (L0021)	Lecture	2	2
Auxiliary Systems on Board of Ships (L1249)	Lecture	2	2
Auxiliary Systems on Board of Ships (L1250)	Recitation Section (large)	1	1
Sustainable Industrial Production (L2863)	Lecture	2	4
Computational Fluid Dynamics - Exercises in OpenFoam (L1375)	Recitation Section (small)	1	1
Computational Fluid Dynamics in Process Engineering (L1052)	Lecture	2	2
Offshore Wind Parks (L0072)	Lecture	2	3
Selected Topics of Experimental and Theoretical Fluiddynamics (L0240)	Lecture	2	3
Turbines and Turbo Compressors (L1564)	Lecture	2	3
Turbines and Turbo Compressors (L1565)	Recitation Section (large)	1	1
Hydrogen Technology (L0060)	Lecture	2	2
Wind Turbine Plants (L0011)	Lecture	2	3

Module Responsible	Prof. Arne Speerforck
Admission Requirements	None
Recommended Previous Knowledge	Basic moduls of mechanical engineering, energy systems and marine technologies
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to • describe selected energy systems and rank the interrrelation with other energy systems.
Skills	The students can • analyse and evaluate tasks in the field of energy systems.
Personal Competence	
Social Competence	The students can • discuss with other students and lecturers different aspects of energy systems.
Autonomy	The students can • define tasks and become acquainted with neccessary knowledge.
Workload in Hours	Depends on choice of courses
Credit points	12
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory

Course L0021: Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	
Lecturer	Prof. Michael Fröba
Language	DE
Cycle	SoSe

Content	1. Introduction to electrochemical energy conversion
	2. Function and structure of electrolyte
	3. Low-temperature fuel cell
	  ◦ Types
	  ◦ Thermodynamics of the PEM fuel cell
	  ◦ Cooling and humidification strategy
	4. High-temperature fuel cell
	  ◦ The MCFC
	  ◦ The SOFC
	  ◦ Integration Strategies and partial reforming
	5. Fuels
	  ◦ Supply of fuel
	  ◦ Reforming of natural gas and biogas
	  ◦ Reforming of liquid hydrocarbons
	6. Energetic Integration and control of fuel cell systems

Literature	• Hamann, C.; Vielstich, W.: Elektrochemie 3. Aufl.; Weinheim: Wiley - VCH, 2003

Course L1249: Auxiliary Systems on Board of Ships	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	20 min
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	SoSe
Content	• Vorschriften zur Schiffsausrüstung • Ausrüstungsanlagen auf Standard-Schiffen • Ausrüstungsanlagen auf Spezial-Schiffen • Grundlagen und Systemtechnik der Hydraulik • Auslegung und Betrieb von Ausrüstungsanlagen
Literature	• H. Meyer-Peter, F. Bernhardt: Handbuch der Schiffsbetriebstechnik • H. Watter: Hydraulik und Pneumatik

Course L1250: Auxiliary Systems on Board of Ships	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	20 min
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	SoSe
Content	
Literature	Siehe korrespondierende Vorlesung

Course L2863: Sustainable Industrial Production	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Dr. Simon Markus Kothe
Language	DE
Cycle	SoSe
Content	Industrial production deals with the manufacture of physical products to satisfy human needs using various manufacturing processes that change the form and physical properties of raw materials. Manufacturing is a central driver of economic development and has a major impact on the well-being of humanity. However, the scale of current manufacturing activities results in enormous global energy and material demands that are harmful to both the environment and people. Historically, industrial activities were mostly oriented towards economic constraints, while social and environmental consequences were only hardly considered. As a result, today's global consumption rates of many resources and associated emissions often exceed the natural regeneration rate of our planet. In this respect, current industrial production can mostly be described as unsustainable. This is emphasized each year by the Earth Overshoot Day, which marks the day when humanity's ecological footprint exceeds the Earth's annual regenerative capacity. This lecture aims to provide the motivation, analytical methods as well as approaches for sustainable industrial production and to clarify the influence of the production phase in relation to the raw material, use and recycling phases in the entire life cycle of products. For this, the following topics will be highlighted: - Motivation for sustainable production, the 17 Sustainable Development Goals (SDGs) of the UN and their relevance for tomorrow's manufacturing; - raw material vs. production phase vs. use phase vs. recycling/end-of-life phase: importance of the production phase for the environmental impact of manufactured products; - Typical energy- and resource-intensive processes in industrial production and innovative approaches to increase energy and resource efficiency; - Methodology for optimizing the energy and resource efficiency of industrial manufacturing chains with the three steps of modeling (1), evaluating (2) and improving (3); - Resource efficiency of industrial manufacturing value chains and its assessment using life cycle analysis (LCA); - Exercise: LCA analysis of a manufacturing process (thermoplastic joining of an aircraft fuselage segment) as part of a product life cycle assessment.
Literature	Literatur: - Stefan Alexander (2020): Resource efficiency in manufacturing value chains. Cham: Springer International Publishing. - Hauschild, Michael Z.; Rosenbaum, Ralph K.; Olsen, Stig Irving (Hg.) (2018): Life Cycle Assessment. Theory and Practice. Cham: Springer International Publishing. - Kishita, Yusuke; Matsumoto, Mitsutaka; Inoue, Masato; Fukushige, Shinichi (2021): EcoDesign and sustainability. Singapore: Springer. - Schebek, Liselotte; Herrmann, Christoph; Cerdas, Felipe (2019): Progress in Life Cycle Assessment. Cham: Springer International Publishing. - Thiede, Sebastian; Hermann, Christoph (2019): Eco-factories of the future. Cham: Springer Nature Switzerland AG. - Vorlesungsskript.

Course L1375: Computational Fluid Dynamics - Exercises in OpenFoam	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Michael Schlüter
Language	EN
Cycle	SoSe
Content	• generation of numerical grids with a common grid generator • selection of models and boundary conditions • basic numerical simulation with OpenFoam within the TUHH CIP-Pool
Literature	OpenFoam Tutorials (StudIP)

Course L1052: Computational Fluid Dynamics in Process Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Michael Schlüter
Language	EN
Cycle	SoSe
Content	• Introduction into partial differential equations • Basic equations • Boundary conditions and grids • Numerical methods • Finite difference method • Finite volume method • Time discretisation and stability • Population balance • Multiphase Systems • Modeling of Turbulent Flows • Exercises: Stability Analysis • Exercises: Example on CFD - analytically/numerically
Literature	Paschedag A.R.: CFD in der Verfahrenstechnik: Allgemeine Grundlagen und mehrphasige Anwendungen, Wiley-VCH, 2004 ISBN 3-527-30994-2. Ferziger, J.H.; Peric, M.: Numerische Strömungsmechanik. Springer-Verlag, Berlin, 2008, ISBN: 3540675868. Ferziger, J.H.; Peric, M.: Computational Methods for Fluid Dynamics. Springer, 2002, ISBN 3-540-42074-6

Course L0072: Offshore Wind Parks	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. Alexander Mitzlaff
Language	DE
Cycle	WiSe
Content	• Nonlinear Waves: Stability, pattern formation, solitary states • Bottom Boundary layers: wave boundary layers, scour, stability of marine slopes • Ice-structure interaction • Wave and tidal current energy conversion
Literature	• Chakrabarti, S., Handbook of Offshore Engineering, vol. I&II, Elsevier 2005. • Mc Cormick, M.E., Ocean Wave Energy Conversion, Dover 2007. • Infeld, E., Rowlands, G., Nonlinear Waves, Solitons and Chaos, Cambridge 2000. • Johnson, R.S., A Modern Introduction to the Mathematical Theory of Water Waves, Cambridge 1997. • Lykousis, V. et al., Submarine Mass Movements and Their Consequences, Springer 2007. • Nielsen, P., Coastal Bottom Boundary Layers and Sediment Transport, World Scientific 2005. • Research Articles.

Course L0240: Selected Topics of Experimental and Theoretical Fluiddynamics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Thomas Rung
Language	DE
Cycle	WiSe
Content	Will be announced at the beginning of the lecture. Exemplary topics are 1. methods and procedures from experimental fluid mechanics 2. rational Approaches towards flow physics modelling 3. selected topics of theoretical computation fluid dynamics 4. turbulent flows
Literature	Wird in der Veranstaltung bekannt gegeben. To be announced during the lecture.

Course L1564: Turbines and Turbo Compressors	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Markus Schatz
Language	DE
Cycle	WiSe
Content	Skript in Papierform im Sekretariat HSU H10 R 310 erhältlich Traupel Thermische Turbomaschinen Bde 1, 2, Springer Verlag Berlin Heidelberg New York 1988 Oertel, Laurien Numerische Strömungsmechanik Springer Verlag Berlin Heidelberg New York 2001
Literature	Topics: 1. Three dimensional flows in axial grids 2. secondary flows in axial turbomachines, 3. basics of computational fluid dynamics (CFD) 4. CFD of turbomachinary 5. basics of radial turbomachines 6. exhaust turbo charger 7. hydrodynamic gears

Course L1565: Turbines and Turbo Compressors	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Markus Schatz
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0060: Hydrogen Technology	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Jun.-Prof. Julian Jepsen
Language	DE
Cycle	SoSe
Content	1. Energy economy 2. Hydrogen economy 3. Occurrence and properties of hydrogen 4. Production of hydrogen (from hydrocarbons and by electrolysis) 5. Separation and purification Storage and transport of hydrogen 6. Security 7. Fuel cells 8. Projects
Literature	• Skriptum zur Vorlesung • Winter, Nitsch: Wasserstoff als Energieträger • Ullmann's Encyclopedia of Industrial Chemistry • Kirk, Othmer: Encyclopedia of Chemical Technology • Larminie, Dicks: Fuel cell systems explained

Course L0011: Wind Turbine Plants	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Dr. Rudolf Zellermann
Language	DE
Cycle	SoSe
Content	• Historical development • Wind: origins, geographic and temporal distribution, locations • Power coefficient, rotor thrust • Aerodynamics of the rotor • Operating performance • Power limitation, partial load, pitch and stall control • Plant selection, yield prediction, economy • Excursion
Literature	Gasch, R., Windkraftanlagen, 4. Auflage, Teubner-Verlag, 2005

Module M1294: Bioenergy

Courses

Title	Typ	Hrs/wk	CP
Biofuels Process Technology (L0061)	Lecture	1	1
Biofuels Process Technology (L0062)	Recitation Section (small)	1	1
World Market for Commodities from Agriculture and Forestry (L1769)	Lecture	1	1
Thermal Biomass Utilization (L1767)	Lecture	2	2
Thermal Biomass Utilization (L2386)	Practical Course	1	1

Module Responsible	Prof. Martin Kaltschmitt
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to reproduce an in-depth outline of energy production from biomass, aerobic and anaerobic waste treatment processes, the gained products and the treatment of produced emissions.
Skills	Students can apply the learned theoretical knowledge of biomass-based energy systems to explain relationships for different tasks, like dimesioning and design of biomass power plants. In this context, students are also able to solve computational tasks for combustion, gasification and biogas, biodiesel and bioethanol use.
Personal Competence	
Social Competence	Students can participate in discussions to design and evaluate energy systems using biomass as an energy source.
Autonomy	Students can independently exploit sources with respect to the emphasis of the lectures. They can choose and aquire the for the particular task useful knowledge. Furthermore, they can solve computational tasks of biomass-based energy systems independently with the assistance of the lecture. Regarding to this they can assess their specific learning level and can consequently define the further workflow.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** Yes / None / Subject theoretical and practical work No / 10 % / Presentation
Examination	Written exam
Examination duration and scale	3 hours written exam
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Energy and Bioprocess Technology: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory

Course L0061: Biofuels Process Technology	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Oliver Lüdtke
Language	DE
Cycle	WiSe

Content	• General introduction
	• What are biofuels?
	• Markets & trends
	• Legal framework
	• Greenhouse gas savings
	• Generations of biofuels
	  ◦ first-generation bioethanol
	  ▪ raw materials
	  ▪ fermentation distillation
	  ◦ biobutanol / ETBE
	  ◦ second-generation bioethanol
	  ▪ bioethanol from straw
	  ◦ first-generation biodiesel
	  ▪ raw materials
	  ▪ Production Process
	  ▪ Biodiesel & Natural Resources
	  ◦ HVO / HEFA
	  ◦ second-generation biodiesel
	  ▪ Biodiesel from Algae
	• Biogas as fuel
	  ◦ the first biogas generation
	  ▪ raw materials
	  ▪ fermentation
	  ▪ purification to biomethane
	  ◦ Biogas second generation and gasification processes
	• Methanol / DME from wood and Tall oil ©

Literature	• Skriptum zur Vorlesung • Drapcho, Nhuan, Walker; Biofuels Engineering Process Technology • Harwardt; Systematic design of separations for processing of biorenewables • Kaltschmitt; Hartmann; Energie aus Biomasse: Grundlagen, Techniken und Verfahren • Mousdale; Biofuels - Biotechnology, Chemistry and Sustainable Development • VDI Wärmeatlas

Course L0062: Biofuels Process Technology	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Oliver Lüdtke
Language	DE
Cycle	WiSe

Content	• Life Cycle Assessment
	  ◦ Good example for the evaluation of CO2 savings potential by alternative fuels - Choice of system boundaries and databases
	• Bioethanol production
	  ◦ Application task in the basics of thermal separation processes (rectification, extraction) will be discussed. The focus is on a column design, including heat demand, number of stages, reflux ratio ...
	• Biodiesel production
	  ◦ Procedural options for solid / liquid separation, including basic equations for estimating power, energy demand, selectivity and throughput
	• Biomethane production
	  ◦ Chemical reactions that are relevant in the production of biofuels, including equilibria, activation energies, shift reactions

Literature	Skriptum zur Vorlesung

Course L1769: World Market for Commodities from Agriculture and Forestry	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Michael Köhl, Bernhard Chilla
Language	DE
Cycle	WiSe
Content	1) Markets for Agricultural Commodities What are the major markets and how are markets functioning Recent trends in world production and consumption. World trade is growing fast. Logistics. Bottlenecks. The major countries with surplus production Growing net import requirements, primarily of China, India and many other countries. Tariff and non-tariff market barriers. Government interferences. 2) Closer Analysis of Individual Markets Thomas Mielke will analyze in more detail the global vegetable oil markets, primarily palm oil, soya oil, rapeseed oil, sunflower oil. Also the raw material (the oilseed) as well as the by-product (oilmeal) will be included. The major producers and consumers. Vegetable oils and oilmeals are extracted from the oilseed. The importance of vegetable oils and animal fats will be highlighted, primarily in the food industry in Europe and worldwide. But in the past 15 years there have also been rapidly rising global requirements of oils & fats for non-food purposes, primarily as a feedstock for biodiesel but also in the chemical industry. Importance of oilmeals as an animal feed for the production of livestock and aquaculture Oilseed area, yields per hectare as well as production of oilseeds. Analysis of the major oilseeds worldwide. The focus will be on soybeans, rapeseed, sunflowerseed, groundnuts and cottonseed. Regional differences in productivity. The winners and losers in global agricultural production. 3) Forecasts: Future Global Demand & Production of Vegetable Oils Big challenges in the years ahead: Lack of arable land for the production of oilseeds, grains and other crops. Competition with livestock. Lack of water. What are possible solutions? Need for better education & management, more mechanization, better seed varieties and better inputs to raise yields. The importance of prices and changes in relative prices to solve market imbalances (shortage situations as well as surplus situations). How does it work? Time lags. Rapidly rising population, primarily the number of people considered “middle class” in the years ahead. Higher disposable income will trigger changing diets in favour of vegetable oils and livestock products. Urbanization. Today, food consumption per caput is partly still very low in many developing countries, primarily in Africa, some regions of Asia and in Central America. What changes are to be expected? The myth and the realities of palm oil in the world of today and tomorrow. Labour issues curb production growth: Some examples: 1) Shortage of labour in oil palm plantations in Malaysia. 2) Structural reforms overdue for the agriculture in India, China and other countries to become more productive and successful, thus improving the standard of living of smallholders.
Literature	Lecture material

Course L1767: Thermal Biomass Utilization	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Martin Kaltschmitt
Language	DE
Cycle	WiSe

Content	Goal of this course is it to discuss the physical, chemical, and biological as well as the technical, economic, and environmental basics of all options to provide energy from biomass from a German and international point of view. Additionally different system approaches to use biomass for energy, aspects to integrate bioenergy within the energy system, technical and economic development potentials, and the current and expected future use within the energy system are presented.
	
	The course is structured as follows:
	
	• Biomass as an energy carrier within the energy system; use of biomass in Germany and world-wide, overview on the content of the course
	• Photosynthesis, composition of organic matter, plant production, energy crops, residues, organic waste
	• Biomass provision chains for woody and herbaceous biomass, harvesting and provision, transport, storage, drying
	• Thermo-chemical conversion of solid biofuels
	  ◦ Basics of thermo-chemical conversion
	  ◦ Direct thermo-chemical conversion through combustion: combustion technologies for small and large scale units, electricity generation technologies, flue gas treatment technologies, ashes and their use
	  ◦ Gasification: Gasification technologies, producer gas cleaning technologies, options to use the cleaned producer gas for the provision of heat, electricity and/or fuels
	  ◦ Fast and slow pyrolysis: Technologies for the provision of bio-oil and/or for the provision of charcoal, oil cleaning technologies, options to use the pyrolysis oil and charcoal as an energy carrier as well as a raw material
	• Physical-chemical conversion of biomass containing oils and/or fats: Basics, oil seeds and oil fruits, vegetable oil production, production of a biofuel with standardized characteristics (trans-esterification, hydrogenation, co-processing in existing refineries), options to use this fuel, options to use the residues (i.e. meal, glycerine)
	• Bio-chemical conversion of biomass
	  ◦ Basics of bio-chemical conversion
	  ◦ Biogas: Process technologies for plants using agricultural feedstock, sewage sludge (sewage gas), organic waste fraction (landfill gas), technologies for the provision of bio methane, use of the digested slurry
	  ◦ Ethanol production: Process technologies for feedstock containing sugar, starch or celluloses, use of ethanol as a fuel, use of the stillage

Literature	**Kaltschmitt, M.; Hartmann, H. (Hrsg.): Energie aus Biomasse; Springer, Berlin, Heidelberg, 2009, 2. Auflage**

Course L2386: Thermal Biomass Utilization	
Typ	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Martin Kaltschmitt, Dr. Marvin Scherzinger
Language	DE
Cycle	WiSe
Content	The experiments of the practical lab course illustrate the different aspects of heat generation from biogenic solid fuels. First, different biomasses (e.g. wood, straw or agricultural residues) will be investigated; the focus will be on the calorific value of the biomass. Furthermore, the used biomass will be pelletized, the pellet properties analysed and a combustion test carried out on a pellet combustion system. The gaseous and solid pollutant emissions, especially the particulate matter emissions, are measured and the composition of the particulate matter is investigated in a further experiment. Another focus of the practical course is the consideration of options for the reduction of particulate matter emissions from biomass combustion. In the practical course, a method for particulate matter reduction will be developed and tested. All experiments will be evaluated and the results presented. Within the practical lab course the students discuss different technical-scientific tasks, both subject-specifically and interdisciplinary. They discuss various approaches to solving the problem and advise on the theoretical or practical implementation.
Literature	- Kaltschmitt, Martin; Hartmann, Hans; Hofbauer, Hermann: Energie aus Biomasse: Grundlagen, Techniken und Verfahren. 3. Auflage. Berlin Heidelberg: Springer Science & Business Media, 2016. -ISBN 978-3-662-47437-2 - Versuchsskript

Module M1250: Electrical Power Systems II: Operation and Information Systems of Electrical Power Grids

Courses

Title	Typ	Hrs/wk	CP
Electrical Power Systems II: Operation and Information Systems of Electrical Power Grids (L1696)	Lecture	3	4
Electrical Power Systems II: Operation and Information Systems of Electrical Power Grids (L1697)	Recitation Section (large)	2	2

Module Responsible	Prof. Christian Becker
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of Electrical Engineering, Electrical Power Systems I, Mathematics I, II, III
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to explain in detail and critically evaluate technologies and information systems for operational management of conventional and modern electric power systems as well as methods and algorithms for steady-state network calculation, failure calculation, power system operation and optimization. They are additonally able to apply these methods to real electric power systems.
Skills	With completion of this module the students are able to apply the acquired skills for planning and analysis of real electric power systems and to critically evaluate the results.
Personal Competence	
Social Competence	The students can participate in specialized and interdisciplinary discussions, advance ideas and represent their own work results in front of others.
Autonomy	Students can independently tap knowledge of the emphasis of the lectures and apply it within further research activities.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	45 min
Assignment for the Following Curricula	Electrical Engineering: Core Qualification: Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Computer Science in Engineering: Specialisation II. Engineering Science: Elective Compulsory

Course L1696: Electrical Power Systems II: Operation and Information Systems of Electrical Power Grids	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe

Content	• steaedy-state modelling of electric power systems
	  ◦ conventional components
	  ◦ Flexible AC Transmission Systems (FACTS) and HVDC
	  ◦ grid modelling
	• grid operation
	  ◦ electric power supply processes
	  ◦ grid and power system management
	  ◦ grid provision
	• grid control systems
	  ◦ information and communication systems for power system management
	  ◦ IT architectures of bay-, substation and network control level
	  ◦ IT integration (energy market / supply shortfall management / asset management)
	  ◦ future trends of process control technology
	  ◦ smart grids
	• functions and steady-state computations for power system operation and plannung
	  ◦ load-flow calculations
	  ◦ sensitivity analysis and power flow control
	  ◦ power system optimization
	  ◦ short-circuit calculation
	  ◦ asymmetric failure calculation
	  ▪ symmetric components
	  ▪ calculation of asymmetric failures
	  ◦ state estimation

Literature	E. Handschin: Elektrische Energieübertragungssysteme, Hüthig Verlag B. R. Oswald: Berechnung von Drehstromnetzen, Springer-Vieweg Verlag V. Crastan: Elektrische Energieversorgung Bd. 1 & 3, Springer Verlag E.-G. Tietze: Netzleittechnik Bd. 1 & 2, VDE-Verlag

Course L1697: Electrical Power Systems II: Operation and Information Systems of Electrical Power Grids	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1710: Smart Grid Technologies

Courses

Title	Typ	Hrs/wk	CP
Smart Grid Technologies (L2706)	Lecture	3	4
Smart Grid Technologies (L2707)	Project-/problem-based Learning	2	2

Module Responsible	Prof. Christian Becker
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of Electrical Engineering, Introduction to Control Systems, Mathematics I, II, III Electrical Power Systems I Electrical Power Systems II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to explain in detail and critically evaluate methods and technologies for operation of smart grids (i.e. intelligent distribution grids).
Skills	With completion of this module the students are able to analyze the impact of emerging technologies (such as renewables, energy storage and demand response) on the electric power system. They can formulate and apply computational intelligence techniques to power system operation problems. They can also explain what ICT technologies (such as digital twins and IoT) are relevant and suitable for distribution grid operation.
Personal Competence	
Social Competence	The students can participate in specialized and interdisciplinary discussions, advance ideas and represent their own work results in front of others.
Autonomy	Students can independently tap knowledge of the emphasis of the lectures and apply it within further research activities.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Presentation
Examination duration and scale	30 min
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Renewable Energies: Specialisation Solar Energy Systems: Elective Compulsory

Course L2706: Smart Grid Technologies	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christian Becker, Dr. Davood Babazadeh
Language	DE/EN
Cycle	WiSe/SoSe

Content	**Introduction to Smart Grids**
	• Intelligent Distribution Grids
	• Paradigm shifts: Digitalization & Sustainability
	Emerging technologies in distribution grids
	• Distributed Energy Resource (DER)
	• Battery Energy Storage (BES) technologies
	• Sector-coupling & EV/V2G
	• Microgrids, Inverter-based Systems
	• Modelling and control of PV & BESS
	Distribution grid management & analysis
	• Distribution grid structure (Hamburg example)
	• Distribution grid management and operation architecture and functions
	  ◦ Fault Detection, Isolation & Restoration
	  ◦ Self-Healing in distribution systems
	  ◦ Volt-Var Optimization
	  ◦ Distribution Load Flow
	• Demand Side Management & Demand Response
	• Lab exercise (Smart Grid Operation)
	Computational intelligence and optimization techniques in Smart Grids
	• Computational challenges in Smart grid
	• Heuristic & Analytic Optimization Methods
	• Intelligent Systems (Expert Systems, ML/AL)
	• Applications (optimal load flow, reactive capacitor placement)
	• Lab exercise (optimization formulation)
	ICT Technologies for Smart Grids
	• Advanced Metering Technologies: Smart Meters, RTU, PMU
	• Telecommunication Systems in Smart Grids (network basics and technologies)
	• Interoperability in Smart grids
	  ◦ Smart Grid Architecture Model
	  ◦ Automation and Communication standards (IEC 61850, c37.118)
	• Cyber security
	• Lab exercise (Grid automation protocols)
	Practical lesson-learned: Stromnetz Hamburg (SNH) perspective
	• Definition of Smart Grid and its requirements from industry view
	• Grid digitalization - examples of industrial projects
	• Flexible load management
	• Electromobility & transportation sector integration
	Study visits:
	• Digital Substation in Harburg
	• Electric Bus charging station
	Stromnetz Hamburg Control Center

Literature	• Buchholz and Styczynski - 2020 - “Smart Grids: Fundamentals and Technologies in Electric Power Systems of the Future”, Springer • Bernardon and Garcia - 2018 - “Smart Operation for Power Distribution Systems: Concepts and Applications”, Springer • Momoh, 2012; “Smart Grid: Fundamentals of Design and Analysis”, Wiley

Course L2707: Smart Grid Technologies	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Becker, Dr. Davood Babazadeh
Language	DE/EN
Cycle	WiSe/SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1354: Advanced Fuels

Courses

Title	Typ	Hrs/wk	CP
Second generation biofuels and electricity based fuels (L2414)	Lecture	2	2
Carbon dioxide as an economic determinant in the mobility sector (L1926)	Lecture	1	1
Mobility and climate protection (L2416)	Recitation Section (small)	2	2
Sustainability aspects and regulatory framework (L2415)	Lecture	1	1

Module Responsible	Prof. Martin Kaltschmitt
Admission Requirements	None
Recommended Previous Knowledge	Bachelor degree in Process Engineering, Bioprocess Engineering or Energy- and Environmental Engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Within the module, students learn about different provision pathways for the production of advanced fuels (biofuels like e.g. alcohol-to-jet; electricity-based fuels like e.g. power-to-liquid). The different processes chains are explained and the regulatory framework for sustainable fuel production is examined. This includes, for example, the requirements of the Renewable Energies Directive II and the conditions and aspects for a market ramp-up of these fuels. For the holistic assessment of the various fuel options, they are also examined under environmental and economic factors.
Skills	After successfully participating, the students are able to solve simulation and application tasks of renewable energy technology: • Module-spanning solutions for the design and presentation of fuel production processes resp. the fuel provision chains • Comprehensive analysis of various fuel production options in technical, ecological and economic terms Through active discussions of the various topics within the lectures and exercises of the module, the students improve their understanding and application of the theoretical foundations and are thus able to transfer the learned to the practice.
Personal Competence	
Social Competence	The students can discuss scientific tasks in a subject-specific and interdisciplinary way and develop joint solutions.
Autonomy	The students are able to access independent sources about the questions to be addressed and to acquire the necessary knowledge. They are able to assess their respective learning situation concretely in consultation with their supervisor and to define further questions and solutions.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6

Course achievement

Compulsory	Bonus	Form	Description
Yes	20 %	Written elaboration	Details werden in der ersten Veranstaltung bekannt gegeben.

Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Energy and Bioprocess Technology: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Aeronautics: Core Qualification: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Renewable Energies: Specialisation Solar Energy Systems: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory

Course L2414: Second generation biofuels and electricity based fuels	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Martin Kaltschmitt
Language	DE/EN
Cycle	WiSe
Content	• General overview of various power-based fuels and their process paths, including power-to-liquid process (Fischer-Tropsch synthesis, methanol synthesis), power-to-gas (Sabatier process) • Origin, production and use of these fuels
Literature	• Vorlesungsskript

Course L1926: Carbon dioxide as an economic determinant in the mobility sector	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Karsten Wilbrand
Language	DE/EN
Cycle	WiSe
Content	• General overview of various advanced biofuels and their process pathways (including gas-to-liquid, HEFA and Alcohol-to-Jet processes) • Origin, production and use of these fuels
Literature	• Babu, V.: Biofuels Production. Beverly, Mass: Scrivener [u.a.], 2013 • Olsson, L.: Biofuels. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg, 2007 • William, L. L.: Distillation Design and Control Using Aspen Simulation; ISBN-10: 0-471-77888-5 • Perry, R.; Green, R.: Perry's Chemical Engineers' Handbook, 8th Edition, McGraw Hill Professional, 20 • Sinnot, R. K.: Chemical Engineering Design, Elsevier, 2014 • Kaltschmitt, M.; Neuling, U. (Ed.): Biokerosene - Status and Prospects; Springer, Berlin, Heidelberg, 2018

Course L2416: Mobility and climate protection	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Benedikt Buchspies, Dr. Karsten Wilbrand
Language	DE/EN
Cycle	WiSe
Content	Application of the acquired theoretical knowledge from the respective lectures on the basis of concrete tasks from practice • Design and simulation of sub-processes of production processes in Aspen Plus ® • Ecological and economic analysis of fuel supply paths • Classification of case studies into applicable regulations
Literature	• Skriptum zur Vorlesung • Aspen Plus® - Aspen Plus User Guide

Course L2415: Sustainability aspects and regulatory framework	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Benedikt Buchspies
Language	DE/EN
Cycle	WiSe
Content	Holistic examination of the different fuel paths with the following main topics, among others: • Consideration of the environmental impact of the various alternative fuels • Economic consideration of the different alternative fuels • Regulatory framework for alternative fuels • Certification of alternative fuels • Market introduction models of alternative fuels
Literature	• European Commission - Joint Research Center (2010): International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance. Joint Research Center (JRC) Institut for Environment and Sustainability, Luxembourg • Richtlinie (EU) 2018/2001 des Europäischen Parlaments und des Rates vom 11. Dezember 2018 zur Förderung der Nutzung von Energie aus erneuerbaren Quellen

Specialization Marine Engineering

The Marine Engineering specialization covers a wide range of marine engineering aspects, such as Ships' Engines, Ship Vibrations, Maritime Technology and Offshore Wind Farms, Ships' Propellers, Ship Acoustics, and Auxiliary Plant on Board Ships, and also conventional energy systems aspects, such as Turbomachines, Thermal Engineering, or Air Conditioning. Here too the focus is on complex marine engineering systems and the efficient provision of electricity, heating, and refrigeration.

Students learn to understand complex ships' systems, to describe them physically, and to model them mathematically. They are able to analyze and assess complex aspects of marine engineering in the context of current maritime issues.

Module M0528: Maritime Technology and Offshore Wind Parks

Courses

Title	Typ	Hrs/wk	CP
Introduction to Maritime Technology (L0070)	Lecture	2	2
Introduction to Maritime Technology (L1614)	Recitation Section (small)	1	1
Offshore Wind Parks (L0072)	Lecture	2	3

Module Responsible	Prof. Moustafa Abdel-Maksoud
Admission Requirements	None
Recommended Previous Knowledge	Qualified Bachelor of a natural or engineering science; Solid knowledge and competences in mathematics, mechanics, fluid dynamics. Basic knowledge of ocean engineering topics (e.g. from an introductory class like 'Introduction to Maritime Technology')
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge*	After successful completion of this class, students should have an overview about phenomena and methods in ocean engineering and the ability to apply and extend the methods presented. In detail, the students should be able to • describe the different aspects and topics in Maritime Technology, • apply existing methods to problems in Maritime Technology, • discuss limitations in present day approaches and perspectives in the future. Based on research topics of present relevance the participants are to be prepared for independent research work in the field. For that purpose specific research problems of workable scope will be addressed in the class. After successful completion of this module, students should be able to • Show present research questions in the field • Explain the present state of the art for the topics considered • Apply given methodology to approach given problems • Evaluate the limits of the present methods • Identify possibilities to extend present methods • Evaluate the feasibility of further developments
Skills	
Personal Competence *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	180 min
Assignment for the Following Curricula	Energy Systems: Specialisation Marine Engineering: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory

Course L0070: Introduction to Maritime Technology	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Walter Kuehnlein, Dr. Sven Hoog
Language	DE
Cycle	WiSe
Content	1. Introduction • Ocean Engineering and Marine Research • The potentials of the seas • Industries and occupational structures 2. Coastal and offshore Environmental Conditions • Physical and chemical properties of sea water and sea ice • Flows, waves, wind, ice • Biosphere 3. Response behavior of Technical Structures 4. Maritime Systems and Technologies • General Design and Installation of Offshore-Structures • Geophysical and Geotechnical Aspects • Fixed and Floating Platforms • Mooring Systems, Risers, Pipelines • Energy conversion: Wind, Waves, Tides
Literature	• Chakrabarti, S., Handbook of Offshore Engineering, vol. I/II, Elsevier 2005. • Gerwick, B.C., Construction of Marine and Offshore Structures, CRC-Press 1999. • Wagner, P., Meerestechnik, Ernst&Sohn 1990. • Clauss, G., Meerestechnische Konstruktionen, Springer 1988. • Knauss, J.A., Introduction to Physical Oceanography, Waveland 2005. • Wright, J. et al., Waves, Tides and Shallow-Water Processes, Butterworth 2006. • Faltinsen, O.M., Sea Loads on Ships and Offshore Structures, Cambridge 1999.

Course L1614: Introduction to Maritime Technology	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Walter Kuehnlein
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0072: Offshore Wind Parks	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Alexander Mitzlaff
Language	DE
Cycle	WiSe
Content	• Nonlinear Waves: Stability, pattern formation, solitary states • Bottom Boundary layers: wave boundary layers, scour, stability of marine slopes • Ice-structure interaction • Wave and tidal current energy conversion
Literature	• Chakrabarti, S., Handbook of Offshore Engineering, vol. I&II, Elsevier 2005. • Mc Cormick, M.E., Ocean Wave Energy Conversion, Dover 2007. • Infeld, E., Rowlands, G., Nonlinear Waves, Solitons and Chaos, Cambridge 2000. • Johnson, R.S., A Modern Introduction to the Mathematical Theory of Water Waves, Cambridge 1997. • Lykousis, V. et al., Submarine Mass Movements and Their Consequences, Springer 2007. • Nielsen, P., Coastal Bottom Boundary Layers and Sediment Transport, World Scientific 2005. • Research Articles.

Module M1210: Selected Topics of Marine Engineering - Option A

Courses

Title	Typ	Hrs/wk	CP
Auxiliary Systems on Board of Ships (L1249)	Lecture	2	2
Auxiliary Systems on Board of Ships (L1250)	Recitation Section (large)	1	1
Cavitation (L1596)	Lecture	2	3
Manoeuvrability of Ships (L1597)	Lecture	2	3
Sustainable Industrial Production (L2863)	Lecture	2	4
Ship Acoustics (L1605)	Lecture	2	3
Marine Propellers (L1269)	Lecture	2	2
Marine Propellers (L1270)	Project-/problem-based Learning	2	1
Special Topics of Ship Propulsion (L1589)	Lecture	3	3
Internal Combustion Engines II (L1079)	Lecture	2	2
Internal Combustion Engines II (L1080)	Recitation Section (large)	1	2

Module Responsible	Prof. Christopher Friedrich Wirz
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
Skills	The students are able to apply their understanding of specific topics in mechanical engineering as well as naval architecture to describe and design complex systems.
Personal Competence	
Social Competence	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.
Autonomy	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.
Workload in Hours	Depends on choice of courses
Credit points	12
Assignment for the Following Curricula	Energy Systems: Specialisation Marine Engineering: Elective Compulsory

Course L1249: Auxiliary Systems on Board of Ships

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	20 min
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	SoSe
Content	• Vorschriften zur Schiffsausrüstung • Ausrüstungsanlagen auf Standard-Schiffen • Ausrüstungsanlagen auf Spezial-Schiffen • Grundlagen und Systemtechnik der Hydraulik • Auslegung und Betrieb von Ausrüstungsanlagen
Literature	• H. Meyer-Peter, F. Bernhardt: Handbuch der Schiffsbetriebstechnik • H. Watter: Hydraulik und Pneumatik

Course L1250: Auxiliary Systems on Board of Ships	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	20 min
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	SoSe
Content	
Literature	Siehe korrespondierende Vorlesung

Course L1596: Cavitation	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE
Cycle	SoSe
Content	• Phenomenon and type of cavitation • Test facilities and instrumentations • Dynamics of bubbles • Bubbles cavitation • Supercavitation • Ventilated supercavities • Vortex cavitation • Sheet cavitation • Cavitation in rotary machines • Numerical cavitation models I • Numerical cavitation models II • Pressure fluctuation • Erosion and noise
Literature	• Lewis, V. E. (Ed.) , Principles of Naval Architecture, Resistance Propulsion, Vibration, Volume II, Controllability, SNAME, New York, 1989. • Isay, W. H., Kavitation, Schiffahrt-Verlag Hansa, Hamburg, 1989. • Franc, J.-P., Michel, J.-M. Fundamentals of Cavitation, Kluwer Academic Publisher, 2004. • Lecoffre, Y., Cavitation Bubble Trackers, Balkema / Rotterdam / Brookfield, 1999. • Brennen, C. E., Cavitation and Bubble Dynamics, Oxford University Press, 1995.

Course L1597: Manoeuvrability of Ships	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE/EN
Cycle	WiSe
Content	• coordinates & degrees of freedom • governing equations of motion • hydrodynamic forces & moments • ruder forces • navigation based on linearised eq.of motion(exemplary solutions, yaw stability) • manoeuvering test (constraint & unconstraint motion) • slender body approximation **Learning Outcomes** Introduction into basic concepts for the assessment and prognosis ship manoeuvrabilit. Ability to develop methods for analysis of manoeuvring behaviour of ships.
Literature	• Crane, C. L. H., Eda, A. L., Principles of Naval Architecture, Chapter 9, Controllability, SNAME, New York, 1989 • Brix, J., Manoeuvring Technical Manual, Seehafen Verlag GmbH, Hamburg 1993 • Söding, H., Manövrieren , Vorlesungsmanuskript, Institut für Fluiddynamik und Schiffstheorie, TUHH, Hamburg, 1995

Course L2863: Sustainable Industrial Production	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Dr. Simon Markus Kothe
Language	DE
Cycle	SoSe
Content	Industrial production deals with the manufacture of physical products to satisfy human needs using various manufacturing processes that change the form and physical properties of raw materials. Manufacturing is a central driver of economic development and has a major impact on the well-being of humanity. However, the scale of current manufacturing activities results in enormous global energy and material demands that are harmful to both the environment and people. Historically, industrial activities were mostly oriented towards economic constraints, while social and environmental consequences were only hardly considered. As a result, today's global consumption rates of many resources and associated emissions often exceed the natural regeneration rate of our planet. In this respect, current industrial production can mostly be described as unsustainable. This is emphasized each year by the Earth Overshoot Day, which marks the day when humanity's ecological footprint exceeds the Earth's annual regenerative capacity. This lecture aims to provide the motivation, analytical methods as well as approaches for sustainable industrial production and to clarify the influence of the production phase in relation to the raw material, use and recycling phases in the entire life cycle of products. For this, the following topics will be highlighted: - Motivation for sustainable production, the 17 Sustainable Development Goals (SDGs) of the UN and their relevance for tomorrow's manufacturing; - raw material vs. production phase vs. use phase vs. recycling/end-of-life phase: importance of the production phase for the environmental impact of manufactured products; - Typical energy- and resource-intensive processes in industrial production and innovative approaches to increase energy and resource efficiency; - Methodology for optimizing the energy and resource efficiency of industrial manufacturing chains with the three steps of modeling (1), evaluating (2) and improving (3); - Resource efficiency of industrial manufacturing value chains and its assessment using life cycle analysis (LCA); - Exercise: LCA analysis of a manufacturing process (thermoplastic joining of an aircraft fuselage segment) as part of a product life cycle assessment.
Literature	Literatur: - Stefan Alexander (2020): Resource efficiency in manufacturing value chains. Cham: Springer International Publishing. - Hauschild, Michael Z.; Rosenbaum, Ralph K.; Olsen, Stig Irving (Hg.) (2018): Life Cycle Assessment. Theory and Practice. Cham: Springer International Publishing. - Kishita, Yusuke; Matsumoto, Mitsutaka; Inoue, Masato; Fukushige, Shinichi (2021): EcoDesign and sustainability. Singapore: Springer. - Schebek, Liselotte; Herrmann, Christoph; Cerdas, Felipe (2019): Progress in Life Cycle Assessment. Cham: Springer International Publishing. - Thiede, Sebastian; Hermann, Christoph (2019): Eco-factories of the future. Cham: Springer Nature Switzerland AG. - Vorlesungsskript.

Course L1605: Ship Acoustics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Dietrich Wittekind
Language	DE
Cycle	SoSe
Content	
Literature	

Course L1269: Marine Propellers	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Stefan Krüger
Language	DE
Cycle	SoSe
Content	The lectures starts with the description of the propeller blade outline parameters. The design fundamantals for the blade parameters are introduced. The momentum theory for screw propellers is treated. The design optimization of the propeller by means of systematic propeller series is considered. The lecture then treats the profile theory of the airfoil with infinite span (singularity methods) for the most common technical profiles. Lifting line theory is introduced as calculation tool for radial circulation distribution. The lecture continues with the interaction propeller and main propulsion plant. Strategies to control a CPP are discussed. The lecture closes with the most important cavitation phenemena which are relevant for the determination of pressure fluctuations.
Literature	W.H. Isay, Propellertheorie. Springer Verlag.

Course L1270: Marine Propellers	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Stefan Krüger
Language	DE
Cycle	SoSe
Content	The lectures starts with the description of the propeller blade outline parameters. The design fundamantals for the blade parameters are introduced. The momentum theory for screw propellers is treated. The design optimization of the propeller by means of systematic propeller series is considered. The lecture then treats the profile theory of the airfoil with infinite span (singularity methods) for the most common technical profiles. Lifting line theory is introduced as calculation tool for radial circulation distribution. The lecture continues with the interaction propeller and main propulsion plant. Strategies to control a CPP are discussed. The lecture closes with the most important cavitation phenemena which are relevant for the determination of pressure fluctuations.
Literature	W.H. Isay, Propellertheorie. Springer Verlag.

Course L1589: Special Topics of Ship Propulsion	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE/EN
Cycle	SoSe
Content	1. Propeller Geometry 2. Cavitation 3. Model Tests, Propeller-Hull Interaction 4. Pressure Fluctuation / Vibration 5. Potential Theory 6. Propeller Design 7. Controllable Pitch Propellers 8. Ducted Propellers 9. Podded Drives 10. Water Jet Propulsion 11. Voith-Schneider-Propulsors
Literature	• Breslin, J., P., Andersen, P., Hydrodynamics of Ship Propellers, Cambridge Ocean Technology, Series 3, Cambridge University Press, 1996. • Lewis, V. E., ed., Principles of Naval Architecture, Volume II Resistance, Propulsion and Vibration, SNAME, 1988. • N. N., International Confrrence Waterjet 4, RINA London, 2004 • N. N., 1st International Conference on Technological Advances in Podded Propulsion, Newcastle, 2004

Course L1079: Internal Combustion Engines II	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Wolfgang Thiemann
Language	DE
Cycle	WiSe
Content	- Engine Examples - Pistons an pistons components - Connecting rod and crankshaft - Engine bearings and engine body - Cylinder head and valve train - Injection and charging systems
Literature	- Vorlesungsskript als Blattsammlung (auch als pdf-download oder CD verfügbar) - Übungsaufgaben mit Lösungsweg - Literaturliste

Course L1080: Internal Combustion Engines II	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Wolfgang Thiemann
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1149: Marine Power Engineering

Courses

Title	Typ	Hrs/wk	CP
Electrical Installation on Ships (L1531)	Lecture	2	2
Electrical Installation on Ships (L1532)	Recitation Section (large)	1	1
Marine Engineering (L1569)	Lecture	2	2
Marine Engineering (L1570)	Recitation Section (large)	1	1

Module Responsible	Prof. Christopher Friedrich Wirz
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe the state-of-the-art regarding the wide range of propulsion components on ships and apply their knowledge. They further know how to analyze and optimize the interaction of the components of the propulsion system and how to describe complex correlations with the specific technical terms in German and English. The students are able to name the operating behaviour of consumers, describe special requirements on the design of supply networks and to the electrical equipment in isolated networks, as e.g. onboard ships, offshore units, factories and emergency power supply systems, explain power generation and distribution in isolated grids, wave generator systems on ships, and name requirements for network protection, selectivity and operational monitoring.
Skills	The students are skilled to employ basic and detail knowledge regarding reciprocating machinery, their selection and operation on board ships. They are further able to assess, analyse and solve technical and operational problems with propulsion and auxiliary plants and to design propulsion systems. The students have the skills to describe complex correlations and bring them into context with related disciplines. Students are able to calculate short-circuit currents, switchgear, and design electrical propulsion systems for ships.
Personal Competence	
Social Competence	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.
Autonomy	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 minutes plus 20 minutes oral exam
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory

Course L1531: Electrical Installation on Ships	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	WiSe
Content	• performance in service of electrical consumers. • special requirements for power supply systems and for electrical equipment in isolated systems/networks e. g. aboard ships, offshore installations, factory systems and emergency power supply systems. • power generation and distribution in isolated networks, shaft generators for ships • calculation of short circuits and behaviour of switching devices • protective devices, selectivity monitoring • electrical Propulsion plants for ships
Literature	H. Meier-Peter, F. Bernhardt u. a.: Handbuch der Schiffsbetriebstechnik, Seehafen Verlag (engl. Version: "Compendium Marine Engineering") Gleß, Thamm: Schiffselektrotechnik, VEB Verlag Technik Berlin

Course L1532: Electrical Installation on Ships	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1569: Marine Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	WiSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1570: Marine Engineering	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1347: Selected Topics of Marine Engineering - Option B

Courses

Title	Typ	Hrs/wk	CP
Auxiliary Systems on Board of Ships (L1249)	Lecture	2	2
Auxiliary Systems on Board of Ships (L1250)	Recitation Section (large)	1	1
Cavitation (L1596)	Lecture	2	3
Manoeuvrability of Ships (L1597)	Lecture	2	3
Sustainable Industrial Production (L2863)	Lecture	2	4
Ship Acoustics (L1605)	Lecture	2	3
Marine Propellers (L1269)	Lecture	2	2
Marine Propellers (L1270)	Project-/problem-based Learning	2	1
Special Topics of Ship Propulsion (L1589)	Lecture	3	3
Internal Combustion Engines II (L1079)	Lecture	2	2
Internal Combustion Engines II (L1080)	Recitation Section (large)	1	2

Module Responsible	Prof. Christopher Friedrich Wirz
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
Skills	The students are able to apply their understanding of specific topics in mechanical engineering as well as naval architecture to describe and design complex systems.
Personal Competence	
Social Competence	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.
Autonomy	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Energy Systems: Specialisation Marine Engineering: Elective Compulsory

Course L1249: Auxiliary Systems on Board of Ships

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	20 min
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	SoSe
Content	• Vorschriften zur Schiffsausrüstung • Ausrüstungsanlagen auf Standard-Schiffen • Ausrüstungsanlagen auf Spezial-Schiffen • Grundlagen und Systemtechnik der Hydraulik • Auslegung und Betrieb von Ausrüstungsanlagen
Literature	• H. Meyer-Peter, F. Bernhardt: Handbuch der Schiffsbetriebstechnik • H. Watter: Hydraulik und Pneumatik

Course L1250: Auxiliary Systems on Board of Ships	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	20 min
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	SoSe
Content	
Literature	Siehe korrespondierende Vorlesung

Course L1596: Cavitation	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE
Cycle	SoSe
Content	• Phenomenon and type of cavitation • Test facilities and instrumentations • Dynamics of bubbles • Bubbles cavitation • Supercavitation • Ventilated supercavities • Vortex cavitation • Sheet cavitation • Cavitation in rotary machines • Numerical cavitation models I • Numerical cavitation models II • Pressure fluctuation • Erosion and noise
Literature	• Lewis, V. E. (Ed.) , Principles of Naval Architecture, Resistance Propulsion, Vibration, Volume II, Controllability, SNAME, New York, 1989. • Isay, W. H., Kavitation, Schiffahrt-Verlag Hansa, Hamburg, 1989. • Franc, J.-P., Michel, J.-M. Fundamentals of Cavitation, Kluwer Academic Publisher, 2004. • Lecoffre, Y., Cavitation Bubble Trackers, Balkema / Rotterdam / Brookfield, 1999. • Brennen, C. E., Cavitation and Bubble Dynamics, Oxford University Press, 1995.

Course L1597: Manoeuvrability of Ships	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE/EN
Cycle	WiSe
Content	• coordinates & degrees of freedom • governing equations of motion • hydrodynamic forces & moments • ruder forces • navigation based on linearised eq.of motion(exemplary solutions, yaw stability) • manoeuvering test (constraint & unconstraint motion) • slender body approximation **Learning Outcomes** Introduction into basic concepts for the assessment and prognosis ship manoeuvrabilit. Ability to develop methods for analysis of manoeuvring behaviour of ships.
Literature	• Crane, C. L. H., Eda, A. L., Principles of Naval Architecture, Chapter 9, Controllability, SNAME, New York, 1989 • Brix, J., Manoeuvring Technical Manual, Seehafen Verlag GmbH, Hamburg 1993 • Söding, H., Manövrieren , Vorlesungsmanuskript, Institut für Fluiddynamik und Schiffstheorie, TUHH, Hamburg, 1995

Course L2863: Sustainable Industrial Production	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	60 min
Lecturer	Dr. Simon Markus Kothe
Language	DE
Cycle	SoSe
Content	Industrial production deals with the manufacture of physical products to satisfy human needs using various manufacturing processes that change the form and physical properties of raw materials. Manufacturing is a central driver of economic development and has a major impact on the well-being of humanity. However, the scale of current manufacturing activities results in enormous global energy and material demands that are harmful to both the environment and people. Historically, industrial activities were mostly oriented towards economic constraints, while social and environmental consequences were only hardly considered. As a result, today's global consumption rates of many resources and associated emissions often exceed the natural regeneration rate of our planet. In this respect, current industrial production can mostly be described as unsustainable. This is emphasized each year by the Earth Overshoot Day, which marks the day when humanity's ecological footprint exceeds the Earth's annual regenerative capacity. This lecture aims to provide the motivation, analytical methods as well as approaches for sustainable industrial production and to clarify the influence of the production phase in relation to the raw material, use and recycling phases in the entire life cycle of products. For this, the following topics will be highlighted: - Motivation for sustainable production, the 17 Sustainable Development Goals (SDGs) of the UN and their relevance for tomorrow's manufacturing; - raw material vs. production phase vs. use phase vs. recycling/end-of-life phase: importance of the production phase for the environmental impact of manufactured products; - Typical energy- and resource-intensive processes in industrial production and innovative approaches to increase energy and resource efficiency; - Methodology for optimizing the energy and resource efficiency of industrial manufacturing chains with the three steps of modeling (1), evaluating (2) and improving (3); - Resource efficiency of industrial manufacturing value chains and its assessment using life cycle analysis (LCA); - Exercise: LCA analysis of a manufacturing process (thermoplastic joining of an aircraft fuselage segment) as part of a product life cycle assessment.
Literature	Literatur: - Stefan Alexander (2020): Resource efficiency in manufacturing value chains. Cham: Springer International Publishing. - Hauschild, Michael Z.; Rosenbaum, Ralph K.; Olsen, Stig Irving (Hg.) (2018): Life Cycle Assessment. Theory and Practice. Cham: Springer International Publishing. - Kishita, Yusuke; Matsumoto, Mitsutaka; Inoue, Masato; Fukushige, Shinichi (2021): EcoDesign and sustainability. Singapore: Springer. - Schebek, Liselotte; Herrmann, Christoph; Cerdas, Felipe (2019): Progress in Life Cycle Assessment. Cham: Springer International Publishing. - Thiede, Sebastian; Hermann, Christoph (2019): Eco-factories of the future. Cham: Springer Nature Switzerland AG. - Vorlesungsskript.

Course L1605: Ship Acoustics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Dietrich Wittekind
Language	DE
Cycle	SoSe
Content	
Literature	

Course L1269: Marine Propellers	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Stefan Krüger
Language	DE
Cycle	SoSe
Content	The lectures starts with the description of the propeller blade outline parameters. The design fundamantals for the blade parameters are introduced. The momentum theory for screw propellers is treated. The design optimization of the propeller by means of systematic propeller series is considered. The lecture then treats the profile theory of the airfoil with infinite span (singularity methods) for the most common technical profiles. Lifting line theory is introduced as calculation tool for radial circulation distribution. The lecture continues with the interaction propeller and main propulsion plant. Strategies to control a CPP are discussed. The lecture closes with the most important cavitation phenemena which are relevant for the determination of pressure fluctuations.
Literature	W.H. Isay, Propellertheorie. Springer Verlag.

Course L1270: Marine Propellers	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Stefan Krüger
Language	DE
Cycle	SoSe
Content	The lectures starts with the description of the propeller blade outline parameters. The design fundamantals for the blade parameters are introduced. The momentum theory for screw propellers is treated. The design optimization of the propeller by means of systematic propeller series is considered. The lecture then treats the profile theory of the airfoil with infinite span (singularity methods) for the most common technical profiles. Lifting line theory is introduced as calculation tool for radial circulation distribution. The lecture continues with the interaction propeller and main propulsion plant. Strategies to control a CPP are discussed. The lecture closes with the most important cavitation phenemena which are relevant for the determination of pressure fluctuations.
Literature	W.H. Isay, Propellertheorie. Springer Verlag.

Course L1589: Special Topics of Ship Propulsion	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE/EN
Cycle	SoSe
Content	1. Propeller Geometry 2. Cavitation 3. Model Tests, Propeller-Hull Interaction 4. Pressure Fluctuation / Vibration 5. Potential Theory 6. Propeller Design 7. Controllable Pitch Propellers 8. Ducted Propellers 9. Podded Drives 10. Water Jet Propulsion 11. Voith-Schneider-Propulsors
Literature	• Breslin, J., P., Andersen, P., Hydrodynamics of Ship Propellers, Cambridge Ocean Technology, Series 3, Cambridge University Press, 1996. • Lewis, V. E., ed., Principles of Naval Architecture, Volume II Resistance, Propulsion and Vibration, SNAME, 1988. • N. N., International Confrrence Waterjet 4, RINA London, 2004 • N. N., 1st International Conference on Technological Advances in Podded Propulsion, Newcastle, 2004

Course L1079: Internal Combustion Engines II	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Wolfgang Thiemann
Language	DE
Cycle	WiSe
Content	- Engine Examples - Pistons an pistons components - Connecting rod and crankshaft - Engine bearings and engine body - Cylinder head and valve train - Injection and charging systems
Literature	- Vorlesungsskript als Blattsammlung (auch als pdf-download oder CD verfügbar) - Übungsaufgaben mit Lösungsweg - Literaturliste

Course L1080: Internal Combustion Engines II	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Wolfgang Thiemann
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1518: Technical Complementary Course for ENTMS, Option A (according to Subject Specific Regulations)

Courses

Title	Typ	Hrs/wk	CP

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	See selected module according to FSPO
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	See selected module according to FSPO
Skills	See selected module according to FSPO
Personal Competence	
Social Competence	See selected module according to FSPO
Autonomy	See selected module according to FSPO
Workload in Hours	Depends on choice of courses
Credit points	12
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory

Module M1504: Technical Complementary Course for ENTMS, Option B (according to Subject Specific Regulations)

Courses

Title	Typ	Hrs/wk	CP

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	See selected module according to FSPO
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	See selected module according to FSPO
Skills	See selected module according to FSPO
Personal Competence	
Social Competence	See selected module according to FSPO
Autonomy	See selected module according to FSPO
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Energy Systems: Core Qualification: Elective Compulsory

Module M1021: Marine Diesel Engine Plants

Courses

Title	Typ	Hrs/wk	CP
Marine Diesel Engine Plants (L0637)	Lecture	3	4
Marine Diesel Engine Plants (L0638)	Recitation Section (large)	1	2

Module Responsible	Prof. Christopher Friedrich Wirz
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can • explain different types four / two-stroke engines and assign types to given engines, • name definitions and characteristics, as well as • elaborate on special features of the heavy oil operation, lubrication and cooling.
Skills	Students can • evaluate the interaction of ship, engine and propeller, • use relationships between gas exchange, flushing, air demand, charge injection and combustion for the design of systems, • design waste heat recovery, starting systems, controls, automation, foundation and design machinery spaces , and • apply evaluation methods for excited motor noise and vibration.
Personal Competence	
Social Competence	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.
Autonomy	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	20 min
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory

Course L0637: Marine Diesel Engine Plants	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	SoSe
Content	• Historischer Überblick • Bauarten von Vier- und Zweitaktmotoren als Schiffsmotoren • Vergleichsprozesse, Definitionen, Kenndaten • Zusammenwirken von Schiff, Motor und Propeller • Ausgeführte Schiffsdieselmotoren • Gaswechsel, Spülverfahren, Luftbedarf • Aufladung von Schiffsdieselmotoren • Einspritzung und Verbrennung • Schwerölbetrieb • Schmierung • Kühlung • Wärmebilanz • Abwärmenutzung • Anlassen und Umsteuern • Regelung, Automatisierung, Überwachung • Motorerregte Geräusche und Schwingungen • Fundamentierung • Gestaltung von Maschinenräumen
Literature	• D. Woodyard: Pounder’s Marine Diesel Engines • H. Meyer-Peter, F. Bernhardt: Handbuch der Schiffsbetriebstechnik • K. Kuiken: Diesel Engines • Mollenhauer, Tschöke: Handbuch Dieselmotoren • Projektierungsunterlagen der Motorenhersteller

Course L0638: Marine Diesel Engine Plants	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0721: Air Conditioning

Courses

Title	Typ	Hrs/wk	CP
Air Conditioning (L0594)	Lecture	3	5
Air Conditioning (L0595)	Recitation Section (large)	1	1

Module Responsible	Prof. Arne Speerforck
Admission Requirements	None
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students know the different kinds of air conditioning systems for buildings and mobile applications and how these systems are controlled. They are familiar with the change of state of humid air and are able to draw the state changes in a h1+x,x-diagram. They are able to calculate the minimum airflow needed for hygienic conditions in rooms and can choose suitable filters. They know the basic flow pattern in rooms and are able to calculate the air velocity in rooms with the help of simple methods. They know the principles to calculate an air duct network. They know the different possibilities to produce cold and are able to draw these processes into suitable thermodynamic diagrams. They know the criteria for the assessment of refrigerants.
Skills	Students are able to configure air condition systems for buildings and mobile applications. They are able to calculate an air duct network and have the ability to perform simple planning tasks, regarding natural heat sources and heat sinks. They can transfer research knowledge into practice. They are able to perform scientific work in the field of air conditioning.
Personal Competence	
Social Competence	In lectures and exercises, the students can use many examples and experiments to discuss in small groups in a goal-oriented manner, develop a solution and present it. Within the exercises, the students can independently develop further questions and work out targeted solutions.
Autonomy	Students are able to define tasks independently, to develop the necessary knowledge themselves based on the knowledge they have received, and to use suitable means for implementation. In the exercises, the students discuss the methods taught in the lectures using complex tasks and critically analyze the results.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	60 min
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0594: Air Conditioning	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Arne Speerforck, Prof. Gerhard Schmitz
Language	DE
Cycle	SoSe
Content	1. Overview 1.1 Kinds of air conditioning systems 1.2 Ventilating 1.3 Function of an air condition system 2. Thermodynamic processes 2.1 Psychrometric chart 2.2 Mixer preheater, heater 2.3 Cooler 2.4 Humidifier 2.5 Air conditioning process in a Psychrometric chart 2.6 Desiccant assisted air conditioning 3. Calculation of heating and cooling loads 3.1 Heating loads 3.2 Cooling loads 3.3 Calculation of inner cooling load 3.4 Calculation of outer cooling load 4. Ventilating systems 4.1 Fresh air demand 4.2 Air flow in rooms 4.3 Calculation of duct systems 4.4 Fans 4.5 Filters 5. Refrigeration systems 5.1. compression chillers 5.2Absorption chillers
Literature	• Schmitz, G.: Klimaanlagen, Skript zur Vorlesung • VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013 • Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009 • Recknagel, H.; Sprenger, E.; Schrammek, E.-R.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013

Course L0595: Air Conditioning	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Arne Speerforck, Prof. Gerhard Schmitz
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1161: Turbomachinery

Courses

Title	Typ	Hrs/wk	CP
Turbomachines (L1562)	Lecture	3	4
Turbomachines (L1563)	Recitation Section (large)	1	2

Module Responsible	Prof. Markus Schatz
Admission Requirements	None
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can • distinguish the physical phenomena of conversion of energy, • understand the different mathematic modelling of turbomachinery, • calculate and evaluate turbomachinery.
Skills	The students are able to - understand the physics of Turbomachinery, - solve excersises self-consistent.
Personal Competence	
Social Competence	The students are able to • discuss in small groups and develop an approach.
Autonomy	The students are able to • develop a complex problem self-consistent, • analyse the results in a critical way, • have an qualified exchange with other students.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory

Course L1562: Turbomachines	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Markus Schatz
Language	DE
Cycle	SoSe
Content	Topics to be covered will include: • Application cases of turbomachinery • Fundamentals of thermodynamics and fluid mechanics • Design fundamentals of turbomachinery • Introduction to the theory of turbine stage • Design and operation of the turbocompressor • Design and operation of the steam turbine • Design and operation of the gas turbine • Physical limits of the turbomachines
Literature	• Traupel: Thermische Turbomaschinen, Springer. Berlin, Heidelberg, New York • Bräunling: Flugzeuggasturbinen, Springer., Berlin, Heidelberg, New York • Seume: Stationäre Gasturbinen, Springer., Berlin, Heidelberg, New York • Menny: Strömungsmaschinen, Teubner., Stuttgart

Course L1563: Turbomachines	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Markus Schatz
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1000: Combined Heat and Power and Combustion Technology

Courses

Title	Typ	Hrs/wk	CP
Combined Heat and Power and Combustion Technology (L0216)	Lecture	3	5
Combined Heat and Power and Combustion Technology (L0220)	Recitation Section (large)	1	1

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	• "Gas-Steam Power Plants" • "Technical Thermodynamics I and II" • "Heat Transfer" • "Fluid Mechanics"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	**VBT/Combustion Engineering** The students outline the thermodynamic and chemical fundamentals of combustion processes and the main characteristics of various fuels. They gain basic knowledge in reaction kinetics and fundamentals of furnace design. The students are able to describe the formation of emissions and the primary reduction measures, and evaluate the impact of regulations and allowable limit levels. **KWK/Combined Heat and Power** The students present the layout, design and operation of Combined Heat and Power plants and are in a position to compare with each other district heating plants with back-pressure steam turbine or condensing turbine with pressure-controlled extraction tapping, CHP plants with gas turbine or with combined steam and gas turbine, or even district heating plants with an internal combustion engine. They can explain and analyse aspects of combined heat, power and cooling (CCHP) and describe the layout of the key components needed. Through this specialised knowledge they are able to evaluate the ecological significance of district CHP generation, as well as its economics. **Storage Technologies** The students present the layout, design and operation of electrical and heat storage technologies and are able to classify these in regards of their optimum operating range and conditions in power plants and complex energy systems. They evaluate the environmental effects of the storage technologies.
Skills	The students will be able to identify optimization possibilities due to combined power and heat production and the usage of short, medium and long-term storage technologies. The detailed understanding of the complete energy conversion chain, starting with the combustion of a fuel, the conversion of the primary energy into heat and power, storage and discharge of the storage enables the students to evaluate the efficiency and economies of the processes and to holistically consider energy utilisation. Examples from practical experience, such as the CHP energy supply facility of the TUHH and the district heating network of Hamburg will be used, to highlight the potential from electricity generation plants with simultaneous heat extraction and storage. Within the framework of the exercises the students deepen their knowledge based on examples from the industries.
Personal Competence	
Social Competence	Especially during the exercises the focus is placed on communication with the tutor. This animates the students to reflect on their existing knowledge and ask specific questions for improving further this knowledge level.
Autonomy	The students assisted by the tutors will be able to perform estimating calculations. In this manner the theoretical and practical knowledge from the lecture is consolidated and the potential impact of different process arrangements and boundary conditions highlighted.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6

Course achievement

Compulsory	Bonus	Form	Description
No	10 %	Written elaboration	Anhand der gelehrten Inhalte werden Kurzfragen gestellt und Projektaufgaben bearbeitet und präsentiert
No	10 %	Written elaboration	Am Ende jeder Vorlesung wird schriftlich eine zu auswertende Kurzfrage (5-10 min) zu der Vorlesung der Vorwoche gestellt. In den Kurzfragen werden kleine Rechenaufgaben, Skizzen oder auch kleine Freitexte zur Beantwortung gestellt.

Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Energy Systems: Specialisation Marine Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory

Course L0216: Combined Heat and Power and Combustion Technology	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	NN
Language	DE
Cycle	SoSe
Content	**Part 1: Combustion Engineering** • Thermodynamic and chemical fundamentals • Fuels • Reaction kinetics • Premixed flames • Systematik of flames and combustion chambers • Combustion Chamber design • Reduction of Emissions **Part 2: Energy Storage** 1.Motivation: Why is Energy storage essential ? 2.Storage of electrical energy • Condensers • Akkumulators • Hydro power stations • Short term storage with fly wheels • Compressed air energy storage CAES • Economics 3.Heat Storage • Sensible heat storage • Latent heat storage • Thermocheical heat storage • Economics 4.Sector coupling and Power to X • PtG • PtL • Research on PtX **Part 3: "Combined Heat and Power":** • Layout, design and operation of Combined Heat and Power plants • District heating plants with back-pressure steam turbine and condensing turbine with pressure-controlled extraction tapping • District heating plants with gas turbine • District heating plants with combined steam and gas turbine • District heating plants with motor engine • Combined cooling heat and power (CCHP) • Layout of the key components • Regulatory framework and allowable limits • Economic significance and calculation of the profitability of district CHP plant
Literature	Bezüglich des Themenbereichs "Kraft-Wärme-Kopplung": • W. Piller, M. Rudolph: Kraft-Wärme-Kopplung, VWEW Verlag • Kehlhofer, Kunze, Lehmann, Schüller: Handbuch Energie, Band 7, Technischer Verlag Resch • W. Suttor: Praxis Kraft-Wärme-Kopplung, C.F. Müller Verlag • K.W. Schmitz, G. Koch: Kraft-Wärme-Kopplung, VDI Verlag • K.-H. Suttor, W. Suttor: Die KWK Fibel, Resch Verlag und für die Grundlagen der "Verbrennungstechnik": • J. Warnatz, U. Maas, R.W. Dibble; Technische Verbrennung: physikalisch-chemische Grundlagen, Modellbildung, Schadstoffentstehung. Springer, Berlin [u. a.], 2001

Course L0220: Combined Heat and Power and Combustion Technology	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	NN
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1146: Ship Vibration

Courses

Title	Typ	Hrs/wk	CP
Ship Vibration (L1528)	Lecture	2	3
Ship Vibration (L1529)	Recitation Section (small)	2	3

Module Responsible	Dr. Rüdiger Ulrich Franz von Bock und Polach
Admission Requirements	None
Recommended Previous Knowledge	Mechanis I - III Structural Analysis of Ships I Fundamentals of Ship Structural Design
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can reproduce the acceptance criteria for vibrations on ships; they can explain the methods for the calculation of natural frequencies and forced vibrations of sructural components and the entire hull girder; they understand the effect of exciting forces of the propeller and main engine and methods for their determination
Skills	Students are capable to apply methods for the calculation of natural frequencies and exciting forces and resulting vibrations of ship structures including their assessment; they can model structures for the vibration analysis
Personal Competence	
Social Competence	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.
Autonomy	Students are able to detect vibration-prone components on ships, to model the structure, to select suitable calculation methods and to assess the results
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	3 hours
Assignment for the Following Curricula	Energy Systems: Specialisation Marine Engineering: Elective Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Compulsory Ship and Offshore Technology: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory

Course L1528: Ship Vibration

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Rüdiger Ulrich Franz von Bock und Polach
Language	EN
Cycle	WiSe
Content	1. Introduction; assessment of vibrations 2. Basic equations 3. Beams with discrete / distributed masses 4. Complex beam systems 5. Vibration of plates and Grillages 6. Deformation method / practical hints / measurements 7. Hydrodynamic masses 8. Spectral method 9. Hydrodynamic masses acc. to Lewis 10. Damping 11. Shaft systems 12. Propeller excitation 13. Engines
Literature	Siehe Vorlesungsskript

Course L1529: Ship Vibration	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Rüdiger Ulrich Franz von Bock und Polach
Language	EN
Cycle	WiSe
Content	1. Introduction; assessment of vibrations 2. Basic equations 3. Beams with discrete / distributed masses 4. Complex beam systems 5. Vibration of plates and Grillages 6. Deformation method / practical hints / measurements 7. Hydrodynamic masses 8. Spectral method 9. Hydrodynamic masses acc. to Lewis 10. Damping 11. Shaft systems 12. Propeller excitation 13. Engines
Literature	Siehe Vorlesungsskript

Module M0742: Thermal Energy Systems

Courses

Title	Typ	Hrs/wk	CP
Thermal Engergy Systems (L0023)	Lecture	3	5
Thermal Engergy Systems (L0024)	Recitation Section (large)	1	1

Module Responsible	Prof. Arne Speerforck
Admission Requirements	None
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students know the different energy conversion stages and the difference between efficiency and annual efficiency. They have increased knowledge in heat and mass transfer, especially in regard to buildings and mobile applications. They are familiar with German energy saving code and other technical relevant rules. They know to differ different heating systems in the domestic and industrial area and how to control such heating systems. They are able to model a furnace and to calculate the transient temperatures in a furnace. They have the basic knowledge of emission formations in the flames of small burners and how to conduct the flue gases into the atmosphere. They are able to model thermodynamic systems with object oriented languages.
Skills	Students are able to calculate the heating demand for different heating systems and to choose the suitable components. They are able to calculate a pipeline network and have the ability to perform simple planning tasks, regarding solar energy. They can write Modelica programs and can transfer research knowledge into practice. They are able to perform scientific work in the field of thermal engineering.
Personal Competence	
Social Competence	In lectures and exercises, the students can use many examples and experiments to discuss in small groups in a goal-oriented manner, develop a solution and present it. Within the exercises, the students can independently develop further questions and work out targeted solutions.
Autonomy	Students are able to define tasks independently, to develop the necessary knowledge themselves based on the knowledge they have received, and to use suitable means for implementation. In the exercises, the students discuss the methods taught in the lectures using complex tasks and critically analyze the results.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	60 min
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0023: Thermal Engergy Systems	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Arne Speerforck
Language	DE
Cycle	WiSe
Content	1. Introduction 2. Fundamentals of Thermal Engineering 2.1 Heat Conduction 2.2 Convection 2.3 Radiation 2.4 Heat transition 2.5 Combustion parameters 2.6 Electrical heating 2.7 Water vapor transport 3. Heating Systems 3.1 Warm water heating systems 3.2 Warm water supply 3.3 piping calculation 3.4 boilers, heat pumps, solar collectors 3.5 Air heating systems 3.6 radiative heating systems 4. Thermal traetment systems 4.1 Industrial furnaces 4.2 Melting furnaces 4.3 Drying plants 4.4 Emission control 4.5 Chimney calculation 4.6 Energy measuring 5. Laws and standards 5.1 Buildings 5.2 Industrial plants
Literature	• Schmitz, G.: Klimaanlagen, Skript zur Vorlesung • VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013 • Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009 • Recknagel, H.; Sprenger, E.; Schrammek, E.-R.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013

Course L0024: Thermal Engergy Systems	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Arne Speerforck
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Supplement Modules Core Studies

see Subject Specific Regulations of Master Program Energy Systems, §8

Module M1805: Computational Mechanics

Courses

Title	Typ	Hrs/wk	CP
Computational Mechanics (Exercises) (L1138)	Recitation Section (small)	2	2
Computational Multibody Dynamics (L1137)	Integrated Lecture	2	2
Computational Stuctural Mechanics (L2475)	Integrated Lecture	2	2

Module Responsible	Prof. Robert Seifried
Admission Requirements	None
Recommended Previous Knowledge	Mathematics I-III and Engineering Mechanics I-III
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can • describe the axiomatic procedure used in mechanical contexts; • explain important steps in model design; • present technical knowledge.
Skills	The students can • explain the important elements of mathematical / mechanical analysis and model formation, and apply it to the context of their own problems; • apply basic methods from numerical mechanics to engineering problems; • estimate the reach and boundaries of the methods and extend them to be applicable to wider problem sets.
Personal Competence	
Social Competence	The students can work in groups and support each other to overcome difficulties.
Autonomy	Students are capable of determining their own strengths and weaknesses and to organize their time and learning based on those.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6

Course achievement

Compulsory	Bonus	Form	Description
No	15 %	Midterm	Midterm Mehrkörpersysteme
No	5 %	Excercises	Hausaufgaben

Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory Mechatronics: Specialisation Medical Engineering: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory

Course L1138: Computational Mechanics (Exercises)

Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried, Prof. Christian Cyron
Language	DE
Cycle	SoSe
Content	
Literature	K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009). D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 1-4. 11. Auflage, Springer (2011).

Course L1137: Computational Multibody Dynamics	
Typ	Integrated Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	SoSe
Content	• Modelling of mechanical systems • Linear versus nonlinear vibration • Numerical methods for time integration • Vibrations with multiple degrees of freedom: free, damped, forced, modal transformation • Concepts from analytical mechanics • Spatial multibody systems • Linearization of multibody systems • Introduction to Matlab
Literature	K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009). D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 1-4. 11. Auflage, Springer (2011). W. Schiehlen, P. Eberhard: Technische Dynamik, Springer (2012).

Course L2475: Computational Stuctural Mechanics	
Typ	Integrated Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	SoSe
Content	The lecture Computational Structural Mechanics extends the content of the lecture Engineering Mechanic II. It bridges the gap between the manual calculation of mechanical stress and deformation in systems with a particularly simple geometry and the efficent computer-based computation of general mechanical systems: • Basics of linear continuum mechanics • Planar structures: plate, membrane, slab • Linientragwerke: beam, cable, truss • Weak form and Galerkin's method • Finite element method: theory and application • Principles of mechanics: principle of virtual work, virtual displacements, virtual forces
Literature	Gross, Hauger, Wriggers, "Technische Mechanik 4", Springer

Module M0684: Heat Transfer

Courses

Title	Typ	Hrs/wk	CP
Heat Transfer (L0458)	Lecture	3	4
Heat Transfer (L0459)	Recitation Section (large)	2	2

Module Responsible	Dr. Andreas Moschallski
Admission Requirements	None
Recommended Previous Knowledge	Technical Thermodynamics I, II and Fluid Dynamics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can - explain the technical terms, - classify the various physical processes of heat transfer in terms of conduction-based and radiation-based mechanisms, - simplify and critically analyze complex heat transfer processes using models, - methodically develop solutions to tasks.
Skills	The students are able to - describe the physics of the different Heat Transfer mechanism, - simplifywith models, calculate and evaluate complex Heat Transfer processes, - critically question and answer statements on heat transfer, - solve excersises self-consistent and in small groups.
Personal Competence	
Social Competence	In lectures and exercises, the students can use many examples and experiments to discuss in small groups in a goal-oriented manner, develop a solution and present it. Within the exercises, the students can independently develop further questions and work out targeted solutions.
Autonomy	The students can check their level of knowledge by means of repetition questions at the beginning of the lectures and describe and discuss answers in exchange with the other students. In the exercises, the students work in small groups on the methods taught in the lectures in complex tasks and critically analyze the results in the auditorium.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory Integrated Building Technology: Core Qualification: Compulsory Mechanical Engineering: Specialisation Energy Systems: Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Elective Compulsory

Course L0458: Heat Transfer	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Dr. Andreas Moschallski
Language	DE
Cycle	WiSe
Content	Dimensional analysis, Heat Conduction (steady and unsteady) , Convective Heat Transfer (natural convection, forced convection), Two-phase Heat Transfer (evaporation, condensation), Thermal Radiation, Heat Transfer on a thermodynamic view, thermotechnical devices, measures of temperature and heat flux
Literature	- Herwig, H.; Moschallski, A.: Wärmeübertragung, 4. Auflage, Springer Vieweg Verlag, Wiesbaden, 2019 - Herwig, H.: Wärmeübertragung von A-Z, Springer- Verlag, Berlin, Heidelberg, 2000 - Baehr, H.D.; Stephan, K.: Wärme- und Stoffübertragung, 2. Auflage, Springer Verlag, Berlin, Heidelberg, 1996

Course L0459: Heat Transfer	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Andreas Moschallski
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0597: Advanced Mechanical Engineering Design

Courses

Title	Typ	Hrs/wk	CP
Advanced Mechanical Engineering Design II (L0264)	Lecture	2	2
Advanced Mechanical Engineering Design II (L0265)	Recitation Section (large)	2	1
Advanced Mechanical Engineering Design I (L0262)	Lecture	2	2
Advanced Mechanical Engineering Design I (L0263)	Recitation Section (large)	2	1

Module Responsible	Prof. Dieter Krause
Admission Requirements	None
Recommended Previous Knowledge	• Fundamentals of Mechanical Engineering Design • Mechanics • Fundamentals of Materials Science • Production Engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After passing the module, students are able to: • explain complex working principles and functions of machine elements and of basic elements of fluidics, • explain requirements, selection criteria, application scenarios and practical examples of complex machine elements, • indicate the background of dimensioning calculations.
Skills	After passing the module, students are able to: • accomplish dimensioning calculations of covered machine elements, • transfer knowledge learned in the module to new requirements and tasks (problem solving skills), • recognize the content of technical drawings and schematic sketches, • evaluate complex designs, technically.
Personal Competence	
Social Competence	• Students are able to discuss technical information in the lecture supported by activating methods.
Autonomy	• Students are able to independently deepen their acquired knowledge in exercises. • Students are able to acquire additional knowledge and to recapitulate poorly understood content e.g. by using the video recordings of the lectures.
Workload in Hours	Independent Study Time 68, Study Time in Lecture 112
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering: Compulsory Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory Engineering Science: Specialisation Mechanical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Compulsory Mechanical Engineering: Core Qualification: Compulsory Naval Architecture: Core Qualification: Compulsory

Course L0264: Advanced Mechanical Engineering Design II	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Dieter Krause, Prof. Dr. Nikola Bursac
Language	DE
Cycle	SoSe

Content	**Advanced Mechanical Engineering Design I & II**
	
	Lecture
	
	• Fundamentals of the following machine elements:
	  ◦ Linear rolling bearings
	  ◦ Axes & shafts
	  ◦ Seals
	  ◦ Clutches & brakes
	  ◦ Belt & chain drives
	  ◦ Gear drives
	  ◦ Epicyclic gears
	  ◦ Crank drives
	  ◦ Sliding bearings
	• Elements of fluidics
	
	Exercise
	
	• Calculation methods of the following machine elements:
	  ◦ Linear rolling bearings
	  ◦ Axes & shafts
	  ◦ Clutches & brakes
	  ◦ Belt & chain drives
	  ◦ Gear drives
	  ◦ Epicyclic gears
	  ◦ Crank gears
	  ◦ Sliding bearings
	• Calculations of hydrostatic systems (fluidics)

Literature	• Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage. • Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage. • Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage. • Einführung in die DIN-Normen; Klein, M., Teubner-Verlag. • Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage. • Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage. • Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage. • Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage. Sowie weitere Bücher zu speziellen Themen

Course L0265: Advanced Mechanical Engineering Design II	
Typ	Recitation Section (large)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Dieter Krause, Prof. Dr. Nikola Bursac
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0262: Advanced Mechanical Engineering Design I	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Dieter Krause, Prof. Dr. Nikola Bursac
Language	DE
Cycle	WiSe

Content	**Advanced Mechanical Engineering Design I & II**
	
	Lecture
	
	• Fundamentals of the following machine elements:
	  ◦ Linear rolling bearings
	  ◦ Axes & shafts
	  ◦ Seals
	  ◦ Clutches & brakes
	  ◦ Belt & chain drives
	  ◦ Gear drives
	  ◦ Epicyclic gears
	  ◦ Crank drives
	  ◦ Sliding bearings
	• Elements of fluidics
	
	Exercise
	
	• Calculation methods of the following machine elements:
	  ◦ Linear rolling bearings
	  ◦ Axes & shafts
	  ◦ Clutches & brakes
	  ◦ Belt & chain drives
	  ◦ Gear drives
	  ◦ Epicyclic gears
	  ◦ Crank gears
	  ◦ Sliding bearings
	• Calculations of hydrostatic systems (fluidics)

Literature	• Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage. • Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage. • Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage. • Einführung in die DIN-Normen; Klein, M., Teubner-Verlag. • Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage. • Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage. • Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage. • Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage. Sowie weitere Bücher zu speziellen Themen

Course L0263: Advanced Mechanical Engineering Design I	
Typ	Recitation Section (large)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Dieter Krause, Prof. Dr. Nikola Bursac
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1022: Reciprocating Machinery

Courses

Title	Typ	Hrs/wk	CP
Fundamentals of Reciprocating Engines and Turbomachinery - Part Reciprocating Engines (L0633)	Lecture	1	1
Fundamentals of Reciprocating Engines and Turbomachinery - Part Reciprocating Engines (L0634)	Recitation Section (large)	1	1
Internal Combustion Engines I (L0059)	Lecture	2	2
Internal Combustion Engines I (L0639)	Recitation Section (large)	1	2

Module Responsible	Prof. Christopher Friedrich Wirz
Admission Requirements	None
Recommended Previous Knowledge	Thermodynamics, Mechanics, Machine Elements
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	As a result of the part module „Fundamentals of Reciprocating Machinery", the students are able to reflect fundamentals regarding power and working machinery and describe the qualitative and quantitative correlations of operating methods and efficiencies of multiple types of engines, compressors and pumps. They are able to utilize technical terms and parameters as well as aspects regarding the development of power density and efficiency, furthermore to give an overview of charging systems, fuels and emissions. The students are able to select specific types of machinery and assess design related and operational problems. As a result of the part module "Internal Combustion Engines I", the students are able reflect and utilize the state-of-the-art regarding efficiency limits. In addition, they are able to utilize their knowledge of design, mechanical and thermodynamic characteristics and the approach of similarity. They are able to explain, assess and develop engines as well as charging systems. Detailed knowledge is present regarding computer-aided process design.
Skills	The students are skilled to employ basic and detail knowledge regarding reciprocating machinery, their selection and operation. They are further able to assess, analyse and solve technical and operational problems and to perform mechanical and thermodynamic design.
Personal Competence	
Social Competence	The students are able to communicate and cooperate in a professional environment in the field of machinery design and application.
Autonomy	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory Mechanical Engineering: Specialisation Energy Systems: Compulsory

Course L0633: Fundamentals of Reciprocating Engines and Turbomachinery - Part Reciprocating Engines	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	WiSe

Content	• Verbrennungsmotoren
	  ◦ Historischer Rückblick
	  ◦ Einteilung der Verbrennungsmotoren
	  ◦ Arbeitsverfahren
	  ◦ Vergleichsprozesse
	  ◦ Arbeit, Mitteldrücke, Leistungen
	  ◦ Arbeitsprozess des wirklichen Motors
	  ◦ Wirkungsgrade
	  ◦ Gemischbildung und Verbrennung
	  ◦ Motorkennfeld und Betriebskennlinien
	  ◦ Abgasentgiftung
	  ◦ Gaswechsel
	  ◦ Aufladung
	  ◦ Kühl- und Schmiersystem
	  ◦ Kräfte im Triebwerk
	• Kolbenverdichter
	  ◦ Thermodynamik des Kolbenverdichters
	  ◦ Einteilung und Verwendung
	• Kolbenpumpen
	  ◦ Prinzip der Kolbenpumpen
	  ◦ Einteilung und Verwendung

Literature	• A. Urlaub: Verbrennungsmotoren • W. Kalide: Kraft- und Arbeitsmaschinen

Course L0634: Fundamentals of Reciprocating Engines and Turbomachinery - Part Reciprocating Engines	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0059: Internal Combustion Engines I	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Wolfgang Thiemann
Language	DE
Cycle	SoSe
Content	• The beginnings of engine development • Design of of motors • Real process calculation • Charging methods • Kinematics of the crank mechanism • Forces in the engine
Literature	• Vorlesungsskript • Übungsaufgaben mit Lösungsweg • Literaturliste

Course L0639: Internal Combustion Engines I	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Wolfgang Thiemann
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0655: Computational Fluid Dynamics I

Courses

Title	Typ	Hrs/wk	CP
Computational Fluid Dynamics I (L0235)	Lecture	2	3
Computational Fluid Dynamics I (L0419)	Recitation Section (large)	2	3

Module Responsible	Prof. Thomas Rung
Admission Requirements	None
Recommended Previous Knowledge	Students should have sound knowledge of engineering mathematics (series expansions, internal & vector calculus), and be familiar with the foundations of partial/ordinary differential equations. They should also be familiar with engineering fluid mechanics and thermodynamics.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will have the required combined knowledge of thermo-/fluid dynamics and numerical analysis to translate general principles of thermo-/fluid engineering into discrete algorithms on the basis of local (finite differences/volumes) and global (potential theory) ansatz functions. They are familiar with the similarities and differences between different discretisation and approximation concepts for investigating coupled systems of non-linear, convective partial differential equations (PDE), and explain the motivation for applying them. Students have the required background knowledge to develop, code, explain and apply numerical algorithms dedicated to the solution of thermofluid dynamic PDEs. They are familiar with most numerical methods used to predict thermofluid dynamic fields, in particular their realms and limitations.
Skills	The students are able choose and apply appropriate numerical procedures that integrate the governing thermofluid dynamic PDEs in space and time. They can apply/optimise numerical analysis concepts to/for fluid dynamic applications. They can code computational algorithms in a structured way, apply these codes for parameter investigations and supplement interfaces to extract simulation data for an engineering analysis.
Personal Competence	
Social Competence	The students are able to discuss problems, present the results of their own analysis, and jointly develop, implement and report on solution strategies that address given technical reference problems.
Autonomy	The students can independently analyse numerical methods to solving fluid engineering problems. They are able to critically analyse own results as well as external data with regards to the plausibility and reliability.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	2h
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0235: Computational Fluid Dynamics I	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Thomas Rung
Language	DE
Cycle	WiSe
Content	Fundamentals of computational modelling of thermofluid dynamic problems. Development of numerical algorithms. 1. Partial differential equations 2. Foundations of finite numerical approximations 3. Computation of potential flows 4. Introduction of finite-differences 5. Approximation of convective, diffusive and transient transport processes 6. Formulation of boundary conditions and initial conditions 7. Assembly and solution of algebraic equation systems 8. Facets of weighted -residual approaches 9. Finite volume methods 10. Basics of grid generation
Literature	Ferziger and Peric: *Computational Methods for Fluid Dynamics*, Springer

Course L0419: Computational Fluid Dynamics I	
Typ	Recitation Section (large)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Thomas Rung
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0639: Gas and Steam Power Plants

Courses

Title	Typ	Hrs/wk	CP
Gas and Steam Power Plants (L0206)	Lecture	3	5
Gas and Steam Power Plants (L0210)	Recitation Section (large)	1	1

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	• "Technical Thermodynamics I and II" • "Heat Transfer" • "Fluid Mechanics"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can evaluate the development of the electricity demand and the energy conversion routes in the thermal power plant, describe the various types of power plant and the layout of the steam generator block. They are also able to determine the operation characteristics of the power plant. Additionally they can describe the exhaust gas cleaning apparatus and the combination possibilities of conventional fossil-fuelled power plants with solar thermal and geothermal power plants or plants equipped with Carbon Capture and Storage. The students have basic knowledge about the principles, operation and design of turbomachinery
Skills	The students will be able, using theories and methods of the energy technology from fossil fuels and based on well-founded knowledge on the function and construction of gas and steam power plants, to identify basic associations in the production of heat and electricity, so as to develop conceptual solutions. Through analysis of the problem and exposure to the interplay between heat and power generation the students are endowed with the capability and methodology to develop realistic optimal concepts for the generation of electricity and the production of heat. From the technical basics the students become the ability to follow better the deliberations on the electricity mix composition within the energy-political triangle (economy, secure supply and environmental protection). Within the framework of the exercise the students learn the use of the specialised software suite EBSILON Professional ^{TM}. With this tool small practical tasks are solved with the PC, to highlight aspects of the design and development of power plant cycles. The students are able to do simplified calculations on turbomachinery either as part of a plant, as single component or at stage level.
Personal Competence	
Social Competence	An excursion within the framework of the lecture is planned for students that are interested. The students get in this manner direct contact with a modern power plant in this region. The students will obtain first-hand experience with a power plant in operation and gain insights into the conflicts between technical and political issues.
Autonomy	The students assisted by the tutors will be able to develop alone simple simulation models and run with these scenario analyses. In this manner the theoretical and practical knowledge from the lecture is consolidated and the potential effects from different process combinations and boundary conditions highlighted. The students are able independently to analyse the operational performance of steam power plants and calculate selected quantities and characteristic curves.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6

Course achievement

Compulsory	Bonus	Form	Description
No	5 %	Excercises	10 Übungsaufgaben im Laufe der Vorlesungen à 5 Minuten; bis zu 5 % Bonus je nach Anteil richtiger Abgaben
No	5 %	Group discussion	gemeinsame Erarbeitung von Inhalten
No	5 %	Written elaboration	Zusammenfassung von Literatur
No	5 %	Presentation	15-minütiges, unbenotetes Testat über EBSILON Professional; nur bestanden/nicht bestanden (keine anteiligen Punkte)

Examination	Written exam
Examination duration and scale	Written examination of 120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory

Course L0206: Gas and Steam Power Plants	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Dr. Kristin Abel-Günther
Language	DE
Cycle	WiSe
Content	In the 1st part of the lecture an overview on thermal power plants is offered, including: • Electricity demand and Forecasting • Thermodynamic fundamentals • Energy Conversion in thermal power plants • Types of power plant • Layout of the power plant block • Individual elements of the power plant • Cooling systems • Flue gas cleaning • Operation characteristics of the power plant • Construction materials for power plants • Location of power plants • Solar thermal plants/geothermal plants/Carbon Capture and Storage plants. These are complemented in the 2nd part of the module by the more specialised issues: • Energy balance of a turbomachine • Theory of turbine and compressor stage • Equal and positive pressure blading • Flow losses • Characteristic numbers • Axial and radial design • Design features • Hydraulic turbomachines • Pump and water turbine designs • Design examples of reciprocating engines and turbomachinery • Steam power plants • Gas turbine systems.
Literature	• Kalide: Kraft- und Arbeitsmaschinen • Thomas, H.J.: Thermische Kraftanlagen. Springer-Verlag, 1985 • Strauß, K.: Kraftwerkstechnik. Springer-Verlag, 2006 • Kugeler und Phlippen: Energietechnik. Springer-Verlag, 1990 • Bohn, T. (Hrsg.): Handbuchreihe Energie, Band 7: Gasturbinenkraftwerke, Kombikraftwerke, Heizkraftwerke und Industriekraftwerke, Technischer Verlag Resch / Verlag TÜV Rheinland

Course L0210: Gas and Steam Power Plants	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Kristin Abel-Günther
Language	DE
Cycle	WiSe
Content	In the 1st part of the lecture a general introduction into fluid-flow machines and steam power plants is offered, including: • Energy balance of a fluid-flow machine • Theory of turbine and compressor stage • Equal and positive pressure blading • Flow losses • Characteristic numbers • Axial and radial design • Design features • Hydraulic fluid-flow machines • Pump and water turbine designs • Design examples of reciprocating engines and turbomachinery • Steam power plants • Gas turbine systems • Diesel engine systems • Waste heat utilisation followed by the more specialised issues: • Electricity Demand and Forecasting • Thermodynamic fundamentals • Energy Conversion in Thermal Power Plants • Types of Power Plant • Layout of the power plant block • Individual elements of the power plant • Cooling systems • Flue gas cleaning • Operation characteristics of the power plant • Construction materials • Location of power plants The environmental impact of acidification, fine particulate or CO_2 emissions and the resulting climatic effects are a special focus of the lecture and the lecture hall exercise. The challenges in plant operation from interconnecting conventional power plants and renewable energy sources are discussed and the technical options for providing security of supply and network stability are presented, also under consideration of cost effectiveness. In this critical review, focus is especially placed on the compatibility of the different solutions with the environment and climate. With this, the awareness for the responsibility of an engineer's own actions are emphasized and the potential extent of the different solutions presented clearly. Within the framework of the exercise the students learn the use of the specialised software suite EBSILON Professional TM. With this tool small tasks are solved on the PC, to highlight aspects of the design and development of power plant cycles. The students present their results orally and can afterwards ask questions and get feedback. The course work has a positive effect on the students final grade.
Literature	• Skripte • Kalide: Kraft- und Arbeitsmaschinen • Thomas, H.J.: Thermische Kraftanlagen. Springer-Verlag, 1985 • Strauß, K.: Kraftwerkstechnik. Springer-Verlag, 2006 • Kugeler und Phlippen: Energietechnik. Springer-Verlag, 1990 • T . Bohn (Hrsg.): Handbuchreihe Energie, Band 7: Gasturbinenkraftwerke, Kombikraftwerke, Heizkraftwerke und Industriekraftwerke, Technischer Verlag Resch / Verlag TÜV Rheinland

Module M0688: Technical Thermodynamics II

Courses

Title	Typ	Hrs/wk	CP
Technical Thermodynamics II (L0449)	Lecture	2	4
Technical Thermodynamics II (L0450)	Recitation Section (large)	1	1
Technical Thermodynamics II (L0451)	Recitation Section (small)	1	1

Module Responsible	Prof. Arne Speerforck
Admission Requirements	None
Recommended Previous Knowledge	Elementary knowledge in Mathematics, Mechanics and Technical Thermodynamics I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are familiar with different cycle processes like Joule, Otto, Diesel, Stirling, Seiliger and Clausius-Rankine. They are able to derive energetic and exergetic efficiencies and know the influence different factors. They know the difference between anti clockwise and clockwise cycles (heat-power cycle, cooling cycle). They have increased knowledge of steam cycles and are able to draw the different cycles in Thermodynamics related diagrams. They know the laws of gas mixtures, especially of humid air processes and are able to perform simple combustion calculations. They are provided with basic knowledge in gas dynamics and know the definition of the speed of sound and know about a Laval nozzle.
Skills	Students are able to use thermodynamic laws for the design of technical processes. Especially they are able to formulate energy, exergy- and entropy balances and by this to optimise technical processes. They are able to perform simple safety calculations in regard to an outflowing gas from a tank. They are able to transform a verbal formulated message into an abstract formal procedure.
Personal Competence	
Social Competence	The students are able to discuss in small groups and develop an approach. You can answer comprehension questions about the content that are provided in the lecture with the ClickerOnline tool "TurningPoint" after discussions with other students.
Autonomy	Students can physically understand and explain the complex problems (cycle processes, air conditioning processes, combustion processes) set in tasks. They are able to select the methods taught in the lecture and exercise to solve complex problems and apply them independently to different types of tasks.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Elective Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Mechatronics: Specialisation Robot- and Machine-Systems: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core Qualification: Compulsory

Course L0449: Technical Thermodynamics II	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Arne Speerforck
Language	DE
Cycle	WiSe
Content	8. Cycle processes 7. Gas - vapor - mixtures 10. Open sytems with constant flow rates 11. Combustion processes 12. Special fields of Thermodynamics
Literature	• Schmitz, G.: Technische Thermodynamik, TuTech Verlag, Hamburg, 2009 • Baehr, H.D.; Kabelac, S.: Thermodynamik, 15. Auflage, Springer Verlag, Berlin 2012 • Potter, M.; Somerton, C.: Thermodynamics for Engineers, Mc GrawHill, 1993

Course L0450: Technical Thermodynamics II	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Arne Speerforck
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0451: Technical Thermodynamics II	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Arne Speerforck
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Thesis

In their master's thesis students work independently on research-oriented problems, structuring the task into different sub-aspects and apply systematically the specialized competences they have acquired in the course of the study program.

Special importance is attached to a scientific approach to the problem including, in addition to an overview of literature on the subject, its classification in relation to current issues, a description of the theoretical foundations, and a critical analysis and assessment of the results.

Module M1801: Master thesis (dual study program)

Courses

Title	Typ	Hrs/wk	CP

Module Responsible	Professoren der TUHH
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Dual students ... • ... use the specialised knowledge (facts, theories and methods) from their field of study and the acquired professional knowledge confidently to deal with technical and practical professional issues. • ... can explain the relevant approaches and terminologies in depth in one or more of their subject's specialist areas, describe current developments and take a critical stance. • ... formulate their own research assignment to tackle a professional problem and contextualise it within their subject area. They ascertain the current state of research and critically assess it.
Skills	Dual students ... • ... can select suitable methods for the respective subject-related professional problem, apply them and develop them further as required. • ... assess knowledge and methods acquired during their studies (including practical phases) and apply their expertise to complex and/or incompletely defined problems in a solution- and application-oriented manner. • ... acquire new academic knowledge in their subject area and critically evaluate it.
Personal Competence	
Social Competence	Dual students ... • ... can present a professional problem in the form of an academic question in a structured, comprehensible and factually correct manner, both in writing and orally, for a specialist audience and for professional stakeholders. • ... answer questions as part of a professional discussion in an expert, appropriate manner. They represent their own points of view and assessments convincingly.
Autonomy	Dual students ... • ... can structure their own project into work packages, work through them at an academic level and reflect on them with regard to feasible courses of action for professional practice. • ... work in-depth in a partially unknown area within the discipline and acquire the information required to do so. • ... apply the techniques of academic work comprehensively in their own research work when dealing with an operational problem and question.
Workload in Hours	Independent Study Time 900, Study Time in Lecture 0
Credit points	30
Course achievement	None
Examination	Thesis
Examination duration and scale	According to General Regulations
Assignment for the Following Curricula	Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Data Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Computer Science in Engineering: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory International Management and Engineering: Thesis: Compulsory Logistics, Infrastructure and Mobility: Thesis: Compulsory Aeronautics: Thesis: Compulsory

	Materials Science and Engineering: Thesis: Compulsory Materials Science: Thesis: Compulsory Mechanical Engineering and Management: Thesis: Compulsory Mechatronics: Thesis: Compulsory Biomedical Engineering: Thesis: Compulsory Microelectronics and Microsystems: Thesis: Compulsory Product Development, Materials and Production: Thesis: Compulsory Renewable Energies: Thesis: Compulsory Naval Architecture and Ocean Engineering: Thesis: Compulsory Theoretical Mechanical Engineering: Thesis: Compulsory Process Engineering: Thesis: Compulsory Water and Environmental Engineering: Thesis: Compulsory