Module Manual

Master of Science (M.Sc.)

Energy Systems

Cohort: Winter Term 2021

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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.

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.

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.

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.

As a part of the Energy Systems specialization, three compulsory modules (Turbomachines, Thermal Engineering, Combined Heat & Power and Combustion Technology) and four mandatory elective modules (out of 11) must be studied. The mandatory electives include an open module, Selected Energy Systems Topics, from which courses counting for 6 credits out of 39 on offer can be chosen.

As a part of the Marine Engineering specialization, students must take two compulsory modules (Energy Systems on Board Ships, Marine Engines) and five mandatory electives (out of 5 on offer). The mandatory electives include an open module, Selected Marine Engineering Topics, from which courses counting for 12 credits out of 22 on offer can be chosen.

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.

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**: Yes; **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 Theoretical Mechanical Engineering: Technical Complementary Course: 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 M0524: Non-technical Courses for Master

Module Responsible	Dagmar Richter
Admission Requirements	None
Recommended Previous Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	**The Nontechnical Academic Programms (NTA)** imparts skills that, in view of the TUHH's training profile, professional engineering studies require but are not able to cover fully. Self-reliance, self-management, collaboration and professional and personnel management competences. The department implements these training objectives in its **teaching architecture**, in its **teaching and learning arrangements**, in **teaching areas** and by means of teaching offerings in which students can qualify by opting for **specific competences** and a **competence level** at the Bachelor's or Master's level. The teaching offerings are pooled in two different catalogues for nontechnical complementary courses. **The Learning Architecture** consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontechnical academic programms follow the specific profiling of TUHH degree courses. The learning architecture demands and trains independent educational planning as regards the individual development of competences. It also provides orientation knowledge in the form of "profiles". The subjects that can be studied in parallel throughout the student's entire study program - if need be, it can be studied in one to two semesters. In view of the adaptation problems that individuals commonly face in their first semesters after making the transition from school to university and in order to encourage individually planned semesters abroad, there is no obligation to study these subjects in one or two specific semesters during the course of studies. **Teaching and Learning Arrangements** provide for students, separated into B.Sc. and M.Sc., to learn with and from each other across semesters. The challenge of dealing with interdisciplinarity and a variety of stages of learning in courses are part of the learning architecture and are deliberately encouraged in specific courses. **Fields of Teaching** are based on research findings from the academic disciplines cultural studies, social studies, arts, historical studies, communication studies, migration studies and sustainability research, and from engineering didactics. In addition, from the winter semester 2014/15 students on all Bachelor's courses will have the opportunity to learn about business management and start-ups in a goal-oriented way. The fields of teaching are augmented by soft skills offers and a foreign language offer. Here, the focus is on encouraging goal-oriented communication skills, e.g. the skills required by outgoing engineers in international and intercultural situations. **The Competence Level** of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. These differences are reflected in the practical examples used, in content topics that refer to different professional application contexts, and in the higher scientific and theoretical level of abstraction in the B.Sc. This is also reflected in the different quality of soft skills, which relate to the different team positions and different group leadership functions of Bachelor's and Master's graduates in their future working life. **Specialized Competence (Knowledge)** Students can • explain specialized areas in context of the relevant non-technical disciplines, • outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning area, • different specialist disciplines relate to their own discipline and differentiate it as well as make connections, • sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of representation in the specialized sciences are subject to individual and socio-cultural interpretation and historicity, • Can communicate in a foreign language in a manner appropriate to the subject.
Skills	**Professional Competence (Skills)** In selected sub-areas students can • apply basic and specific methods of the said scientific disciplines, • aquestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline, • to handle simple and advanced questions in aforementioned scientific disciplines in a sucsessful manner, • justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relationship to the subject.

Personal Competence	
Social Competence	**Personal Competences (Social Skills)** Students will be able • to learn to collaborate in different manner, • to present and analyze problems in the abovementioned fields in a partner or group situation in a manner appropriate to the addressees, • to express themselves competently, in a culturally appropriate and gender-sensitive manner in the language of the country (as far as this study-focus would be chosen), • to explain nontechnical items to auditorium with technical background knowledge.
Autonomy	**Personal Competences (Self-reliance)** Students are able in selected areas • to reflect on their own profession and professionalism in the context of real-life fields of application • to organize themselves and their own learning processes • to reflect and decide questions in front of a broad education background • to communicate a nontechnical item in a competent way in writen form or verbaly • to organize themselves as an entrepreneurial subject country (as far as this study-focus would be chosen)
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 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.
Skills	Students are able to denote methods of Vibration Theory and develop them further.
Personal Competence	
Social Competence	Students can reach working results also in groups.
Autonomy	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: Technical Complementary Course: 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 Oscillations and Waves.
Literature	K. Magnus, K. Popp, W. Sextro: Schwingungen. Physikalische Grundlagen und mathematische Behandlung von Schwingungen. Springer Verlag, 2013.

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. Otto von Estorff
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: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: 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 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. Otto von Estorff
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. Otto von Estorff
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	Prof. Herbert Werner
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 Computational Science and Engineering: Specialisation II. Engineering Science: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: 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: 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	Prof. Herbert Werner
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	Prof. Herbert Werner
Language	EN
Cycle	WiSe
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	NN
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	NN, Dr. Kristin Abel-Günther
Language	DE
Cycle	WiSe
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 M1204: Modelling and Optimization in Dynamics

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Flexible Multibody Systems (L1632)	Lecture	2	3
Optimization of dynamical systems (L1633)	Lecture	2	3

Module Responsible	Prof. Robert Seifried
Admission Requirements	None
Recommended Previous Knowledge	• Mathematics I, II, III • Mechanics I, II, III, IV • Simulation of dynamical Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students demonstrate basic knowledge and understanding of modeling, simulation and analysis of complex rigid and flexible multibody systems and methods for optimizing dynamic systems after successful completion of the module.
Skills	Students are able + to think holistically + to independently, securly and critically analyze and optimize basic problems of the dynamics of rigid and flexible multibody systems + to describe dynamics problems mathematically + to optimize dynamics problems
Personal Competence	
Social Competence	Students are able to + solve problems in heterogeneous groups and to document the corresponding results.
Autonomy	Students are able to + assess their knowledge by means of exercises. + acquaint themselves with the necessary knowledge to solve research oriented tasks.
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: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1632: Flexible Multibody Systems	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried, Dr. Alexander Held
Language	DE
Cycle	WiSe
Content	1. Basics of Multibody Systems 2. Basics of Continuum Mechanics 3. Linear finite element modelles and modell reduction 4. Nonlinear finite element Modelles: absolute nodal coordinate formulation 5. Kinematics of an elastic body 6. Kinetics of an elastic body 7. System assembly
Literature	Schwertassek, R. und Wallrapp, O.: Dynamik flexibler Mehrkörpersysteme. Braunschweig, Vieweg, 1999. Seifried, R.: Dynamics of Underactuated Multibody Systems, Springer, 2014. Shabana, A.A.: Dynamics of Multibody Systems. Cambridge Univ. Press, Cambridge, 2004, 3. Auflage.

Course L1633: Optimization of dynamical systems	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	WiSe
Content	1. Formulation and classification of optimization problems 2. Scalar Optimization 3. Sensitivity Analysis 4. Unconstrained Parameter Optimization 5. Constrained Parameter Optimization 6. Stochastic optimization 7. Multicriteria Optimization 8. Topology Optimization
Literature	Bestle, D.: Analyse und Optimierung von Mehrkörpersystemen. Springer, Berlin, 1994. Nocedal, J. , Wright , S.J. : Numerical Optimization. New York: Springer, 2006.

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 M0604: High-Order FEM

Courses

Title	Typ	Hrs/wk	CP
High-Order FEM (L0280)	Lecture	3	4
High-Order FEM (L0281)	Recitation Section (large)	1	2

Module Responsible	Prof. Alexander Düster
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of partial differential equations is recommended.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to + give an overview of the different (h, p, hp) finite element procedures. + explain high-order finite element procedures. + specify problems of finite element procedures, to identify them in a given situation and to explain their mathematical and mechanical background.
Skills	Students are able to + apply high-order finite elements to problems of structural mechanics. + select for a given problem of structural mechanics a suitable finite element procedure. + critically judge results of high-order finite elements. + transfer their knowledge of high-order finite elements to new problems.
Personal Competence	
Social Competence	Students are able to + solve problems in heterogeneous groups and to document the corresponding results.
Autonomy	Students are able to + assess their knowledge by means of exercises and E-Learning. + acquaint themselves with the necessary knowledge to solve research oriented tasks.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory**: No; **Bonus**: 10 %; **Form**: Presentation; **Description**: Forschendes Lernen
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Energy Systems: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

Course L0280: High-Order FEM	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Alexander Düster
Language	EN
Cycle	SoSe
Content	1. Introduction 2. Motivation 3. Hierarchic shape functions 4. Mapping functions 5. Computation of element matrices, assembly, constraint enforcement and solution 6. Convergence characteristics 7. Mechanical models and finite elements for thin-walled structures 8. Computation of thin-walled structures 9. Error estimation and hp-adaptivity 10. High-order fictitious domain methods
Literature	[1] Alexander Düster, High-Order FEM, Lecture Notes, Technische Universität Hamburg-Harburg, 164 pages, 2014 [2] Barna Szabo, Ivo Babuska, Introduction to Finite Element Analysis – Formulation, Verification and Validation, John Wiley & Sons, 2011

Course L0281: High-Order FEM	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Alexander Düster
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

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	Basics of computational and general thermo/fluid dynamics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Establish a thorough understanding of Finite-Volume approaches. Familiarise with details of the theoretical background of complex CFD algorithms.
Skills	Ability to manage of interface problems and build-up of coding skills. Ability to evaluate, assess and benchmark different solution options.
Personal Competence	
Social Competence	Practice of team working during team exercises.
Autonomy	Indenpendent analysis of specific solution approaches.
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: Technical Complementary Course: 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 M0805: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)

Courses

Title	Typ	Hrs/wk	CP
Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics) (L0516)	Lecture	2	3
Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics) (L0518)	Recitation Section (large)	2	3

Module Responsible	Prof. Otto von Estorff
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 in acoustics regarding acoustic waves, noise protection, and psycho acoustics and are able to give an overview of the corresponding theoretical and methodical basis.
Skills	The students are capable to handle engineering problems in acoustics by theory-based application of the demanding methodologies and measurement procedures treated within the module.
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 acoustical problems in the areas treated within the module. Possible conflicting issues and limitations 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	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory

Course L0516: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	SoSe
Content	- Introduction and Motivation - Acoustic quantities - Acoustic waves - Sound sources, sound radiation - Sound engergy and intensity - Sound propagation - Signal processing - Psycho acoustics - Noise - Measurements in acoustics
Literature	Cremer, L.; Heckl, M. (1996): Körperschall. Springer Verlag, Berlin Veit, I. (1988): Technische Akustik. Vogel-Buchverlag, Würzburg Veit, I. (1988): Flüssigkeitsschall. Vogel-Buchverlag, Würzburg

Course L0518: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)	
Typ	Recitation Section (large)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0807: Boundary Element Methods

Courses

Title	Typ	Hrs/wk	CP
Boundary Element Methods (L0523)	Lecture	2	3
Boundary Element Methods (L0524)	Recitation Section (large)	2	3

Module Responsible	Prof. Otto von Estorff
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 boundary 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 boundary 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 boundary 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	90 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Energy Systems: Core qualification: Elective Compulsory Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L0523: Boundary Element Methods	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	SoSe
Content	- Boundary value problems - Integral equations - Fundamental Solutions - Element formulations - Numerical integration - Solving systems of equations (statics, dynamics) - Special BEM formulations - Coupling of FEM and BEM - Hands-on Sessions (programming of BE routines) - Applications
Literature	Gaul, L.; Fiedler, Ch. (1997): Methode der Randelemente in Statik und Dynamik. Vieweg, Braunschweig, Wiesbaden Bathe, K.-J. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin

Course L0524: Boundary 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. Otto von Estorff
Language	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	Prof. Herbert Werner
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 Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: 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: Technical Complementary Course: 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	Prof. Herbert Werner
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	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1343: Structure and properties of fibre-polymer-composites

Courses

Title	Typ	Hrs/wk	CP
Structure and properties of fibre-polymer-composites (L1894)	Lecture	2	3
Structure and properties of fibre-polymer-composites (L2614)	Project-/problem-based Learning	2	2
Structure and properties of fibre-polymer-composites (L2613)	Recitation Section (large)	1	1

Module Responsible	Prof. Bodo Fiedler
Admission Requirements	None
Recommended Previous Knowledge	Basics: chemistry / physics / materials science
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can use the knowledge of fiber-reinforced composites (FRP) and its constituents to play (fiber / matrix) and define the necessary testing and analysis. They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, their processing with the different fiber types, including to explain neighboring contexts (e.g. sustainability, environmental protection).
Skills	Students are capable of • using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials. • approximate sizing using the network theory of the structural elements implement and evaluate. • selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance.
Personal Competence	
Social Competence	Students can • arrive at funded work results in heterogenius groups and document them. • provide appropriate feedback and handle feedback on their own performance constructively.
Autonomy	Students are able to - assess their own strengths and weaknesses. - assess their own state of learning in specific terms and to define further work steps on this basis. - assess possible consequences of their professional activity.
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 min
Assignment for the Following Curricula	Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Materials Science: Specialisation Engineering Materials: Elective Compulsory Mechanical Engineering and Management: 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: Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Renewable Energies: Specialisation Solar Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1894: Structure and properties of fibre-polymer-composites	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bodo Fiedler
Language	EN
Cycle	SoSe
Content	- Microstructure and properties of the matrix and reinforcing materials and their interaction - Development of composite materials - Mechanical and physical properties - Mechanics of Composite Materials - Laminate theory - Test methods - Non destructive testing - Failure mechanisms - Theoretical models for the prediction of properties - Application
Literature	Hall, Clyne: Introduction to Composite materials, Cambridge University Press Daniel, Ishai: Engineering Mechanics of Composites Materials, Oxford University Press Mallick: Fibre-Reinforced Composites, Marcel Deckker, New York

Course L2614: Structure and properties of fibre-polymer-composites	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Bodo Fiedler
Language	DE/EN
Cycle	SoSe
Content	
Literature	

Course L2613: Structure and properties of fibre-polymer-composites	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Bodo Fiedler
Language	EN
Cycle	SoSe
Content	
Literature	

Module M0714: Numerical Treatment of 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 für Ingenieurstudierende (deutsch oder englisch) oder Analysis & Lineare Algebra I + II sowie Analysis III für Technomathematiker • Basic MATLAB knowledge
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to • list numerical methods for the solution of ordinary differential equations and explain their core ideas, • repeat convergence statements for the treated numerical methods (including the prerequisites tied to the underlying problem), • explain aspects regarding the practical execution of a method. • select the appropriate numerical method for concrete problems, implement the numerical algorithms efficiently and interpret the numerical results
Skills	Students are able to • implement (MATLAB), apply and compare numerical methods for the solution of ordinary differential equations, • to justify the convergence behaviour of numerical methods with respect to the posed problem and selected algorithm, • for a given problem, develop a suitable solution approach, if necessary by the composition of several algorithms, to execute this approach and to critically evaluate the results.
Personal Competence	
Social Competence	Students are able to • work together in heterogeneously composed teams (i.e., teams from different study programs and 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 supporting theoretical and practical excercises are better solved individually or in a team, • 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 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 Mechatronics: Specialisation Intelligent Systems and Robotics: 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 • variational 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

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 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	Attendance of a computational fluid dynamics course (CFD1/CFD2) Competent knowledge of numerical analysis in addition to general and computational thermo/fluid dynamics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Student can explain the theoretical background of different CFD strategies (e.g. Lattice-Boltzmann, Smoothed Particle-Hydrodynamics, Finite-Volume methods) and describe the fundamentals of simulation-based optimisation.
Skills	Student is able to identify an appropriate CFD-based solution strategy on a jusitfied basis.
Personal Competence	
Social Competence	Student should practice her/his team-working abilities, learn to lead team sessions and present solutions to experts.
Autonomy	Student should be able to structure and perform a simulation-based project independently,
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** Yes; **Bonus** 20 %; **Form** Written elaboration; **Description**
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: Technical Complementary Course: 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

Module M1208: Project Work Energy Systems

Courses			
Title	**Typ**	**Hrs/wk**	**CP**

Module Responsible	NN
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	NN
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	NN
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

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 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 • Hydraulics • Control Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • Describe essential components and design points of hydraulic, electrical and high-lift systems • Give an overview of the functionality of air conditioning systems • Explain the need for high-lift systems such as ist functionality and effects • Assess the challenge during the design of supply systems of an aircraft
Skills	Students are able to: • Design hydraulic and electric supply systems of aircrafts • Design high-lift systems of aircrafts • Analyze the thermodynamic behaviour of air conditioning systems
Personal Competence	
Social Competence	Students are able to: • Perform system design in groups and present and discuss results
Autonomy	Students are able to: • Reflect the contents of lectures autonomously
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 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: Technical Complementary Course: 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 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

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	NN
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	The students are able to discuss in small groups and develop an approach.
Autonomy	Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.
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 and Environmental Engineering: Specialisation Energy 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 Theoretical Mechanical Engineering: Technical Complementary Course: 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	NN
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	NN
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 Theoretical Mechanical Engineering: Technical Complementary Course: 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 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 and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Systems: Elective Compulsory Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Renewable Energies: Core qualification: Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective 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 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	NN
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	The students are able to discuss in small groups and develop an approach.
Autonomy	Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.
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 and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory 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: Technical Complementary Course: 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	NN
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	NN
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: Technical Complementary Course: 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 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
Steam turbines in energy, environmental and Power Train Engineering (L1286)	Lecture	3	5
Steam turbines in energy, environmental and Power Train Engineering (L1287)	Recitation Section (small)	1	1
Gas Distribution Systems (L1639)	Lecture	2	3
Auxiliary Systems on Board of Ships (L1249)	Lecture	2	2
Auxiliary Systems on Board of Ships (L1250)	Recitation Section (large)	1	1
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
System Simulation (L1820)	Lecture	2	2
System Simulation (L1821)	Recitation Section (large)	1	2
Turbines and Turbo Compressors (L1564)	Lecture	2	3
Turbines and Turbo Compressors (L1565)	Recitation Section (large)	1	1
Internal Combustion Engines II (L1079)	Lecture	2	2
Internal Combustion Engines II (L1080)	Recitation Section (large)	1	2
Hydrogen Technology (L0060)	Lecture	2	2
Wind Turbine Plants (L0011)	Lecture	2	3
Reliability in Engineering Dynamics (L1303)	Recitation Section (small)	1	2

Module Responsible	NN
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 L1286: Steam turbines in energy, environmental and Power Train Engineering	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Dr. Christian Scharfetter
Language	DE
Cycle	WiSe
Content	• Introduction • Construction Aspects of a Steam Turbine • Energy Conversion in a Steam Turbine • Construction Types of Steam Turbines • Behaviour of Steam Turbines • Sealing Systems for Steam Turbines • Axial Thrust • Regulation of Steam Turbines • Stiffness Calculation of the Blades • Blade and Rotor Oscillations • Fundamentals of a Safe Steam Turbine Operation • Application in Conventional and Renewable Power Stations • Connection to thermal and electrical energy networks, interfaces • Conventional and regenerative power plant concepts, drive technology • Analysis of the global energy supply market • Applications in conventional and regenerative power plants • Different power plant concepts and their influence on the steam turbine (engine and gas turbine power plants with waste heat utilization, geothermal energy, solar thermal energy, biomass, biogas, waste incineration). • Classic combined heat and power generation as a combined product of the manufacturing industry • Impact of change in the energy market, operating profiles • Applications in drive technology • Operating and maintenance concepts The lecture will be deepened by means of examples, tasks and two excursions
Literature	• Traupel, W.: Thermische Turbomaschinen. Berlin u. a., Springer (TUB HH: Signatur MSI-105) • Menny, K.: Strömungsmaschinen: hydraulische und thermische Kraft- und Arbeitsmaschinen. Ausgabe: 5. Wiesbaden, Teubner, 2006 (TUB HH: Signatur MSI-121) • Bohl, W.: Aufbau und Wirkungsweise. Ausgabe 6. Würzburg, Vogel, 1994 (TUB HH: Signatur MSI-109) • Bohl, W.: Berechnung und Konstruktion. Ausgabe 6. Aufl. Würzburg, Vogel, 1999 (TUB HH: Signatur MSI-110)

Course L1287: Steam turbines in energy, environmental and Power Train Engineering	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Dr. Christian Scharfetter
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1639: Gas Distribution Systems	
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. Bernhard Klocke
Language	DE/EN
Cycle	SoSe
Content	• Introduction - A general survey of gas supply • Grid layout • Gas pressure control system • Pipeline technology • Gas metering and energy calculation • Construction of network • Operation of network • In-House installation • Injection of Biomethane • Technical directives and standards
Literature	• Homann, K.; Reimert, R.; Klocke, B.: The Gas Engineer's Dictionary Oldenbourg Industrieverlag, 2013 ISBN 978-3-8356-3214-1 • Cerbe, G.: Grundlagen der Gastechnik: Gasbeschaffung - Gasverteilung - Gasverwendung 7. Auflage 2008 ISBN 978-3-446-41352-8 • Homann, K., Hüwener, T., Klocke, B., Wernekinck, U.: Handbuch der Gasversorgungstechnik Deutscher Industrieverlag GmbH, 2017 ISBN: 978-3-8356-7299-4 (Print); ISBN: 978-3-8356-7298-7 (eBook) • Klocke, B., Heimlich, F., Petermann, H.: Handbuch der Gasverwendungstechnik - Greening of Gas - Technologien für die Energiewende Vulkan-Verlag GmbH. 2020 ISBN: 978-3-8356-7372-4 (Print); ISBN: 978-3-8356-7373-1 (eBook)

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 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 L1820: System Simulation	
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	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica. • 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 3.4", Linköping, Sweden, 2 0 1 7 [2] M. Tiller: “Modelica by Example", http://book.xogeny.com, 2014. [3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000. [4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015. [5] P. Fritzson: “Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica”, Wiley, New York, 2011.

Course L1821: System Simulation	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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 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

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	Dr. Martin Dornheim
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

Course L1303: Reliability in Engineering Dynamics	
Typ	Recitation Section (small)
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	NN
Language	EN
Cycle	SoSe
Content	Method for calculation and testing of reliability of dynamic machine systems • Modeling • System identification • Simulation • Processing of measurement data • Damage accumulation • Test planning and execution
Literature	Bertsche, B.: Reliability in Automotive and Mechanical Engineering. Springer, 2008. ISBN: 978-3-540-33969-4 Inman, Daniel J.: Engineering Vibration. Prentice Hall, 3rd Ed., 2007. ISBN-13: 978-0132281737 Dresig, H., Holzweißig, F.: Maschinendynamik, Springer Verlag, 9. Auflage, 2009. ISBN 3540876936. VDA (Hg.): Zuverlässigkeitssicherung bei Automobilherstellern und Lieferanten. Band 3 Teil 2, 3. überarbeitete Auflage, 2004. ISSN 0943-9412

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
Steam turbines in energy, environmental and Power Train Engineering (L1286)	Lecture	3	5
Steam turbines in energy, environmental and Power Train Engineering (L1287)	Recitation Section (small)	1	1
Gas Distribution Systems (L1639)	Lecture	2	3
Auxiliary Systems on Board of Ships (L1249)	Lecture	2	2
Auxiliary Systems on Board of Ships (L1250)	Recitation Section (large)	1	1
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
System Simulation (L1820)	Lecture	2	2
System Simulation (L1821)	Recitation Section (large)	1	2
Turbines and Turbo Compressors (L1564)	Lecture	2	3
Turbines and Turbo Compressors (L1565)	Recitation Section (large)	1	1
Internal Combustion Engines II (L1079)	Lecture	2	2
Internal Combustion Engines II (L1080)	Recitation Section (large)	1	2
Hydrogen Technology (L0060)	Lecture	2	2
Wind Turbine Plants (L0011)	Lecture	2	3

Module Responsible	NN
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 L1286: Steam turbines in energy, environmental and Power Train Engineering	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Dr. Christian Scharfetter
Language	DE
Cycle	WiSe
Content	• Introduction • Construction Aspects of a Steam Turbine • Energy Conversion in a Steam Turbine • Construction Types of Steam Turbines • Behaviour of Steam Turbines • Sealing Systems for Steam Turbines • Axial Thrust • Regulation of Steam Turbines • Stiffness Calculation of the Blades • Blade and Rotor Oscillations • Fundamentals of a Safe Steam Turbine Operation • Application in Conventional and Renewable Power Stations • Connection to thermal and electrical energy networks, interfaces • Conventional and regenerative power plant concepts, drive technology • Analysis of the global energy supply market • Applications in conventional and regenerative power plants • Different power plant concepts and their influence on the steam turbine (engine and gas turbine power plants with waste heat utilization, geothermal energy, solar thermal energy, biomass, biogas, waste incineration). • Classic combined heat and power generation as a combined product of the manufacturing industry • Impact of change in the energy market, operating profiles • Applications in drive technology • Operating and maintenance concepts The lecture will be deepened by means of examples, tasks and two excursions
Literature	• Traupel, W.: Thermische Turbomaschinen. Berlin u. a., Springer (TUB HH: Signatur MSI-105) • Menny, K.: Strömungsmaschinen: hydraulische und thermische Kraft- und Arbeitsmaschinen. Ausgabe: 5. Wiesbaden, Teubner, 2006 (TUB HH: Signatur MSI-121) • Bohl, W.: Aufbau und Wirkungsweise. Ausgabe 6. Würzburg, Vogel, 1994 (TUB HH: Signatur MSI-109) • Bohl, W.: Berechnung und Konstruktion. Ausgabe 6. Aufl. Würzburg, Vogel, 1999 (TUB HH: Signatur MSI-110)

Course L1287: Steam turbines in energy, environmental and Power Train Engineering	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Dr. Christian Scharfetter
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1639: Gas Distribution Systems	
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. Bernhard Klocke
Language	DE/EN
Cycle	SoSe
Content	• Introduction - A general survey of gas supply • Grid layout • Gas pressure control system • Pipeline technology • Gas metering and energy calculation • Construction of network • Operation of network • In-House installation • Injection of Biomethane • Technical directives and standards
Literature	• Homann, K.; Reimert, R.; Klocke, B.: The Gas Engineer's Dictionary Oldenbourg Industrieverlag, 2013 ISBN 978-3-8356-3214-1 • Cerbe, G.: Grundlagen der Gastechnik: Gasbeschaffung - Gasverteilung - Gasverwendung 7. Auflage 2008 ISBN 978-3-446-41352-8 • Homann, K., Hüwener, T., Klocke, B., Wernekinck, U.: Handbuch der Gasversorgungstechnik Deutscher Industrieverlag GmbH, 2017 ISBN: 978-3-8356-7299-4 (Print); ISBN: 978-3-8356-7298-7 (eBook) • Klocke, B., Heimlich, F., Petermann, H.: Handbuch der Gasverwendungstechnik - Greening of Gas - Technologien für die Energiewende Vulkan-Verlag GmbH. 2020 ISBN: 978-3-8356-7372-4 (Print); ISBN: 978-3-8356-7373-1 (eBook)

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 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 L1820: System Simulation	
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	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica. • 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 3.4", Linköping, Sweden, 2 0 1 7 [2] M. Tiller: “Modelica by Example", http://book.xogeny.com, 2014. [3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000. [4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015. [5] P. Fritzson: “Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica”, Wiley, New York, 2011.

Course L1821: System Simulation	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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 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

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	Dr. Martin Dornheim
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 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: Technical Complementary Course: 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 evaluate 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	None
Examination	Written exam
Examination duration and scale	3 hours written exam
Assignment for the Following Curricula	Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory 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 Theoretical Mechanical Engineering: Technical Complementary Course: 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, Paola Pignatelli
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 M0641: Steam Generators

Courses

Title	Typ	Hrs/wk	CP
Steam Generators (L0213)	Lecture	3	5
Steam Generators (L0214)	Recitation Section (large)	1	1

Module Responsible	Dr. Kristin Abel-Günther
Admission Requirements	None
Recommended Previous Knowledge	• "Technical Thermodynamics I and II" • "Heat Transfer" • "Fluid Mechanics" • "Steam Power Plants"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students know the thermodynamic base principles for steam generators and their types. They are able to describe the basic principles of steam generators and sketch the combustion and fuel supply aspects of fossil-fuelled power plants. They can perform thermal design calculations and conceive the water-steam side, as well as they are able to define the constructive details of the steam generator. The students can describe and evaluate the operational behaviour of steam generators and explain these in the context of related disciplines.
Skills	The students will be able, using detailed knowledge on the calculation, design, and construction of steam generators, linked with a wide theoretical and methodical foundation, to understand the main design and construction aspects of steam generators. Through problem definition and formalisation, modelling of processes, and training in the solution methodology for partial problems a good overview of this key component of the power plant will be obtained. Within the framework of the exercise the students obtain the ability to draw the balances, and design the steam generator and its components. For this purpose small but close to lifelike tasks are solved, to highlight aspects of the design of steam generators.
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 to further improve their understanding.
Autonomy	The students will be able to perform basic calculations covering aspects of the steam generator, with only the help of smaller clues, on their own. This way the theoretical and practical knowledge from the lecture is consolidated and the potential effects from different process schemata and boundary conditions are highlighted.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory**: No; **Bonus**: 5 %; **Form**: Excercises; **Description**: Den Studierenden wird eine kleine Aufgabe (in ca. 5 min lösbar) zur Vorlesung der Vorwoche gestellt. Die Antworten müssen üblicherweise als Freitext gegeben werden, aber auch Zeichnungen, Stichpunkte oder, in seltenen Fällen, Multiple Choice sind möglich.
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L0213: Steam Generators	
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	SoSe
Content	• Thermodynamics of steam • Basic principles of steam generators • Types of steam generators • Fuels and combustion systems • Coal pulverisers and coal drying • Modes of operation • Thermal analysis and design • Fluid dynamics in steam generators • Design of the water-steam side • Construction aspects • Stress analysis • Feed water for steam generators • Operating behaviour of steam Generators
Literature	• Dolezal, R.: Dampferzeugung. Springer-Verlag, 1985 • Thomas, H.J.: Thermische Kraftanlagen. Springer-Verlag, 1985 • Steinmüller-Taschenbuch: Dampferzeuger-Technik. Vulkan-Verlag, Essen, 1992 • Kakaç, Sadık: Boilers, Evaporators and Condensers. John Wiley & Sons, New York, 1991 • Stultz, S.C. and Kitto, J.B. (Ed.): Steam - its generation and use. 40th edition, The Babcock & Wilcox Company, Barberton, Ohio, USA, 1992

Course L0214: Steam Generators	
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	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	Dr. Kristin Abel-Günther
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	The students outline the thermodynamic and chemical fundamentals of combustion processes. From the knowledge of the characteristics and reaction kinetics of various fuels they can describe the behaviour of premixed flames and non-premixed flames, in order to describe the fundamentals of furnace design in gas-, oil- and coal combustion plant. The students are furthermore able to describe the formation of NO_x and the primary NO_x reduction measures, and evaluate the impact of regulations and allowable limit levels. 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.
Skills	Using thermodynamic calculations and considering the reaction kinetics the students will be able to determine interdisciplinary correlations between thermodynamic and chemical processes during combustion. This then enables quantitative analysis of the combustion of gaseous, liquid and solid fuels and determination of the quantities and concentrations of the exhaust gases. In this module the first step toward the utilisation of an energy source (combustion) to provide usable energy (electricity and heat) is taught. An understanding of both procedures enables the students to holistically consider energy utilisation. Examples taken from the praxis, 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. Within the framework of the exercises the students will first learn to calculate the energetic and mass balances of combustion processes. Moreover, the students will gain a deeper understanding of the combustion processes by the calculation of reaction kinetics.
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**: No; **Bonus**: 10 %; **Form**: Written elaboration; **Description**: 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 Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: 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	Dr. Kristin Abel-Günther
Language	DE
Cycle	SoSe
Content	The subject area of "Combined Heat and Power" covers the following themes: • 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 whereas the subject of Combustion Technology includes: • Thermodynamic and chemical fundamentals • Fuels • Reaction kinetics • Premixed flames • Non-premixed flames • Combustion of gaseous fuels • Combustion of liquid fuels • Combustion of solid fuels • Combustion Chamber design • NO_x reduction
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	Dr. Kristin Abel-Günther
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1155: Aircraft Cabin Systems

Courses

Title	Typ	Hrs/wk	CP
Aircraft Cabin Systems (L1545)	Lecture	3	4
Aircraft Cabin Systems (L1546)	Recitation Section (large)	1	2

Module Responsible	Prof. Ralf God
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Control Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • describe cabin operations, equipment in the cabin and cabin Systems • explain the functional and non-functional requirements for cabin Systems • elucidate the necessity of cabin operating systems and emergency Systems • assess the challenges human factors integration in a cabin environment
Skills	Students are able to: • design a cabin layout for a given business model of an Airline • design cabin systems for safe operations • design emergency systems for safe man-machine interaction • solve comfort needs and entertainment requirements in the cabin
Personal Competence	
Social Competence	Students are able to: • understand existing system solutions and discuss their ideas with experts
Autonomy	Students are able to: • Reflect the contents of lectures and expert presentations self-dependent
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 Minutes
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Aircraft Systems Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: 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 Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1545: Aircraft Cabin Systems	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge about aircraft cabin systems and cabin operations. A basic understanding of technological and systems engineering effort to maintain an artificial but comfortable and safe travel and working environment at cruising altitude is to be achieved. The course provides a comprehensive overview of current technology and cabin systems in modern passenger aircraft. The Fulfillment of requirements for the cabin as the central system of work are covered on the basis of the topics comfort, ergonomics, human factors, operational processes, maintenance and energy supply: • Materials used in the cabin • Ergonomics and human factors • Cabin interior and non-electrical systems • Cabin electrical systems and lights • Cabin electronics, communication-, information- and IFE-systems • Cabin and passenger process chains • RFID Aircraft Parts Marking • Energy sources and energy conversion
Literature	- Skript zur Vorlesung - Jenkinson, L.R., Simpkin, P., Rhodes, D.: Civil Jet Aircraft Design. London: Arnold, 1999 - Rossow, C.-C., Wolf, K., Horst, P. (Hrsg.): Handbuch der Luftfahrzeugtechnik. Carl Hanser Verlag, 2014 - Moir, I., Seabridge, A.: Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration, Wiley 2008 - Davies, M.: The standard handbook for aeronautical and astronautical engineers. McGraw-Hill, 2003 - Kompendium der Flugmedizin. Verbesserte und ergänzte Neuauflage, Nachdruck April 2006. Fürstenfeldbruck, 2006 - Campbell, F.C.: Manufacturing Technology for Aerospace Structural Materials. Elsevier Ltd., 2006

Course L1546: Aircraft Cabin Systems	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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	None
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 and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Renewable Energies: Core qualification: Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory

<table>
<tr><th colspan="2">Course L0061: Biofuels Process Technology</th></tr>
<tr><td>Typ</td><td>Lecture</td></tr>
<tr><td>Hrs/wk</td><td>1</td></tr>
<tr><td>CP</td><td>1</td></tr>
<tr><td>Workload in Hours</td><td>Independent Study Time 16, Study Time in Lecture 14</td></tr>
<tr><td>Lecturer</td><td>Prof. Oliver Lüdtke</td></tr>
<tr><td>Language</td><td>DE</td></tr>
<tr><td>Cycle</td><td>WiSe</td></tr>
<tr><td>Content</td><td>

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 ©

</td></tr>
<tr><td>Literature</td><td>

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

</td></tr>
</table>

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. Isabel Höfer
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

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

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. Sven Hoog
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 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

Module M1210: Selected Topics of Marine Engineering - Option A

Courses

Title	Typ	Hrs/wk	CP
Fundamentals of Naval Architecture for Marine Engineers (L1704)	Lecture	2	2
Fundamentals of Naval Architecture for Marine Engineers (L1705)	Recitation Section (large)	1	2
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
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
System Simulation (L1820)	Lecture	2	2
System Simulation (L1821)	Recitation Section (large)	1	2
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 L1704: Fundamentals of Naval Architecture for Marine Engineers

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. Eike Lehmann
Language	DE
Cycle	WiSe
Content	
Literature	

Course L1705: Fundamentals of Naval Architecture for Marine Engineers

Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Eike Lehmann
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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 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 L1820: System Simulation	
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	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica. • 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 3.4", Linköping, Sweden, 2 0 1 7 [2] M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014. [3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000. [4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015. [5] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.

Course L1821: System Simulation	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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 Theoretical Mechanical Engineering: Technical Complementary Course: 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
Fundamentals of Naval Architecture for Marine Engineers (L1704)	Lecture	2	2
Fundamentals of Naval Architecture for Marine Engineers (L1705)	Recitation Section (large)	1	2
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
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
System Simulation (L1820)	Lecture	2	2
System Simulation (L1821)	Recitation Section (large)	1	2
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 L1704: Fundamentals of Naval Architecture for Marine Engineers

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. Eike Lehmann
Language	DE
Cycle	WiSe
Content	
Literature	

Course L1705: Fundamentals of Naval Architecture for Marine Engineers

Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Eike Lehmann
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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 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 L1820: System Simulation	
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	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica. • 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 3.4", Linköping, Sweden, 2 0 1 7 [2] M. Tiller: “Modelica by Example", http://book.xogeny.com, 2014. [3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000. [4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015. [5] P. Fritzson: “Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica”, Wiley, New York, 2011.

Course L1821: System Simulation	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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 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: Technical Complementary Course: 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	NN
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	The students are able to discuss in small groups and develop an approach.
Autonomy	Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.
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 and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory 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: Technical Complementary Course: 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	NN
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	NN
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: Technical Complementary Course: 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 M0641: Steam Generators

Courses

Title	Typ	Hrs/wk	CP
Steam Generators (L0213)	Lecture	3	5
Steam Generators (L0214)	Recitation Section (large)	1	1

Module Responsible	Dr. Kristin Abel-Günther
Admission Requirements	None
Recommended Previous Knowledge	• "Technical Thermodynamics I and II" • "Heat Transfer" • "Fluid Mechanics" • "Steam Power Plants"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students know the thermodynamic base principles for steam generators and their types. They are able to describe the basic principles of steam generators and sketch the combustion and fuel supply aspects of fossil-fuelled power plants. They can perform thermal design calculations and conceive the water-steam side, as well as they are able to define the constructive details of the steam generator. The students can describe and evaluate the operational behaviour of steam generators and explain these in the context of related disciplines.
Skills	The students will be able, using detailed knowledge on the calculation, design, and construction of steam generators, linked with a wide theoretical and methodical foundation, to understand the main design and construction aspects of steam generators. Through problem definition and formalisation, modelling of processes, and training in the solution methodology for partial problems a good overview of this key component of the power plant will be obtained. Within the framework of the exercise the students obtain the ability to draw the balances, and design the steam generator and its components. For this purpose small but close to lifelike tasks are solved, to highlight aspects of the design of steam generators.
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 to further improve their understanding.
Autonomy	The students will be able to perform basic calculations covering aspects of the steam generator, with only the help of smaller clues, on their own. This way the theoretical and practical knowledge from the lecture is consolidated and the potential effects from different process schemata and boundary conditions are highlighted.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory**: No; **Bonus**: 5 %; **Form**: Excercises; **Description**: Den Studierenden wird eine kleine Aufgabe (in ca. 5 min lösbar) zur Vorlesung der Vorwoche gestellt. Die Antworten müssen üblicherweise als Freitext gegeben werden, aber auch Zeichnungen, Stichpunkte oder, in seltenen Fällen, Multiple Choice sind möglich.
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L0213: Steam Generators	
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	SoSe
Content	• Thermodynamics of steam • Basic principles of steam generators • Types of steam generators • Fuels and combustion systems • Coal pulverisers and coal drying • Modes of operation • Thermal analysis and design • Fluid dynamics in steam generators • Design of the water-steam side • Construction aspects • Stress analysis • Feed water for steam generators • Operating behaviour of steam Generators
Literature	• Dolezal, R.: Dampferzeugung. Springer-Verlag, 1985 • Thomas, H.J.: Thermische Kraftanlagen. Springer-Verlag, 1985 • Steinmüller-Taschenbuch: Dampferzeuger-Technik. Vulkan-Verlag, Essen, 1992 • Kakaç, Sadık: Boilers, Evaporators and Condensers. John Wiley & Sons, New York, 1991 • Stultz, S.C. and Kitto, J.B. (Ed.): Steam - its generation and use. 40^{th} edition, The Babcock & Wilcox Company, Barberton, Ohio, USA, 1992

Course L0214: Steam Generators	
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	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	Dr. Kristin Abel-Günther
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	The students outline the thermodynamic and chemical fundamentals of combustion processes. From the knowledge of the characteristics and reaction kinetics of various fuels they can describe the behaviour of premixed flames and non-premixed flames, in order to describe the fundamentals of furnace design in gas-, oil- and coal combustion plant. The students are furthermore able to describe the formation of NO_x and the primary NO_x reduction measures, and evaluate the impact of regulations and allowable limit levels. 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.
Skills	Using thermodynamic calculations and considering the reaction kinetics the students will be able to determine interdisciplinary correlations between thermodynamic and chemical processes during combustion. This then enables quantitative analysis of the combustion of gaseous, liquid and solid fuels and determination of the quantities and concentrations of the exhaust gases. In this module the first step toward the utilisation of an energy source (combustion) to provide usable energy (electricity and heat) is taught. An understanding of both procedures enables the students to holistically consider energy utilisation. Examples taken from the praxis, 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. Within the framework of the exercises the students will first learn to calculate the energetic and mass balances of combustion processes. Moreover, the students will gain a deeper understanding of the combustion processes by the calculation of reaction kinetics.
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 / 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 Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: 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	Dr. Kristin Abel-Günther
Language	DE
Cycle	SoSe
Content	The subject area of "Combined Heat and Power" covers the following themes: • 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 whereas the subject of Combustion Technology includes: • Thermodynamic and chemical fundamentals • Fuels • Reaction kinetics • Premixed flames • Non-premixed flames • Combustion of gaseous fuels • Combustion of liquid fuels • Combustion of solid fuels • Combustion Chamber design • NO_x reduction
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	Dr. Kristin Abel-Günther
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 Theoretical Mechanical Engineering: Technical Complementary Course: 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	NN
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	The students are able to discuss in small groups and develop an approach.
Autonomy	Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.
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 and Environmental Engineering: Specialisation Energy 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 Theoretical Mechanical Engineering: Technical Complementary Course: 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	NN
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	NN
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 M0960: Mechanics IV (Oscillations, Analytical Mechanics, Multibody Systems, Numerical Mechanics)

Courses

Title	Typ	Hrs/wk	CP
Mechanics IV (Oscillations, Analytical Mechanics, Numerical Mechanics) (L1137)	Lecture	3	3
Mechanics IV (Oscillations, Analytical Mechanics, Numerical Mechanics) (L1138)	Recitation Section (small)	2	2
Mechanics IV (Oscillations, Analytical Mechanics, Numerical Mechanics) (L1139)	Recitation Section (large)	1	1

Module Responsible	Prof. Robert Seifried
Admission Requirements	None
Recommended Previous Knowledge	Mathematics I-III and 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 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	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: 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 Naval Architecture: Core qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory

Course L1137: Mechanics IV (Oscillations, Analytical Mechanics, Numerical Mechanics)	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	SoSe
Content	• Elements of vibration theory • Vibration of Multi-degree of freedom systems • Analytical Mechanics • Multibody Systems • Numerical methods for time integration • 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 L1138: Mechanics IV (Oscillations, Analytical Mechanics, Numerical Mechanics)	
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
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1139: Mechanics IV (Oscillations, Analytical Mechanics, Numerical Mechanics)	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

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 are able to - describe the different physical mechanism of Heat Transfer, - explain the technical terms, - to analyse comlex heat transfer processes in a critical way.
Skills	The students are able to - understand the physics of Heat Transfer, - calculate and evaluate complex Heat Transfer processes, - solve excersises self-consistent and in small groups.
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 and analyse the results in a critical way. A qualified exchange with other students is given.
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 General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: 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 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 and Environmental Engineering: Core qualification: Elective Compulsory Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: 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	• Mathematical Methods for Engineers • Fundamentals of Differential/integral calculus and series expansions
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to list the basic numerics of partial differential equations.
Skills	The students are able develop appropriate numerical integration in space and time for the governing partial differential equations. They can code computational algorithms in a structured way.
Personal Competence	
Social Competence	The students can arrive at work results in groups and document them.
Autonomy	The students can independently analyse approaches to solving specific problems.
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 Theoretical Mechanical Engineering: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Naval Architecture: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Mechanical Engineering: Specialisation Aircraft Systems Engineering: 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 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 General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory Energy and Environmental Engineering: Core qualification: Elective 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 General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: 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. Otto von Estorff
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. Otto von Estorff
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. Otto von Estorff
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. Otto von Estorff
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	Dr. Kristin Abel-Günther
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 inherent 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 % / Attestation / 15-minütiges, unbenotetes Testat über EBSILON Professional; nur bestanden/nicht bestanden (keine anteiligen Punkte) No / 5 % / Excercises / 10 Übungsaufgaben im Laufe der Vorlesungen à 5 Minuten; bis zu 5 % Bonus je nach Anteil richtiger Abgaben
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 and Environmental Engineering: Core qualification: Elective Compulsory Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Systems: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: 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	NN
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.
Autonomy	Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.
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 Energy and Environmental 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 Mechanical Engineering: Core qualification: Compulsory Mechatronics: Core qualification: 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	NN
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	NN
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	NN
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 M-002: Master Thesis

Courses	
Title	**Typ** **Hrs/wk** **CP**
Module Responsible	Professoren der TUHH
Admission Requirements	• According to General Regulations §21 (1): At least 60 credit points have to be achieved in study programme. The examinations board decides on exceptions.
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• The students can use specialized knowledge (facts, theories, and methods) of their subject competently on specialized issues. • The students can explain in depth the relevant approaches and terminologies in one or more areas of their subject, describing current developments and taking up a critical position on them. • The students can place a research task in their subject area in its context and describe and critically assess the state of research.
Skills	The students are able: • To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question. • To apply knowledge they have acquired and methods they have learnt in the course of their studies to complex and/or incompletely defined problems in a solution-oriented way. • To develop new scientific findings in their subject area and subject them to a critical assessment.
Personal Competence	
Social Competence	Students can • Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structured way. • Deal with issues competently in an expert discussion and answer them in a manner that is appropriate to the addressees while upholding their own assessments and viewpoints convincingly.
Autonomy	Students are able: • To structure a project of their own in work packages and to work them off accordingly. • To work their way in depth into a largely unknown subject and to access the information required for them to do so. • To apply the techniques of scientific work comprehensively in research of their own.
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 Electrical Engineering: Thesis: Compulsory Energy and Environmental Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Computational Science and Engineering: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory

	Interdisciplinary Mathematics: Thesis: Compulsory International Management and Engineering: Thesis: Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Thesis: Compulsory Logistics, Infrastructure and Mobility: 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 Ship and Offshore Technology: Thesis: Compulsory Teilstudiengang Lehramt Metalltechnik: Thesis: Compulsory Theoretical Mechanical Engineering: Thesis: Compulsory Process Engineering: Thesis: Compulsory Water and Environmental Engineering: Thesis: Compulsory Certification in Engineering & Advisory in Aviation: Thesis: Compulsory