



Module Manual

Master of Science (M.Sc.)

Energy Systems Dual study program

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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.

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

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

Career prospects

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

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

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

Learning target

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

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

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

Program structure

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

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

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.

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

Core Qualification

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

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

Module M0508: Fluid Mechanics and Ocean Energy				
Courses				
Title		Typ	Hrs/wk	CP
Energy from the Ocean (L0002)		Lecture	2	2
Fluid Mechanics II (L0001)		Lecture	2	4
Module Responsible	Prof. Michael Schlüter			
Admission Requirements	None			
Recommended Previous Knowledge	Technische Thermodynamik I-II Wärme- und Stoffübertragung			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	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).			
<i>Skills</i>	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				
<i>Social Competence</i>	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.			
<i>Autonomy</i>	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	Bonus	Form	Description
	No	10 %	Group discussion	
Examination	Written exam			
Examination duration and scale	3h			
Assignment for the Following Curricula	Energy Systems: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory			

Course L0002: Energy from the Ocean	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE
Cycle	WiSe
Content	<ol style="list-style-type: none"> 1. Introduction to ocean energy conversion 2. Wave properties <ul style="list-style-type: none"> ◦ Linear wave theory ◦ Nonlinear wave theory ◦ Irregular waves ◦ Wave energy ◦ Refraction, reflection and diffraction of waves 3. Wave energy converters <ul style="list-style-type: none"> ◦ Overview of the different technologies ◦ Methods for design and calculation 4. Ocean current turbine
Literature	<ul style="list-style-type: none"> • 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., Østergaard, 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	<ul style="list-style-type: none"> • 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 threwn porous structures - heterogeneous catalysis • Pumps and turbines - Energy- and Environmental Process Engineering • Wind- and Wave-Turbines - Renewable Energy • Introduction into Computational Fluid Dynamics
Literature	<ol style="list-style-type: none"> 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 <i>Knowledge</i> <ul style="list-style-type: none"> • 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. <i>Skills</i> <ul style="list-style-type: none"> • 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 <i>Social Competence</i> <ul style="list-style-type: none"> • Students are able to communicate in small interdisciplinary groups and to jointly develop solutions for complex problems <i>Autonomy</i> <ul style="list-style-type: none"> • 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 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	<ul style="list-style-type: none"> • Calculus • Linear Algebra • Engineering Mechanics 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<ul style="list-style-type: none"> • Students are able to denote terms and concepts of Vibration Theory and develop them further. • Students know methods of modeling and simulation for free, driven, self-excited and parameter driven vibrations. • Students know about concepts of linear and nonlinear vibration problems. • Students know basic tasks of vibration problems of discrete and continuous systems. 			
<i>Knowledge</i>				
<i>Skills</i>				
Personal Competence				
<i>Social Competence</i>	<ul style="list-style-type: none"> • Students are able to denote methods of Vibration Theory and develop them further. • Students are able to apply and expand methods of modeling and simulation for free, forced, self-excited and parameter driven vibrations. • Students are able to solve linear and nonlinear vibration problems. 			
<i>Autonomy</i>	<ul style="list-style-type: none"> • Students can analyze vibration problems, work on them, and reach working results also in teams or groups. • Students are able to document the results of vibration studies also in groups. 			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following Curricula	Energy Systems: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

Course L0701: Vibration Theory	
Typ	Integrated Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Norbert Hoffmann
Language	DE/EN
Cycle	WiSe
Content	<p>Linear and Nonlinear Single and Multiple Degree of Freedom Vibrations</p> <ul style="list-style-type: none"> • Free vibration • Self-excited vibration • Parameter driven vibration • Forced vibration • Multi degree of freedom vibration • Continuum vibration • Irregular vibration
Literature	<p>German - K. Magnus, K. Popp, W. Sextro: Schwingungen. Physikalische Grundlagen und mathematische Behandlung von Schwingungen.</p> <p>English - K. Magnus: Vibrations.</p>

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				
<i>Knowledge</i>	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.			
<i>Skills</i>	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				
<i>Social Competence</i>	Students can work in small groups on specific problems to arrive at joint solutions.			
<i>Autonomy</i>	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	Bonus	Form	Description
	No	20 %	Midterm	
Examination	Written exam			
Examination duration and scale	120 min			
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory 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	<ul style="list-style-type: none"> - 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	<p><i>Knowledge</i></p> <ul style="list-style-type: none"> 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 <p><i>Skills</i></p> <ul style="list-style-type: none"> 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) <p>Personal Competence</p> <p><i>Social Competence</i> Students can work in small groups on specific problems to arrive at joint solutions.</p> <p><i>Autonomy</i> Students can obtain information from provided sources (lecture notes, software documentation, experiment guides) and use it when solving given problems.</p> <p>They can assess their knowledge in weekly on-line tests and thereby control their learning progress.</p>			
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 Computer Science in 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	<p>State space methods (single-input single-output)</p> <ul style="list-style-type: none"> • 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 <p>Multi-input multi-output systems</p> <ul style="list-style-type: none"> • 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 <p>Digital Control</p> <ul style="list-style-type: none"> • 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 <p>System identification and model order reduction</p> <ul style="list-style-type: none"> • Least squares estimation, ARX models, persistent excitation • Identification of state space models, subspace identification • Balanced realization and model order reduction <p>Case study</p> <ul style="list-style-type: none"> • Modelling and multivariable control of a process evaporator using Matlab and Simulink <p>Software tools</p> <ul style="list-style-type: none"> • Matlab/Simulink
Literature	<ul style="list-style-type: none"> • 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 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	<ul style="list-style-type: none"> • 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	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> Students are able</p> <ul style="list-style-type: none"> + to think holistically + to independently, securely 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				
<i>Social Competence</i>				
<i>Autonomy</i>	<p>Students are able to</p> <ul style="list-style-type: none"> + solve problems in heterogeneous groups and to document the corresponding results. <p>Students are able to</p> <ul style="list-style-type: none"> + 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 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			

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	<ol style="list-style-type: none"> 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	<p>Schwertassek, R. und Wallrapp, O.: Dynamik flexibler Mehrkörpersysteme. Braunschweig, Vieweg, 1999.</p> <p>Seifried, R.: Dynamics of Underactuated Multibody Systems, Springer, 2014.</p> <p>Shabana, A.A.: Dynamics of Multibody Systems. Cambridge Univ. Press, Cambridge, 2004, 3. Auflage.</p>

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, Dr. Svenja Drücker
Language	DE
Cycle	WiSe
Content	<ol style="list-style-type: none"> 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	<p>Bestle, D.: Analyse und Optimierung von Mehrkörpersystemen. Springer, Berlin, 1994.</p> <p>Nocedal, J. , Wright , S.J. : Numerical Optimization. New York: Springer, 2006.</p>

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			
<i>Knowledge</i>	See selected module according to FSPO		
<i>Skills</i>	See selected module according to FSPO		
Personal Competence			
<i>Social Competence</i>	See selected module according to FSPO		
<i>Autonomy</i>	See selected module according to FSPO		
Workload in Hours	Depends on choice of courses		
Credit points	6		
Assignment for the Following Curricula	Energy Systems: Core Qualification: Elective Compulsory		

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

Course L2890: Responsible Project Management in Engineering (for Dual Study Program)	
Typ	Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Henning Haschke, Heiko Sieben
Language	DE
Cycle	WiSe/SoSe
Content	<ul style="list-style-type: none"> • Theories and methods of project management • Innovation management • Agile project management • Fundamentals of classic and agile methods • Hybrid use of classic and agile methods • Roles, perspectives and stakeholders throughout the project • Initiating and coordinating complex engineering projects • Principles of moderation, team management, team leadership, conflict management • Communication structures: in-house, cross-company • Public information policy • Promoting commitment and empowerment • Sharing experience with specialists and managers from the engineering sector • Documenting and reflecting on learning experiences
Literature	Seminarapparat

Course L2891: Responsible Change and Transformation Management in Engineering (for Dual Study Program)	
Typ	Seminar
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Henning Haschke, Heiko Sieben
Language	DE
Cycle	WiSe/SoSe
Content	<ul style="list-style-type: none"> • Basic concepts, opportunities and limits of organisational change • Models and methods of organisational design and development • Strategic orientation and change, and their short-, medium- and long-term consequences for individuals, organisations and society as a whole • Roles, perspectives and stakeholders in change processes • Initiating and coordinating change measures in engineering • Phase models of organisational change (Lewin, Kotter, etc.) • Change-oriented information policy and dealing with resistance and uncertainty • Promoting commitment and empowerment • Successfully handling change and transformation: personally, as an employee, as a manager (personal, professional, organisational) • Company-level and globally (systemic) • Sharing experience with specialists and managers from the engineering sector • Documenting and reflecting on learning experiences
Literature	Seminarapparat

Module M1756: Practical module 1 (dual study program, Master's degree)			
Courses			
Title	Typ	Hrs/wk	CP
Practical term 1 (dual study program, Master's degree) (L2887)		0	10
Module Responsible	Dr. Henning Haschke		
Admission Requirements	None		
Recommended Previous Knowledge	<ul style="list-style-type: none"> Successful completion of a compatible dual B.Sc. at TU Hamburg or comparable practical work experience and competences in the area of interlinking theory and practice Course D from the module on interlinking theory and practice as part of the dual Master's course 		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence	<p><i>Knowledge</i> Dual students ...</p> <ul style="list-style-type: none"> ... combine their knowledge of facts, principles, theories and methods gained from previous study content with acquired practical knowledge - in particular their knowledge of practical professional procedures and approaches, in the current field of activity in engineering. ... have a critical understanding of the practical applications of their engineering subject. <p><i>Skills</i> Dual students ...</p> <ul style="list-style-type: none"> ... apply technical theoretical knowledge to complex, interdisciplinary problems within the company, and evaluate the associated work processes and results, taking into account different possible courses of action. ... implement the university's application recommendations with regard to their current tasks. ... develop solutions as well as procedures and approaches in their field of activity and area of responsibility. 		
Personal Competence	<p><i>Social Competence</i> Dual students ...</p> <ul style="list-style-type: none"> ... work responsibly in project teams within their working area and proactively deal with problems within their team. ... represent complex engineering viewpoints, facts, problems and solution approaches in discussions with internal and external stakeholders. <p><i>Autonomy</i> Dual students ...</p> <ul style="list-style-type: none"> ... define goals for their own learning and working processes as engineers. ... reflect on learning and work processes in their area of responsibility. ... reflect on the relevance of subject modules specialisations and specialisation for work as an engineer, and also implement the university's application recommendations and the associated challenges to positively transfer knowledge between theory and practice. 		
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0		
Credit points	10		
Course achievement	None		
Examination	Written elaboration		
Examination duration and scale	Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the dual@TUHH Coordination Office that the dual student has completed the practical phase.		
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Computer Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Compulsory Environmental Engineering: Core Qualification: Compulsory Aircraft Systems Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Information and Communication Systems: Core Qualification: Compulsory International Management and Engineering: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Core Qualification: Compulsory Materials Science: Core Qualification: Compulsory Mechanical Engineering and Management: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Core Qualification: Compulsory Microelectronics and Microsystems: Core Qualification: Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Renewable Energies: Core Qualification: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory		

Course L2887: Practical term 1 (dual study program, Master's degree)	
Typ	
Hrs/wk	0
CP	10
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Lecturer	Dr. Henning Haschke
Language	DE
Cycle	WiSe/SoSe
Content	<p>Company onboarding process</p> <ul style="list-style-type: none"> • Assigning a professional field of activity as an engineer (B.Sc.) and associated fields of work • Establishing responsibilities and authorisation of the dual student within the company as an engineer (B.Sc.) • Working independently in a team and on selected projects - across departments and, if applicable, across companies • Scheduling the current practical module with a clear correlation to work structures • Scheduling the examination phase/subsequent study semester <p>Operational knowledge and skills</p> <ul style="list-style-type: none"> • Company-specific: Responsibility as an engineer (B.Sc.) in their own area of work, coordinating team and project work, dealing with complex contexts and unsolved problems, developing and implementing innovative solutions • Subject specialisation (corresponding to the chosen course [M.Sc.]) in the field of activity • Systemic skills • Implementing the university's application recommendations (theory-practice transfer) in corresponding work and task areas across the company <p>Sharing/reflecting on learning</p> <ul style="list-style-type: none"> • Creating an e-portfolio • Importance of course contents (M.Sc.) when working as an engineer • Importance of development and innovation when working as an engineer
Literature	<ul style="list-style-type: none"> • Studierendenhandbuch • Betriebliche Dokumente • Hochschulseitige Handlungsempfehlungen zum Theorie-Praxis-Transfer

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				
<i>Knowledge</i>	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.			
<i>Skills</i>	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				
<i>Social Competence</i>	Students are able to + solve problems in heterogeneous groups. + present and discuss their results in front of others. + give and accept professional constructive criticism.			
<i>Autonomy</i>	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. + to transform the acquired knowledge to similar problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	No	10 %	Presentation	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: 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	<ol style="list-style-type: none"> 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	<p>[1] Alexander Düster, High-Order FEM, Lecture Notes, Technische Universität Hamburg-Harburg, 164 pages, 2014</p> <p>[2] Barna Szabo, Ivo Babuska, Introduction to Finite Element Analysis - Formulation, Verification and Validation, John Wiley & Sons, 2011</p>

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

Course L0237: Computational Fluid Dynamics II	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Thomas Rung
Language	DE/EN
Cycle	SoSe
Content	Computational Modelling of complex single- and multiphase flows using higher-order approximations for unstructured grids and meshless 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				
<i>Knowledge</i>	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.			
<i>Skills</i>	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				
<i>Social Competence</i>	Students can work in small groups on specific problems to arrive at joint solutions.			
<i>Autonomy</i>	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: Specialisation Product Development and Production: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: 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. Benedikt Kriegesmann, Dr.-Ing. Sören Keuchel			
Language	EN			
Cycle	SoSe			
Content	<ul style="list-style-type: none"> - Introduction and Motivation - Acoustic quantities - Acoustic waves - Sound sources, sound radiation - Sound energy 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. Benedikt Kriegesmann, Dr.-Ing. Sören Keuchel
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				
<i>Knowledge</i>	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.			
<i>Skills</i>	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				
<i>Social Competence</i>	Students can work in small groups on specific problems to arrive at joint solutions.			
<i>Autonomy</i>	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	Bonus	Form	Description
	No	20 %	Midterm	
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: 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	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> • 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 <i>Knowledge</i>	<ul style="list-style-type: none"> • 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. 			
<i>Skills</i>	<ul style="list-style-type: none"> • 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 <i>Social Competence</i>	Students can work in small groups on specific problems to arrive at joint solutions.			
<i>Autonomy</i>	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: 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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. Postlewaite "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	<p><i>Knowledge</i> Students can use the knowledge of fiber-reinforced composites (FRP) and its constituents to play (fiber / matrix) and define the necessary testing and analysis.</p> <p>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).</p> <p><i>Skills</i> Students are capable of</p> <ul style="list-style-type: none"> • 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	<p><i>Social Competence</i> Students can</p> <ul style="list-style-type: none"> • arrive at funded work results in heterogenius groups and document them. • provide appropriate feedback and handle feedback on their own performance constructively. <p><i>Autonomy</i> Students are able to</p> <ul style="list-style-type: none"> - 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		

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	<ul style="list-style-type: none"> - 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 Dekker, 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 Methods for Ordinary Differential Equations			
Courses			
Title		Typ	Hrs/wk CP
Numerical Treatment of Ordinary Differential Equations (L0576)		Lecture	2 3
Numerical Treatment of Ordinary Differential Equations (L0582)		Recitation Section (small)	2 3
Module Responsible	Prof. Daniel Ruprecht		
Admission Requirements	None		
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Mathematik I, II, III für Ingenieurstudierende (deutsch oder englisch) oder Analysis & Lineare Algebra I + II sowie Analysis III für Technomathematiker • Basic knowledge of MATLAB, Python or a similar programming language 		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence	<p><i>Knowledge</i> Students are able to</p> <ul style="list-style-type: none"> • list numerical methods for the solution of ordinary differential equations and explain their core ideas, • formulate convergence statements for the treated numerical methods (including the assumptions about the underlying problem), • explain aspects regarding the practical realisation of a method. • select the appropriate numerical method for concrete problems, implement the numerical algorithms efficiently and interpret the numerical results <p><i>Skills</i> Students are able to</p> <ul style="list-style-type: none"> • implement, apply and compare numerical methods for the solution of ordinary differential equations, • justify the convergence behaviour of numerical methods with respect to the posed problem and selected algorithm, • develop a suitable solution approach for a given problem, if necessary by combining of several algorithms, and to realise this approach and critically evaluate the results. <p>Personal Competence</p> <p><i>Social Competence</i> Students are able to</p> <ul style="list-style-type: none"> • 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. <p><i>Autonomy</i> Students are capable</p> <ul style="list-style-type: none"> • to assess whether the supporting theoretical and practical exercises 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	<p>Numerical methods for Initial Value Problems</p> <ul style="list-style-type: none"> • single step methods • multistep methods • stiff problems • differential algebraic equations (DAE) of index 1 <p>Numerical methods for Boundary Value Problems</p> <ul style="list-style-type: none"> • multiple shooting method • difference methods
Literature	<ul style="list-style-type: none"> • E. Hairer, S. Noersett, G. Wanner: Solving Ordinary Differential Equations I: Nonstiff Problems. • E. Hairer, G. Wanner: Solving Ordinary Differential Equations II: Stiff and Differential-Algebraic Problems. • D. Griffiths, D. Higham: Numerical Methods for Ordinary Differential Equations.

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

Module M1201: Practical Course Energy Systems			
Courses			
Title	Typ	Hrs/wk	CP
Practical Course Energy Systems (L1629)	Practical Course	6	6
Module Responsible	Prof. Arne Speerforck		
Admission Requirements	None		
Recommended Previous Knowledge	Heat Transfer, Gas and Steam Power Plants, Reciprocating Machinery		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	The participating students can <ul style="list-style-type: none"> • 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). 		
<i>Skills</i>	Students are able to <ul style="list-style-type: none"> • set sensors in relevant positions, • plan experiments and identify the relevant parameters, • generate test charts, • write a test report including sources of errors and literature comparison. 		
Personal Competence			
<i>Social Competence</i>	Students can <ul style="list-style-type: none"> • 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. 		
<i>Autonomy</i>	Students are able to <ul style="list-style-type: none"> • familiarize with the measurement documents, • apply measurement methods, • plan the test procedure and operate the experiments autonomously, • give short presentations to selected topics, • estimate own asset and weakness. 		
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84		
Credit points	6		
Course achievement	None		
Examination	Written elaboration		
Examination duration and scale	90 minutes		
Assignment for the Following Curricula	Energy Systems: Core Qualification: Compulsory		

Course L1629: Practical Course Energy Systems	
Typ	Practical Course
Hrs/wk	6
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Arne Speerforck, Dr. Kristin Abel-Günther
Language	DE
Cycle	SoSe
Content	<p>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 concluded in a test report and critically analysed.</p> <p>Following experiments are offered:</p> <ul style="list-style-type: none"> • 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	<p>Versuchsmanuskripte werden zu den einzelnen Versuchen zur Verfügung gestellt.</p> <p>Pfeifer, T.; Profos, P.: Handbuch der industriellen Messtechnik, 6. Auflage, 1994, Oldenbourg Verlag München</p>

Module M1757: Practical module 2 (dual study program, Master's degree)			
Courses			
Title	Typ	Hrs/wk	CP
Practical term 2 (dual study program, Master's degree) (L2888)		0	10
Module Responsible	Dr. Henning Haschke		
Admission Requirements	None		
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Successful completion of practical module 1 as part of the dual Master's course • course D from the module on interlinking theory and practice as part of the dual Master's course 		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence	<p><i>Knowledge</i> Dual students ...</p> <ul style="list-style-type: none"> • ... combine their knowledge of facts, principles, theories and methods gained from previous study content with acquired practical knowledge - in particular their knowledge of practical professional procedures and approaches, in the current field of activity in engineering. • ... have a critical understanding of the practical applications of their engineering subject. <p><i>Skills</i> Dual students ...</p> <ul style="list-style-type: none"> • ... apply technical theoretical knowledge to complex, interdisciplinary problems within the company, and evaluate the associated work processes and results, taking into account different possible courses of action. • ... implement the university's application recommendations with regard to their current tasks. • ... develop (new) solutions as well as procedures and approaches in their field of activity and area of responsibility - including in the case of frequently changing requirements (systemic skills). <p>Personal Competence</p> <p><i>Social Competence</i> Dual students ...</p> <ul style="list-style-type: none"> • ... work responsibly in cross-departmental and interdisciplinary project teams and proactively deal with problems within their team. • ... represent complex engineering viewpoints, facts, problems and solution approaches in discussions with internal and external stakeholders and develop these further together. <p><i>Autonomy</i> Dual students ...</p> <ul style="list-style-type: none"> • ... define goals for their own learning and working processes as engineers. • ... reflect on learning and work processes in their area of responsibility. • ... reflect on the relevance of subject modules specialisations and specialisation for work as an engineer, and also implement the university's application recommendations and the associated challenges to positively transfer knowledge between theory and practice. 		
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0		
Credit points	10		
Course achievement	None		
Examination	Written elaboration		
Examination duration and scale	Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the dual@TUHH Coordination Office that the dual student has completed the practical phase.		
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Computer Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Compulsory Environmental Engineering: Core Qualification: Compulsory Aircraft Systems Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Information and Communication Systems: Core Qualification: Compulsory International Management and Engineering: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Core Qualification: Compulsory Materials Science: Core Qualification: Compulsory Mechanical Engineering and Management: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Core Qualification: Compulsory Microelectronics and Microsystems: Core Qualification: Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Renewable Energies: Core Qualification: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory		

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

Course L2888: Practical term 2 (dual study program, Master's degree)	
Typ	
Hrs/wk	0
CP	10
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Lecturer	Dr. Henning Haschke
Language	DE
Cycle	WiSe/SoSe
Content	<p>Company onboarding process</p> <ul style="list-style-type: none"> • Assigning a professional field of activity as an engineer (B.Sc.) and associated fields of work • Establishing responsibilities and authorisation of the dual student within the company as an engineer (B.Sc.) • Taking personal responsibility within a team and on selected projects - across departments and, if applicable, across companies • Scheduling the current practical module with a clear correlation to work structures • Scheduling the examination phase/subsequent study semester <p>Operational knowledge and skills</p> <ul style="list-style-type: none"> • Company-specific: Responsibility as an engineer (B.Sc.) in their own area of work, coordinating team and project work, dealing with complex contexts and unsolved problems, developing and implementing innovative solutions • Subject specialisation (corresponding to the chosen course [M.Sc.]) in the field of activity • Systemic skills • Implementing the university's application recommendations (theory-practice transfer) in corresponding work and task areas across the company <p>Sharing/reflecting on learning</p> <ul style="list-style-type: none"> • Updating their e-portfolio • Importance of course contents (M.Sc.) when working as an engineer • Importance of development and innovation when working as an engineer
Literature	<ul style="list-style-type: none"> • Studierendenhandbuch • Betriebliche Dokumente • Hochschulseitige Anwendungsempfehlungen zum Theorie-Praxis-Transfer

Module M1208: Project Work Energy Systems			
Courses			
Title	Typ	Hrs/wk	CP
Module Responsible	Prof. Arne Speerforck		
Admission Requirements	None		
Recommended Previous Knowledge	Basic moduls of mechanical engineering, energy systems and marine technologies		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence	<p><i>Knowledge</i> The students can</p> <ul style="list-style-type: none"> • 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. <p><i>Skills</i> The students are able to</p> <ul style="list-style-type: none"> • 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. <p>Personal Competence</p> <p><i>Social Competence</i> The students can</p> <ul style="list-style-type: none"> • discuss selected aspects of the work with the technical and scientific staff, • present intermediate and final results adapted to the addressee. <p><i>Autonomy</i> Students are able to</p> <ul style="list-style-type: none"> • define on the base of their specific knowledge reasonable tasks in an autonomous way, • select appropriate solution methods, • approach to a necessary additional knowledge for handling the task, • plan and manage experiments and simulations. 		
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0		
Credit points	12		
Course achievement	None		
Examination	Study work		
Examination duration and scale	depending on task		
Assignment for the Following Curricula	Energy Systems: Core Qualification: Compulsory		

Module M1159: Seminar Energy Systems				
Courses				
Title	Typ	Hrs/wk	CP	
Seminar Energy Systems (L1560)	Seminar	6	6	
Module Responsible	Prof. Arne Speerforck			
Admission Requirements	None			
Recommended Previous Knowledge	Basic moduls of mechanical engineering, energy systems and marine technologies			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can <ul style="list-style-type: none"> • 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. 			
<i>Skills</i>	The students can <ul style="list-style-type: none"> • 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, • conclude 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				
<i>Social Competence</i>	The students can <ul style="list-style-type: none"> • 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. 			
<i>Autonomy</i>	The students can <ul style="list-style-type: none"> • define the task in an autonomous way, • develop the necessary knowledge, • use appropriate work equipment, • coordinate with other students, • - guided by an instructor - critically check the working status. 			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and scale	45 min			
Assignment for the Following Curricula	Energy Systems: Core Qualification: Elective Compulsory			

Course L1560: Seminar Energy Systems	
Typ	Seminar
Hrs/wk	6
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Arne Speerforck
Language	DE
Cycle	WiSe
Content	<p>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.</p> <p>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.</p>
Literature	Allg. Literatur zu Rhetorik und Präsentationstechniken

Module M1758: Practical module 3 (dual study program, Master's degree)			
Courses			
Title	Typ	Hrs/wk	CP
Practical term 3 (dual study program, Master's degree) (L2889)		0	10
Module Responsible	Dr. Henning Haschke		
Admission Requirements	None		
Recommended Previous Knowledge	<ul style="list-style-type: none"> Successful completion of practical module 2 as part of the dual Master's course course E from the module on interlinking theory and practice as part of the dual Master's course 		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence	<p><i>Knowledge</i> Dual students ...</p> <ul style="list-style-type: none"> ... combine their comprehensive and specialised engineering knowledge acquired from previous study contents with the strategy-oriented practical knowledge gained from their current field of work and area of responsibility. ... have a critical understanding of the practical applications of their engineering subject, as well as related fields when implementing innovations. <p><i>Skills</i> Dual students ...</p> <ul style="list-style-type: none"> ... apply specialised and conceptual skills to solve complex, sometimes interdisciplinary problems within the company, and evaluate the associated work processes and results, taking into account different possible courses of action. ... implement the university's application recommendations with regard to their current tasks. ... develop new solutions as well as procedures and approaches to implement operational projects and assignments - even when facing frequently changing requirements and unpredictable changes (systemic skills). ... can use academic methods to develop new ideas and procedures for operational problems and issues, and to assess these with regard to their usability. 		
Personal Competence	<p><i>Social Competence</i> Dual students ...</p> <ul style="list-style-type: none"> ... work responsibly in cross-departmental and interdisciplinary project teams and proactively deal with problems within their team. ... can promote the professional development of others in a targeted manner. ... represent complex and interdisciplinary engineering viewpoints, facts, problems and solution approaches in discussions with internal and external stakeholders and develop these further together. <p><i>Autonomy</i> Dual students ...</p> <ul style="list-style-type: none"> ... reflect on learning and work processes in their area of responsibility. ... define goals for new application-oriented tasks, projects and innovation plans while reflecting on potential effects on the company and the public. ... reflect on the relevance of areas of specialisation and research for work as an engineer, and also implement the university's application recommendations and the associated challenges to positively transfer knowledge between theory and practice. 		
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0		
Credit points	10		
Course achievement	None		
Examination	Written elaboration		
Examination duration and scale	Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the dual@TUHH Coordination Office that the dual student has completed the practical phase.		
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Computer Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Compulsory Environmental Engineering: Core Qualification: Compulsory Aircraft Systems Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Information and Communication Systems: Core Qualification: Compulsory International Management and Engineering: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Core Qualification: Compulsory Aeronautics: Core Qualification: Compulsory Materials Science and Engineering: Core Qualification: Compulsory Materials Science: Core Qualification: Compulsory		

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

Course L2889: Practical term 3 (dual study program, Master's degree)	
Typ	
Hrs/wk	0
CP	10
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Lecturer	Dr. Henning Haschke
Language	DE
Cycle	WiSe/SoSe
Content	<p>Company onboarding process</p> <ul style="list-style-type: none"> • Assigning a future professional field of activity as an engineer (M.Sc.) and associated fields of work • Extending responsibilities and authorisation of the dual student within the company up to the intended first assignment after completing their studies • Working responsibly in a team; project responsibility within own area - as well as across divisions and companies if necessary • Scheduling the final practical module with a clear correlation to work structures • Internal agreement on a potential topic or innovation project for the Master's dissertation • Planning the Master's dissertation within the company in cooperation with TU Hamburg • Scheduling the examination phase/subsequent study semester <p>Operational knowledge and skills</p> <ul style="list-style-type: none"> • Company-specific: dealing with change, project and team development, responsibility as an engineer in their future field of work (M.Sc.), dealing with complex contexts, frequent and unpredictable changes, developing and implementing innovative solutions • Specialising in one field of work (final dissertation) • Systemic skills • Implementing the university's application recommendations (theory-practice transfer) in corresponding work and task areas across the company <p>Sharing/reflecting on learning</p> <ul style="list-style-type: none"> • E-portfolio • Relevance of study content and personal specialisation when working as an engineer • Relevance of research and innovation when working as an engineer
Literature	<ul style="list-style-type: none"> • Studierendenhandbuch • betriebliche Dokumente • Hochschulseitige Anwendungsempfehlungen zum Theorie-Praxis-Transfer

Module M0658: Innovative CFD Approaches				
Courses				
Title		Typ	Hrs/wk	CP
Application of Innovative CFD Methods in Research and Development (L0239)		Lecture	2	3
Application of Innovative CFD Methods in Research and Development (L1685)		Recitation Section (small)	2	3
Module Responsible	Prof. Thomas Rung			
Admission Requirements	None			
Recommended Previous Knowledge	Students should have sound knowledge of engineering mathematics (series expansions, internal & vector calculus), and be familiar with the foundations of partial/ordinary differential equations. They are expected to be familiar with engineering fluid mechanics. Basic knowledge of numerical analysis or computational fluid dynamics, e.g. acquired in previous CFD courses, is of advantage but not necessary.			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	Students will acquire a deeper knowledge of recent trends in computational fluid dynamics (CFD), i.e. finite volume, smoothed particle hydrodynamics and lattice Boltzmann approaches, and can relate recent innovations with present challenges in computational fluid mechanics. They are familiar with the similarities and differences between different Eulerian and Lagrangian discretisation and approximation concepts for investigating on the basis of continuum and kinetic theories. Students have the required knowledge to develop, explain, code and apply numerical models concepts to approximate multiphase and multifield problems with grid and particle based methods, respectively. Students know the fundamentals of simulation based PDE constraint optimisation.			
<i>Knowledge</i>				
<i>Skills</i>	The students are able choose and apply appropriate discretisation concepts and flow physics models. They acquire the ability to code computational algorithms dedicated to finite volumes on unstructured grids & particle-based discretisations & structured lattice Boltzmann arrangements, apply these codes for parameter investigations and supplement interfaces to extract simulation data for an engineering analysis. They are able to sophisticatedly judge different solution strategies.			
Personal Competence	The students are able to discuss problems, present the results of their own analysis, and jointly develop, implement and report on solution strategies that address given technical reference problems in a team. They to lead team sessions and present solutions to experts.			
<i>Social Competence</i>				
<i>Autonomy</i>	The students can independently analyse innovative methods to solving fluid engineering problems. They are able to critically analyse own results as well as external data with regards to the plausibility and reliability. Students are able to structure and perform a simulation-based investigation.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	20 %	Written elaboration	
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Energy Systems: Core Qualification: Elective Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Ship and Offshore Technology: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory			

Course L0239: Application of Innovative CFD Methods in Research and Development	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Thomas Rung
Language	DE/EN
Cycle	WiSe
Content	Computational Optimisation, Parallel Computing, Efficient CFD-Procedures for GPU Architectures, Alternative Approximations (Lattice-Boltzmann Methods, Particle Methods), Fluid/Structure-Interaction, Modelling of Hybrid Continua
Literature	Vorlesungsmaterialien /lecture notes

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

Specialization Energy Systems

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

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

Module M0742: Thermal Energy Systems			
Courses			
Title	Typ	Hrs/wk	CP
Thermal Energy Systems (L0023)	Lecture	3	5
Thermal Energy Systems (L0024)	Recitation Section (large)	1	1
Module Responsible	Prof. Arne Speerforck		
Admission Requirements	None		
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	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.		
<i>Skills</i>	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			
<i>Social Competence</i>	In lectures and exercises, the students can use many examples and experiments to discuss in small groups in a goal-oriented manner, develop a solution and present it. Within the exercises, the students can independently develop further questions and work out targeted solutions.		
<i>Autonomy</i>	Students are able to define tasks independently, to develop the necessary knowledge themselves based on the knowledge they have received, and to use suitable means for implementation. In the exercises, the students discuss the methods taught in the lectures using complex tasks and critically analyze the results.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	60 min		
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory		

Course L0023: Thermal Energy Systems	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Arne Speerforck, Prof. Gerhard Schmitz
Language	DE
Cycle	WiSe
Content	<p>1. Introduction</p> <p>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</p> <p>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</p> <p>4. Thermal treatment 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</p> <p>5. Laws and standards 5.1 Buildings 5.2 Industrial plants</p>
Literature	<ul style="list-style-type: none"> • Schmitz, G.: Klimateanlagen, 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 Energy Systems	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Arne Speerforck
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0763: Aircraft Energy Systems				
Courses				
Title	Typ	Hrs/wk	CP	
Aircraft Energy Systems (L0735)	Lecture	3	4	
Aircraft Energy Systems (L0739)	Recitation Section (large)	2	2	
Module Responsible	Prof. Frank Thielecke			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge in: <ul style="list-style-type: none"> • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Fluid mechanics 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<p><i>Knowledge</i> Students are able to:</p> <ul style="list-style-type: none"> • Assess challenges during the design of aircraft energy systems • Describe essential components and design points of hydraulic and electrical supply systems • Give an overview of the functionality of air conditioning systems • Describe different system concepts for de-icing • Identify constraints for the electrification of aircraft systems, and evaluate possible concepts and limitations • Describe architectures for fuel supply systems and illustrate design examples • Explain possible approaches for the integration of fuel cell systems and evaluate zero-emission concepts <p><i>Skills</i> Students are able to:</p> <ul style="list-style-type: none"> • Design hydraulic and electric supply systems of aircrafts • Analyze the thermodynamic behavior of air conditioning systems • Design ice protection systems • Apply possible electrification concepts to existing aircraft systems • Design fuel supply systems • Perform the design of a fuel cell system <p>Personal Competence</p> <p><i>Social Competence</i> Students are able to:</p> <ul style="list-style-type: none"> • Perform system design in groups and present and discuss results • Present systems engineering problems and discuss solutions with experts <p><i>Autonomy</i> Students are able to:</p> <ul style="list-style-type: none"> • Reflect on the content of lectures autonomously • Apply methods learned in the course of exercises to more advanced problems • Identify complex system dependencies autonomously and abstract simplified models and design processes 			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	165 Minutes			
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory			

Course L0735: Aircraft Energy Systems	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Frank Thielecke
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Moir, Seabridge: Aircraft Systems Green: Aircraft Hydraulic Systems Torenbek: Synthesis of Subsonic Airplane Design SAE1991: ARP; Air Conditioning Systems for Subsonic Airplanes

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

Module M1149: Marine Power Engineering			
Courses			
Title	Typ	Hrs/wk	CP
Electrical Installation on Ships (L1531)	Lecture	2	2
Electrical Installation on Ships (L1532)	Recitation Section (large)	1	1
Marine Engineering (L1569)	Lecture	2	2
Marine Engineering (L1570)	Recitation Section (large)	1	1
Module Responsible	Prof. Christopher Friedrich Wirz		
Admission Requirements	None		
Recommended Previous Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	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.		
<i>Skills</i>	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			
<i>Social Competence</i>	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.		
<i>Autonomy</i>	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.		
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84		
Credit points	6		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	90 minutes plus 20 minutes oral exam		
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory		

Course L1531: Electrical Installation on Ships	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • performance in service of electrical consumers. • special requirements for power supply systems and for electrical equipment in isolated systems/networks e. g. aboard ships, offshore installations, factory systems and emergency power supply systems. • power generation and distribution in isolated networks, shaft generators for ships • calculation of short circuits and behaviour of switching devices • protective devices, selectivity monitoring • electrical Propulsion plants for ships
Literature	H. Meier-Peter, F. Bernhardt u. a.: Handbuch der Schiffsbetriebstechnik, Seehafen Verlag (engl. Version: "Compendium Marine Engineering") Gleß, Thamm: Schiffselektrotechnik, VEB Verlag Technik Berlin

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

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

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

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

Courses			
Title	Typ	Hrs/wk	CP
Module Responsible	NN		
Admission Requirements	None		
Recommended Previous Knowledge	See selected module according to FSPO		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	See selected module according to FSPO		
<i>Skills</i>	See selected module according to FSPO		
Personal Competence			
<i>Social Competence</i>	See selected module according to FSPO		
<i>Autonomy</i>	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			
<i>Knowledge</i>	See selected module according to FSPO		
<i>Skills</i>	See selected module according to FSPO		
Personal Competence			
<i>Social Competence</i>	See selected module according to FSPO		
<i>Autonomy</i>	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 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				
<i>Knowledge</i>	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.			
<i>Skills</i>	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				
<i>Social Competence</i>	The students can participate in specialized and interdisciplinary discussions, advance ideas and represent their own work results in front of others.			
<i>Autonomy</i>	Students can independently tap knowledge of the emphasis of the lectures.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 - 150 minutes			
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory Data Science: Core Qualification: Elective Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Engineering Science: Specialisation Electrical Engineering: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Systems: Elective Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Integrated Building Technology: Core Qualification: Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory			

Course L1670: Electrical Power Systems I: Introduction to Electrical Power Systems	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • fundamentals and current development trends in electric power engineering • tasks and history of electric power systems • symmetric three-phase systems • fundamentals and modelling of electric power systems <ul style="list-style-type: none"> ◦ lines ◦ transformers ◦ synchronous machines ◦ induction machines ◦ loads and compensation ◦ grid structures and substations • fundamentals of energy conversion <ul style="list-style-type: none"> ◦ electro-mechanical energy conversion ◦ thermodynamics ◦ power station technology ◦ renewable energy conversion systems • steady-state network calculation <ul style="list-style-type: none"> ◦ 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	<p>K. Heuck, K.-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013</p> <p>A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017</p> <p>R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008</p>

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	<ul style="list-style-type: none"> • fundamentals and current development trends in electric power engineering • tasks and history of electric power systems • symmetric three-phase systems • fundamentals and modelling of electric power systems <ul style="list-style-type: none"> ◦ lines ◦ transformers ◦ synchronous machines ◦ induction machines ◦ loads and compensation ◦ grid structures and substations • fundamentals of energy conversion <ul style="list-style-type: none"> ◦ electro-mechanical energy conversion ◦ thermodynamics ◦ power station technology ◦ renewable energy conversion systems • steady-state network calculation <ul style="list-style-type: none"> ◦ 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	<p>K. Heuck, K.-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013</p> <p>A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017</p> <p>R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008</p>

Module M0721: Air Conditioning				
Courses				
Title	Typ	Hrs/wk	CP	
Air Conditioning (L0594)	Lecture	3	5	
Air Conditioning (L0595)	Recitation Section (large)	1	1	
Module Responsible	Prof. Arne Speerforck			
Admission Requirements	None			
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	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.			
<i>Skills</i>	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				
<i>Social Competence</i>	In lectures and exercises, the students can use many examples and experiments to discuss in small groups in a goal-oriented manner, develop a solution and present it. Within the exercises, the students can independently develop further questions and work out targeted solutions.			
<i>Autonomy</i>	Students are able to define tasks independently, to develop the necessary knowledge themselves based on the knowledge they have received, and to use suitable means for implementation. In the exercises, the students discuss the methods taught in the lectures using complex tasks and critically analyze the results.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 min			
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory			

Course L0594: Air Conditioning	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Arne Speerforck, Prof. Gerhard Schmitz
Language	DE
Cycle	SoSe
Content	1. Overview 1.1 Kinds of air conditioning systems 1.2 Ventilating 1.3 Function of an air condition system 2. Thermodynamic processes 2.1 Psychrometric chart 2.2 Mixer preheater, heater 2.3 Cooler 2.4 Humidifier 2.5 Air conditioning process in a Psychrometric chart 2.6 Desiccant assisted air conditioning 3. Calculation of heating and cooling loads 3.1 Heating loads 3.2 Cooling loads 3.3 Calculation of inner cooling load 3.4 Calculation of outer cooling load 4. Ventilating systems 4.1 Fresh air demand 4.2 Air flow in rooms 4.3 Calculation of duct systems 4.4 Fans 4.5 Filters 5. Refrigeration systems 5.1. compression chillers 5.2 Absorption chillers
Literature	<ul style="list-style-type: none"> • Schmitz, G.: Klimaanlage, Skript zur Vorlesung • VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013 • Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009 • Recknagel, H.; Sprenger, E.; Schrammek, E.-R.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013

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

Module M1021: Marine Diesel Engine Plants				
Courses				
Title		Typ	Hrs/wk	CP
Marine Diesel Engine Plants (L0637)		Lecture	3	4
Marine Diesel Engine Plants (L0638)		Recitation Section (large)	1	2
Module Responsible	Prof. Christopher Friedrich Wirz			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students can <ul style="list-style-type: none"> • 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. 			
<i>Skills</i>	Students can <ul style="list-style-type: none"> • 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				
<i>Social Competence</i>	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.			
<i>Autonomy</i>	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	20 min			
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory			

Course L0637: Marine Diesel Engine Plants	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	SoSe
Content	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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
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 Fluid Dynamics (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	Prof. Arne Speerforck		
Admission Requirements	None		
Recommended Previous Knowledge	Basic moduls of mechanical engineering, energy systems and marine technologies		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	The students are able to		
	<ul style="list-style-type: none"> describe selected energy systems and rank the interrelation with other energy systems. 		
<i>Skills</i>	The students can		
	<ul style="list-style-type: none"> analyse and evaluate tasks in the field of energy systems. 		
Personal Competence			
<i>Social Competence</i>	The students can		
	<ul style="list-style-type: none"> discuss with other students and lecturers different aspects of energy systems. 		
<i>Autonomy</i>	The students can		
	<ul style="list-style-type: none"> define tasks and become acquainted with necessary 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	<ol style="list-style-type: none"> 1. Introduction to electrochemical energy conversion 2. Function and structure of electrolyte 3. Low-temperature fuel cell <ul style="list-style-type: none"> ◦ Types ◦ Thermodynamics of the PEM fuel cell ◦ Cooling and humidification strategy 4. High-temperature fuel cell <ul style="list-style-type: none"> ◦ The MCFC ◦ The SOFC ◦ Integration Strategies and partial reforming 5. Fuels <ul style="list-style-type: none"> ◦ Supply of fuel ◦ Reforming of natural gas and biogas ◦ Reforming of liquid hydrocarbons 6. Energetic Integration and control of fuel cell systems
Literature	<ul style="list-style-type: none"> • Hamann, C.; Vielstich, W.: Elektrochemie 3. Aufl.; Weinheim: Wiley - VCH, 2003

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	NN
Language	DE/EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Vorschriften zur Schiffsausrüstung • Ausrüstungsanlagen auf Standard-Schiffen • Ausrüstungsanlagen auf Spezial-Schiffen • Grundlagen und Systemtechnik der Hydraulik • Auslegung und Betrieb von Ausrüstungsanlagen
Literature	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<p>Paschedag A.R.: CFD in der Verfahrenstechnik: Allgemeine Grundlagen und mehrphasige Anwendungen, Wiley-VCH, 2004 ISBN 3-527-30994-2.</p> <p>Ferziger, J.H.; Peric, M.: Numerische Strömungsmechanik. Springer-Verlag, Berlin, 2008, ISBN: 3540675868.</p> <p>Ferziger, J.H.; Peric, M.: Computational Methods for Fluid Dynamics. Springer, 2002, ISBN 3-540-42074-6</p>

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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 Fluidynamics	
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	<p>Will be announced at the beginning of the lecture. Exemplary topics are</p> <ol style="list-style-type: none"> 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, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	<p>Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica 1.17.0.</p> <ul style="list-style-type: none"> • 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	<p>[1] Modelica Association: "Modelica Language Specification - Version 3.5", Linköping, Sweden, 2021.</p> <p>[2] OpenModelica: OpenModelica 1.17.0, https://www.openmodelica.org (siehe Download), 2021.</p> <p>[3] M. Tiller: "Modelica by Example", https://book.xogeny.com, 2014.</p> <p>[4] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</p> <p>[5] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</p> <p>[6] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</p>

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, Dr. Johannes Brunnemann
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 turbomachinery 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	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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	Jun.-Prof. Julian Jepsen
Language	DE
Cycle	SoSe
Content	<ol style="list-style-type: none"> 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 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
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 Fluid Dynamics (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	Prof. Arne Speerforck
Admission Requirements	None
Recommended Previous Knowledge	Basic moduls of mechanical engineering, energy systems and marine technologies
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
<i>Knowledge</i>	The students are able to describe selected energy systems and rank the interrelation with other energy systems.
<i>Skills</i>	The students can analyse and evaluate tasks in the field of energy systems.
Personal Competence	
<i>Social Competence</i>	The students can discuss with other students and lecturers different aspects of energy systems.
<i>Autonomy</i>	The students can define tasks and become acquainted with necessary 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	<ol style="list-style-type: none"> 1. Introduction to electrochemical energy conversion 2. Function and structure of electrolyte 3. Low-temperature fuel cell <ul style="list-style-type: none"> ◦ Types ◦ Thermodynamics of the PEM fuel cell ◦ Cooling and humidification strategy 4. High-temperature fuel cell <ul style="list-style-type: none"> ◦ The MCFC ◦ The SOFC ◦ Integration Strategies and partial reforming 5. Fuels <ul style="list-style-type: none"> ◦ Supply of fuel ◦ Reforming of natural gas and biogas ◦ Reforming of liquid hydrocarbons 6. Energetic Integration and control of fuel cell systems
Literature	<ul style="list-style-type: none"> • Hamann, C.; Vielstich, W.: Elektrochemie 3. Aufl.; Weinheim: Wiley - VCH, 2003

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	NN
Language	DE/EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Vorschriften zur Schiffsausrüstung • Ausrüstungsanlagen auf Standard-Schiffen • Ausrüstungsanlagen auf Spezial-Schiffen • Grundlagen und Systemtechnik der Hydraulik • Auslegung und Betrieb von Ausrüstungsanlagen
Literature	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<p>Paschedag A.R.: CFD in der Verfahrenstechnik: Allgemeine Grundlagen und mehrphasige Anwendungen, Wiley-VCH, 2004 ISBN 3-527-30994-2.</p> <p>Ferziger, J.H.; Peric, M.: Numerische Strömungsmechanik. Springer-Verlag, Berlin, 2008, ISBN: 3540675868.</p> <p>Ferziger, J.H.; Peric, M.: Computational Methods for Fluid Dynamics. Springer, 2002, ISBN 3-540-42074-6</p>

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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 Fluidynamics	
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	<p>Will be announced at the beginning of the lecture. Exemplary topics are</p> <ol style="list-style-type: none"> 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, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	<p>Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica 1.17.0.</p> <ul style="list-style-type: none"> • 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	<p>[1] Modelica Association: "Modelica Language Specification - Version 3.5", Linköping, Sweden, 2021.</p> <p>[2] OpenModelica: OpenModelica 1.17.0, https://www.openmodelica.org (siehe Download), 2021.</p> <p>[3] M. Tiller: "Modelica by Example", https://book.xogeny.com, 2014.</p> <p>[4] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</p> <p>[5] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</p> <p>[6] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</p>

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, Dr. Johannes Brunnemann
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	<p>Skript in Papierform im Sekretariat HSU H10 R 310 erhältlich</p> <p>Traupel Thermische Turbomaschinen Bde 1, 2, Springer Verlag Berlin Heidelberg New York 1988</p> <p>Oertel, Laurien Numerische Strömungsmechanik Springer Verlag Berlin Heidelberg New York 2001</p>
Literature	<p>Topics:</p> <ol style="list-style-type: none"> 1. Three dimensional flows in axial grids 2. secondary flows in axial turbomachines, 3. basics of computational fluid dynamics (CFD) 4. CFD of turbomachinery 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	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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	Jun.-Prof. Julian Jepsen
Language	DE
Cycle	SoSe
Content	<ol style="list-style-type: none"> 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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				
<i>Knowledge</i>	The students can <ul style="list-style-type: none"> distinguish the physical phenomena of conversion of energy, understand the different mathematic modelling of turbomachinery, calculate and evaluate turbomachinery. 			
<i>Skills</i>	The students are able to <ul style="list-style-type: none"> - understand the physics of Turbomachinery, - solve excersises self-consistent. 			
Personal Competence				
<i>Social Competence</i>	The students are able to <ul style="list-style-type: none"> discuss in small groups and develop an approach. 			
<i>Autonomy</i>	The students are able to <ul style="list-style-type: none"> develop a complex problem self-consistent, analyse the results in a critical way, have an qualified exchange with other students. 			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory			

Course L1562: Turbomachines	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Markus Schatz
Language	DE
Cycle	SoSe
Content	<p>Topics to be covered will include:</p> <ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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				
<i>Knowledge</i>	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.			
<i>Skills</i>	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 evaluate the economic and ecologic conditions of these systems. They can select calculation methods within the radiation theory for these topics.			
Personal Competence				
<i>Social Competence</i>	Students are able to discuss issues in the thematic fields in the renewable energy sector addressed within the module.			
<i>Autonomy</i>	Students can independently exploit sources and acquire the particular knowledge about the subject area with respect to emphasis for the lectures. Furthermore, with the assistance of lecturers, they can discrete use calculation methods for analysing and dimensioning solar energy systems. Based on this procedure they can concrete assess their specific learning level and can consequently define the further workflow.			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	20 %	Written elaboration	
Examination	Written exam			
Examination duration and scale	3 hours written exam			
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory			

Course L0016: Energy Meteorology	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Volker Matthias, Dr. Beate Geyer
Language	DE
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Introduction: radiation source Sun, Astronomical Foundations, Fundamentals of radiation • Structure of the atmosphere • Properties and laws of radiation <ul style="list-style-type: none"> ◦ 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	<ul style="list-style-type: none"> • Helmut Kraus: Die Atmosphäre der Erde • Hans Häckel: Meteorologie • Grant W. Petty: A First Course in Atmospheric 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Vorlesungsskript. • Kaltschmitt, Streicher und Wiese (Hrsg.). Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, 5. Auflage, Springer, 2013. • Stieglitz und Heinzel .Thermische Solarenergie: Grundlagen, Technologie, Anwendungen. Springer, 2012. • Von Böckh und Wetzel. Wärmeübertragung: Grundlagen und Praxis, Springer, 2011. • Baehr und Stephan. Wärme- und Stoffübertragung. Springer, 2009. • de Vos. Thermodynamics of solar energy conversion. Wiley-VCH, 2008. • Mohr, Svoboda und Unger. Praxis solarthermischer Kraftwerke. Springer, 1999.

Course L0015: Solar Power Generation	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Martin Schlecht, Prof. Alf Mews, Roman Fritsches-Baguhl
Language	DE
Cycle	SoSe
Content	<p>Photovoltaics:</p> <ol style="list-style-type: none"> 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 <p>Concentrating solar power plants:</p> <ol style="list-style-type: none"> 1. Introduction 2. Point focused technologies 3. Line focused technologies 4. Design of CSP projects
Literature	<ul style="list-style-type: none"> • 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. Quaschnig: 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	<ul style="list-style-type: none"> • "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	<p><i>Knowledge</i></p> <p>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.</p> <p><i>Skills</i></p> <p>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.</p> <p>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.</p> <p>Personal Competence</p> <p><i>Social Competence</i></p> <p>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.</p> <p><i>Autonomy</i></p> <p>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.</p>			
Workload in Hours				
Credit points				
Course achievement				
	Compulsory	Bonus	Form	Description
	No	5 %	Exercises	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 International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Dolezal, R.: Dampferzeugung. Springer-Verlag, 1985 • Thomas, H.J.: Thermische Kraftanlagen. Springer-Verlag, 1985 • Steinmüller-Taschenbuch: Dampferzeuger-Technik. Vulkan-Verlag, Essen, 1992 • Kakaç, Sadik: 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	<ul style="list-style-type: none"> "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	<p><i>Knowledge</i></p> <p>VBT/Combustion Engineering</p> <p>The students outline the thermodynamic and chemical fundamentals of combustion processes and the main characteristics of various fuels. They gain basic knowledge in reaction kinetics and fundamentals of furnace design. The students are able to describe the formation of emissions and the primary reduction measures, and evaluate the impact of regulations and allowable limit levels.</p> <p>KWK/Combined Heat and Power</p> <p>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.</p> <p>Storage Technologies</p> <p>The students present the layout, design and operation of electrical and heat storage technologies and are able to classify these in regards of their optimum operating range and conditions in power plants and complex energy systems. They evaluate the environmental effects of the storage technologies.</p> <p><i>Skills</i></p> <p>The students will be able to identify optimization possibilities due to combined power and heat production and the usage of short, medium and long-term storage technologies. The detailed understanding of the complete energy conversion chain, starting with the combustion of a fuel, the conversion of the primary energy into heat and power, storage and discharge of the storage enables the students to evaluate the efficiency and economies of the processes and to holistically consider energy utilisation. Examples from practical experience, such as the CHP energy supply facility of the TUHH and the district heating network of Hamburg will be used, to highlight the potential from electricity generation plants with simultaneous heat extraction and storage.</p> <p>Within the framework of the exercises the students deepen their knowledge based on examples from the industries.</p> <p>Personal Competence</p> <p><i>Social Competence</i></p> <p>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.</p> <p><i>Autonomy</i></p> <p>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.</p>			
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.
	No	10 %	Written elaboration	Anhand der gelehnten Inhalte werden Kurzfragen gestellt und Projektaufgaben bearbeitet und präsentiert
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 International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory			

Course L0216: Combined Heat and Power and Combustion Technology	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Dr. Kristin Abel-Günther
Language	DE
Cycle	SoSe
Content	<p>Part 1: Combustion Engineering</p> <ul style="list-style-type: none"> • Thermodynamic and chemical fundamentals • Fuels • Reaction kinetics • Premixed flames • Systematik of flames and combustion chambers • Combustion Chamber design • Reduction of Emissions <p>Part 2: Energy Storage</p> <p>1.Motivation: Why is Energy storage essential ?</p> <p>2.Storage of electrical energy</p> <ul style="list-style-type: none"> • Condensers • Akkumulators • Hydro power stations • Short term storage with fly wheels • Compressed air energy storage CAES • Economics <p>3.Heat Storage</p> <ul style="list-style-type: none"> • Sensible heat storage • Latent heat storage • Thermocheical heat storage • Economics <p>4.Sector coupling and Power to X</p> <ul style="list-style-type: none"> • PtG • PTL • Research on PtX <p>Part 3: "Combined Heat and Power":</p> <ul style="list-style-type: none"> • Layout, design and operation of Combined Heat and Power plants • District heating plants with back-pressure steam turbine and condensing turbine with pressure-controlled extraction tapping • District heating plants with gas turbine • District heating plants with combined steam and gas turbine • District heating plants with motor engine • Combined cooling heat and power (CCHP) • Layout of the key components • Regulatory framework and allowable limits • Economic significance and calculation of the profitability of district CHP plant
Literature	<p>Bezüglich des Themenbereichs "Kraft-Wärme-Kopplung":</p> <ul style="list-style-type: none"> • W. Piller, M. Rudolph: Kraft-Wärme-Kopplung, VWEV 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 <p>und für die Grundlagen der "Verbrennungstechnik":</p> <ul style="list-style-type: none"> • 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 M1309: Dimensioning and Assessment of Renewable Energy Systems				
Courses				
Title		Typ	Hrs/wk	CP
Environmental Technology and Energy Economics (L0137)		Project-/problem-based Learning	2	2
Electricity Generation from Renewable Sources of Energy (L0046)		Seminar	2	2
Heat Provision from Renewable Sources of Energy (L0045)		Seminar	2	2
Module Responsible	Prof. Martin Kaltschmitt			
Admission Requirements	None			
Recommended Previous Knowledge	none			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<p><i>Knowledge</i> The students can describe current issue and problems in the field of renewable energies. Furthermore, they can explain aspects in relation to the provision of heat or electricity through different renewable technologies, and explain and assess them in a technical, economical and environmental way.</p> <p><i>Skills</i> Students are able to solve scientific problems in the context of heat and electricity supply using renewable energy systems by:</p> <ul style="list-style-type: none"> • using module-comprehensive knowledge for different applications, • evaluating alternative input parameter regarding the solution of the task in the case of incomplete information (technical, economical and ecological parameter), • a systematic documentation of the work results in form of a written version, the presentation itself and the defense of contents. <p>Personal Competence</p> <p><i>Social Competence</i> Students can</p> <ul style="list-style-type: none"> • respectfully work together as a team with around 2-3 members, • participate in subject-specific and interdisciplinary discussions in the area of dimensioning and analysis of potentials of heat and electricity supply using renewable energy, and can develop cooperated solutions, • defend their own work results in front of fellow students and • assess the performance of fellow students in comparison to their own performance. Furthermore, they can accept professional constructive criticism. <p><i>Autonomy</i> Students can independently tap knowledge regarding to the given task. They are capable, in consultation with supervisors, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact.</p>			
Workload in Hours				
Credit points				
Course achievement				
Examination	Written elaboration			
Examination duration and scale	per course: 20 minutes presentation + written report			
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Renewable Energies: Core Qualification: Compulsory			
Course L0137: Environmental Technology and Energy Economics				
Typ	Project-/problem-based Learning			
Hrs/wk	2			
CP	2			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Lecturer	Prof. Martin Kaltschmitt			
Language	DE			
Cycle	WiSe			
Content	<ul style="list-style-type: none"> • Preliminary discussion with the rules of the lecture • Issue of topics from the field of renewable energy technology in the form of a tender of engineering services to a group of students (depending on the number of participating students) • "Procurement" deal with aspects of the design, costing and environmental, economic and technical evaluation of various energy generation concepts (eg onshore wind power generation, commercial-scale photovoltaic power generation, biogas production, geothermal power and heat generation) under very special circumstances • Submission of a written solution of the task and distribution to the participants by the student / group of students • Presentation of the edited theme (20 min) with PPT presentation and subsequent discussion (20 minutes) • Attendance is mandatory for all seminars 			
Literature	Eigenständiges Literaturstudium in der Bibliothek und aus anderen Quellen.			

Course L0046: Electricity Generation from Renewable Sources of Energy	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Martin Kaltschmitt
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Preliminary discussion with the seminar rules • Distribution of the topics related to the subject of the seminar to individual students / groups of students (depending on the number of participating students) • Delivery of a five-page summary of the seminar topic and distribution to the participants by the student / group of students • Presentation of the processed topic (30 min) with PPT presentation and subsequent discussion (20 minutes) • Attendance is mandatory for all seminars
Literature	<ul style="list-style-type: none"> • Eigenständiges Literaturstudium in der Bibliothek und aus anderen Quellen.

Course L0045: Heat Provision from Renewable Sources of Energy	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Martin Kaltschmitt
Language	DE
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Preliminary discussion with the seminar rules • Distribution of the topics related to the subject of the seminar to individual students / groups of students (depending on the number of participating students) • Delivery of a five-page summary of the seminar topic and distribution to the participants by the student / group of students • Presentation of the processed topic (30 min) with PPT presentation and subsequent discussion (20 minutes) • Attendance is mandatory for all seminars
Literature	Eigenständiges Literaturstudium in der Bibliothek und aus anderen Quellen.

Module 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				
<i>Knowledge</i>	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.			
<i>Skills</i>	Students can apply the learned theoretical knowledge of biomass-based energy systems to explain relationships for different tasks, like dimensioning 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				
<i>Social Competence</i>	Students can participate in discussions to design and evaluate energy systems using biomass as an energy source.			
<i>Autonomy</i>	Students can independently exploit sources with respect to the emphasis of the lectures. They can choose and acquire the for the particular task useful knowledge. Furthermore, they can solve computational tasks of biomass-based energy systems independently with the assistance of the lecture. Regarding to this they can assess their specific learning level and can consequently define the further workflow.			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	None	Subject	theoretical and practical work
	No	10 %	Presentation	
Examination	Written exam			
Examination duration and scale	3 hours written exam			
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Energy and Bioprocess Technology: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory			

Course L0061: Biofuels Process Technology	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Oliver Lüdtkke
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • General introduction • What are biofuels? • Markets & trends • Legal framework • Greenhouse gas savings • Generations of biofuels <ul style="list-style-type: none"> ◦ first-generation bioethanol <ul style="list-style-type: none"> ▪ raw materials ▪ fermentation distillation ◦ biobutanol / ETBE ◦ second-generation bioethanol <ul style="list-style-type: none"> ▪ bioethanol from straw ◦ first-generation biodiesel <ul style="list-style-type: none"> ▪ raw materials ▪ Production Process ▪ Biodiesel & Natural Resources ◦ HVO / HEFA ◦ second-generation biodiesel <ul style="list-style-type: none"> ▪ Biodiesel from Algae • Biogas as fuel <ul style="list-style-type: none"> ◦ the first biogas generation <ul style="list-style-type: none"> ▪ raw materials ▪ fermentation ▪ purification to biomethane ◦ Biogas second generation and gasification processes • Methanol / DME from wood and Tall oil ©
Literature	<ul style="list-style-type: none"> • Skriptum zur Vorlesung • Drapcho, Nhuan, Walker; Biofuels Engineering Process Technology • Harwardt; Systematic design of separations for processing of biorenewables • Kaltschmitt; Hartmann; Energie aus Biomasse: Grundlagen, Techniken und Verfahren • Mousdale; Biofuels - Biotechnology, Chemistry and Sustainable Development • VDI Wärmeatlas

Course L0062: Biofuels Process Technology	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Oliver Lüdtke
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Life Cycle Assessment <ul style="list-style-type: none"> ◦ Good example for the evaluation of CO₂ savings potential by alternative fuels - Choice of system boundaries and databases • Bioethanol production <ul style="list-style-type: none"> ◦ 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 <ul style="list-style-type: none"> ◦ Procedural options for solid / liquid separation, including basic equations for estimating power, energy demand, selectivity and throughput • Biomethane production <ul style="list-style-type: none"> ◦ 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	<p>1) Markets for Agricultural Commodities</p> <p>What are the major markets and how are markets functioning</p> <p>Recent trends in world production and consumption.</p> <p>World trade is growing fast. Logistics. Bottlenecks.</p> <p>The major countries with surplus production</p> <p>Growing net import requirements, primarily of China, India and many other countries.</p> <p>Tariff and non-tariff market barriers. Government interferences.</p> <p>2) Closer Analysis of Individual Markets</p> <p>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.</p> <p>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.</p> <p>Importance of oilmeals as an animal feed for the production of livestock and aquaculture</p> <p>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.</p> <p>Regional differences in productivity. The winners and losers in global agricultural production.</p> <p>3) Forecasts: Future Global Demand & Production of Vegetable Oils</p> <p>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.</p> <p>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.</p> <p>Rapidly rising population, primarily the number of people considered "middle class" in the years ahead.</p> <p>Higher disposable income will trigger changing diets in favour of vegetable oils and livestock products.</p> <p>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?</p> <p>The myth and the realities of palm oil in the world of today and tomorrow.</p> <p>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.</p>
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	<p>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.</p> <p>The course is structured as follows:</p> <ul style="list-style-type: none"> • 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 <ul style="list-style-type: none"> ◦ 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 <ul style="list-style-type: none"> ◦ Basics of bio-chemical conversion ◦ Biogas: Process technologies for plants using agricultural feedstock, sewage sludge (sewage gas), organic waste fraction (landfill gas), technologies for the provision of bio methane, use of the digested slurry ◦ Ethanol production: Process technologies for feedstock containing sugar, starch or celluloses, use of ethanol as a fuel, use of the stillage
Literature	Kaltschmitt, M.; Hartmann, H. (Hrsg.): Energie aus Biomasse; Springer, Berlin, Heidelberg, 2009, 2. Auflage

Course L2386: Thermal Biomass Utilization	
Typ	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Martin Kaltschmitt, Dr. Marvin Scherzinger
Language	DE
Cycle	WiSe
Content	<p>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.</p> <p>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.</p>
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	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 additionally able to apply these methods to real electric power systems.		
<i>Knowledge</i>			
<i>Skills</i>	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	The students can participate in specialized and interdisciplinary discussions, advance ideas and represent their own work results in front of others.		
<i>Social Competence</i>			
<i>Autonomy</i>	Students can independently tap knowledge of the emphasis of the lectures and apply it within further research activities.		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70		
Credit points	6		
Course achievement	None		
Examination	Oral exam		
Examination duration and scale	45 min		
Assignment for the Following Curricula	Electrical Engineering: Core Qualification: Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Computer Science in Engineering: Specialisation II. Engineering Science: Elective Compulsory		

Course L1696: Electrical Power Systems II: Operation and Information Systems of Electrical Power Grids	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • steady-state modelling of electric power systems <ul style="list-style-type: none"> ◦ conventional components ◦ Flexible AC Transmission Systems (FACTS) and HVDC ◦ grid modelling • grid operation <ul style="list-style-type: none"> ◦ electric power supply processes ◦ grid and power system management ◦ grid provision • grid control systems <ul style="list-style-type: none"> ◦ 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 planning <ul style="list-style-type: none"> ◦ load-flow calculations ◦ sensitivity analysis and power flow control ◦ power system optimization ◦ short-circuit calculation ◦ asymmetric failure calculation <ul style="list-style-type: none"> ▪ symmetric components ▪ calculation of asymmetric failures ◦ state estimation
Literature	E. Handschin: Elektrische Energieübertragungssysteme, Hüthig Verlag B. R. Oswald: Berechnung von Drehstromnetzen, Springer-Vieweg Verlag V. Crastan: Elektrische Energieversorgung Bd. 1 & 3, Springer Verlag E.-G. Tietze: Netzleittechnik Bd. 1 & 2, VDE-Verlag

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

Module M1710: Smart Grid Technologies				
Courses				
Title		Typ	Hrs/wk	CP
Smart Grid Technologies (L2706)		Lecture	3	4
Smart Grid Technologies (L2707)		Project-/problem-based Learning	2	2
Module Responsible	Prof. Christian Becker			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of Electrical Engineering, Introduction to Control Systems, Mathematics I, II, III Electrical Power Systems I Electrical Power Systems II			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able to explain in detail and critically evaluate methods and technologies for operation of smart grids (i.e. intelligent distribution grids).			
<i>Skills</i>	With completion of this module the students are able to analyze the impact of emerging technologies (such as renewables, energy storage and demand response) on the electric power system. They can formulate and apply computational intelligence techniques to power system operation problems. They can also explain what ICT technologies (such as digital twins and IoT) are relevant and suitable for distribution grid operation.			
Personal Competence				
<i>Social Competence</i>	The students can participate in specialized and interdisciplinary discussions, advance ideas and represent their own work results in front of others.			
<i>Autonomy</i>	Students can independently tap knowledge of the emphasis of the lectures and apply it within further research activities.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Renewable Energies: Specialisation Solar Energy Systems: Elective Compulsory			

Course L2706: Smart Grid Technologies	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christian Becker, Dr. Davood Babazadeh
Language	DE/EN
Cycle	WiSe/SoSe
Content	<p>Introduction to Smart Grids</p> <ul style="list-style-type: none"> • Intelligent Distribution Grids • Paradigm shifts: Digitalization & Sustainability <p>Emerging technologies in distribution grids</p> <ul style="list-style-type: none"> • Distributed Energy Resource (DER) • Battery Energy Storage (BES) technologies • Sector-coupling & EV/V2G • Microgrids, Inverter-based Systems • Modelling and control of PV & BESS <p>Distribution grid management & analysis</p> <ul style="list-style-type: none"> • Distribution grid structure (Hamburg example) • Distribution grid management and operation architecture and functions <ul style="list-style-type: none"> ◦ Fault Detection, Isolation & Restoration ◦ Self-Healing in distribution systems ◦ Volt-Var Optimization ◦ Distribution Load Flow • Demand Side Management & Demand Response • Lab exercise (Smart Grid Operation) <p>Computational intelligence and optimization techniques in Smart Grids</p> <ul style="list-style-type: none"> • Computational challenges in Smart grid • Heuristic & Analytic Optimization Methods • Intelligent Systems (Expert Systems, ML/AL) • Applications (optimal load flow, reactive capacitor placement) • Lab exercise (optimization formulation) <p>ICT Technologies for Smart Grids</p> <ul style="list-style-type: none"> • Advanced Metering Technologies: Smart Meters, RTU, PMU • Telecommunication Systems in Smart Grids (network basics and technologies) • Interoperability in Smart grids <ul style="list-style-type: none"> ◦ Smart Grid Architecture Model ◦ Automation and Communication standards (IEC 61850, c37.118) • Cyber security • Lab exercise (Grid automation protocols) <p>Practical lesson-learned: Stromnetz Hamburg (SNH) perspective</p> <ul style="list-style-type: none"> • Definition of Smart Grid and its requirements from industry view • Grid digitalization - examples of industrial projects • Flexible load management • Electromobility & transportation sector integration <p>Study visits:</p> <ul style="list-style-type: none"> • Digital Substation in Harburg • Electric Bus charging station <p>Stromnetz Hamburg Control Center</p>
Literature	<ul style="list-style-type: none"> • Buchholz and Styczynski - 2020 - "Smart Grids: Fundamentals and Technologies in Electric Power Systems of the Future", Springer • Bernardon and Garcia - 2018 - "Smart Operation for Power Distribution Systems: Concepts and Applications", Springer • Momoh, 2012; "Smart Grid: Fundamentals of Design and Analysis", Wiley

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

Module M1354: Advanced Fuels				
Courses				
Title		Typ	Hrs/wk	CP
Second generation biofuels and electricity based fuels (L2414)		Lecture	2	2
Carbon dioxide as an economic determinant in the mobility sector (L1926)		Lecture	1	1
Mobility and climate protection (L2416)		Recitation Section (small)	2	2
Sustainability aspects and regulatory framework (L2415)		Lecture	1	1
Module Responsible	Prof. Martin Kaltschmitt			
Admission Requirements	None			
Recommended Previous Knowledge	Bachelor degree in Process Engineering, Bioprocess Engineering or Energy- and Environmental Engineering			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Within the module, students learn about different provision pathways for the production of advanced fuels (biofuels like e.g. alcohol-to-jet; electricity-based fuels like e.g. power-to-liquid). The different processes chains are explained and the regulatory framework for sustainable fuel production is examined. This includes, for example, the requirements of the Renewable Energies Directive II and the conditions and aspects for a market ramp-up of these fuels. For the holistic assessment of the various fuel options, they are also examined under environmental and economic factors.			
<i>Skills</i>	After successfully participating, the students are able to solve simulation and application tasks of renewable energy technology: <ul style="list-style-type: none"> • Module-spanning solutions for the design and presentation of fuel production processes resp. the fuel provision chains • Comprehensive analysis of various fuel production options in technical, ecological and economic terms Through active discussions of the various topics within the lectures and exercises of the module, the students improve their understanding and application of the theoretical foundations and are thus able to transfer the learned to the practice.			
Personal Competence				
<i>Social Competence</i>	The students can discuss scientific tasks in a subject-specific and interdisciplinary way and develop joint solutions.			
<i>Autonomy</i>	The students are able to access independent sources about the questions to be addressed and to acquire the necessary knowledge. They are able to assess their respective learning situation concretely in consultation with their supervisor and to define further questions and solutions.			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	20 %	Written elaboration	Details werden in der ersten Veranstaltung bekannt gegeben.
Examination	Written exam			
Examination duration and scale	120 min			
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Energy and Bioprocess Technology: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Aeronautics: Core Qualification: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Renewable Energies: Specialisation Solar Energy Systems: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory			

Course L2414: Second generation biofuels and electricity based fuels	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Martin Kaltschmitt
Language	DE/EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • General overview of various power-based fuels and their process paths, including power-to-liquid process (Fischer-Tropsch synthesis, methanol synthesis), power-to-gas (Sabatier process) • Origin, production and use of these fuels
Literature	<ul style="list-style-type: none"> • Vorlesungsskript

Course L1926: Carbon dioxide as an economic determinant in the mobility sector	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Karsten Wilbrand
Language	DE/EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • General overview of various advanced biofuels and their process pathways (including gas-to-liquid, HEFA and Alcohol-to-Jet processes) • Origin, production and use of these fuels
Literature	<ul style="list-style-type: none"> • Babu, V.: Biofuels Production. Beverly, Mass: Scrivener [u.a.], 2013 • Olsson, L.: Biofuels. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg, 2007 • William, L. L.: Distillation Design and Control Using Aspen Simulation; ISBN-10: 0-471-77888-5 • Perry, R.; Green, R.: Perry's Chemical Engineers' Handbook, 8th Edition, McGraw Hill Professional, 20 • Sinnott, R. K.: Chemical Engineering Design, Elsevier, 2014 • Kaltschmitt, M.; Neuling, U. (Ed.): Biokerosene - Status and Prospects; Springer, Berlin, Heidelberg, 2018

Course L2416: Mobility and climate protection	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Benedikt Buchspies, Dr. Karsten Wilbrand
Language	DE/EN
Cycle	WiSe
Content	Application of the acquired theoretical knowledge from the respective lectures on the basis of concrete tasks from practice <ul style="list-style-type: none"> • Design and simulation of sub-processes of production processes in Aspen Plus ® • Ecological and economic analysis of fuel supply paths • Classification of case studies into applicable regulations
Literature	<ul style="list-style-type: none"> • Skriptum zur Vorlesung • Aspen Plus® - Aspen Plus User Guide

Course L2415: Sustainability aspects and regulatory framework	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Benedikt Buchspies
Language	DE/EN
Cycle	WiSe
Content	<p>Holistic examination of the different fuel paths with the following main topics, among others:</p> <ul style="list-style-type: none"> • Consideration of the environmental impact of the various alternative fuels • Economic consideration of the different alternative fuels • Regulatory framework for alternative fuels • Certification of alternative fuels • Market introduction models of alternative fuels
Literature	<ul style="list-style-type: none"> • European Commission - Joint Research Center (2010): International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance. Joint Research Center (JRC) Institut for Environment and Sustainability, Luxembourg • Richtlinie (EU) 2018/2001 des Europäischen Parlaments und des Rates vom 11. Dezember 2018 zur Förderung der Nutzung von Energie aus erneuerbaren Quellen

Specialization Marine Engineering

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

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

Module M0528: Maritime Technology and Offshore Wind Parks

Courses			
Title	Typ	Hrs/wk	CP
Introduction to Maritime Technology (L0070)	Lecture	2	2
Introduction to Maritime Technology (L1614)	Recitation Section (small)	1	1
Offshore Wind Parks (L0072)	Lecture	2	3
Module Responsible	Prof. Moustafa Abdel-Maksoud		
Admission Requirements	None		
Recommended Previous Knowledge	<p>Qualified Bachelor of a natural or engineering science; Solid knowledge and competences in mathematics, mechanics, fluid dynamics.</p> <p>Basic knowledge of ocean engineering topics (e.g. from an introductory class like 'Introduction to Maritime Technology')</p>		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence <i>Knowledge</i>	<p>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</p> <ul style="list-style-type: none"> • 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. <p>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.</p> <p>After successful completion of this module, students should be able to</p> <ul style="list-style-type: none"> • 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 		
Personal Competence <i>Skills</i> <i>Social Competence</i> <i>Autonomy</i>			
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	<p>1. Introduction</p> <ul style="list-style-type: none"> • Ocean Engineering and Marine Research • The potentials of the seas • Industries and occupational structures <p>2. Coastal and offshore Environmental Conditions</p> <ul style="list-style-type: none"> • Physical and chemical properties of sea water and sea ice • Flows, waves, wind, ice • Biosphere <p>3. Response behavior of Technical Structures</p> <p>4. Maritime Systems and Technologies</p> <ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Chakrabarti, S., Handbook of Offshore Engineering, vol. I/II, Elsevier 2005. • Gerwick, B.C., Construction of Marine and Offshore Structures, CRC-Press 1999. • Wagner, P., Meerestechnik, Ernst&Sohn 1990. • Clauss, G., Meerestechnische Konstruktionen, Springer 1988. • Knauss, J.A., Introduction to Physical Oceanography, Waveland 2005. • Wright, J. et al., Waves, Tides and Shallow-Water Processes, Butterworth 2006. • Faltinsen, O.M., Sea Loads on Ships and Offshore Structures, Cambridge 1999.

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

Course L0072: Offshore Wind Parks	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Alexander Mitzlaff
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • coordinates & degrees of freedom • governing equations of motion • hydrodynamic forces & moments • ruder forces • navigation based on linearised eq.of motion(exemplary solutions, yaw stability) • manoeuvring test (constraint & unconstraint motion) • slender body approximation <p>Learning Outcomes</p> <p>Introduction into basic concepts for the assessment and prognosis ship manoeuvrabilit.</p> <p>Ability to develop methods for analysis of manoeuvring behaviour of ships.</p>
Literature	<ul style="list-style-type: none"> • 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 Fluidodynamik 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	<ol style="list-style-type: none"> 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	<ul style="list-style-type: none"> • 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 Cnfrrence 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, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	<p>Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica 1.17.0.</p> <ul style="list-style-type: none"> • 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	<p>[1] Modelica Association: "Modelica Language Specification - Version 3.5", Linköping, Sweden, 2021.</p> <p>[2] OpenModelica: OpenModelica 1.17.0, https://www.openmodelica.org (siehe Download), 2021.</p> <p>[3] M. Tiller: "Modelica by Example", https://book.xogeny.com, 2014.</p> <p>[4] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</p> <p>[5] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</p> <p>[6] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</p>

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, Dr. Johannes Brunnemann
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	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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			
<i>Knowledge</i>	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.		
<i>Skills</i>	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			
<i>Social Competence</i>	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.		
<i>Autonomy</i>	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.		
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84		
Credit points	6		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	90 minutes plus 20 minutes oral exam		
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory		

Course L1531: Electrical Installation on Ships	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • performance in service of electrical consumers. • special requirements for power supply systems and for electrical equipment in isolated systems/networks e. g. aboard ships, offshore installations, factory systems and emergency power supply systems. • power generation and distribution in isolated networks, shaft generators for ships • calculation of short circuits and behaviour of switching devices • protective devices, selectivity monitoring • electrical Propulsion plants for ships
Literature	H. Meier-Peter, F. Bernhardt u. a.: Handbuch der Schiffsbetriebstechnik, Seehafen Verlag (engl. Version: "Compendium Marine Engineering") Gleß, Thamm: Schiffselektrotechnik, VEB Verlag Technik Berlin

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

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

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

Module M1347: Selected Topics of Marine Engineering - Option B	
Courses	
Title	Typ Hrs/wk CP
Auxiliary Systems on Board of Ships (L1249)	Lecture 2 2
Auxiliary Systems on Board of Ships (L1250)	Recitation Section (large) 1 1
Cavitation (L1596)	Lecture 2 3
Manoeuvrability of Ships (L1597)	Lecture 2 3
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 <i>Knowledge</i> <i>Skills</i>	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 <i>Social Competence</i>	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.
<i>Autonomy</i>	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Energy Systems: Specialisation Marine Engineering: Elective Compulsory

Course L1249: Auxiliary Systems on Board of Ships	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	20 min
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Vorschriften zur Schiffsausrüstung • Ausrüstungsanlagen auf Standard-Schiffen • Ausrüstungsanlagen auf Spezial-Schiffen • Grundlagen und Systemtechnik der Hydraulik • Auslegung und Betrieb von Ausrüstungsanlagen
Literature	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • coordinates & degrees of freedom • governing equations of motion • hydrodynamic forces & moments • ruder forces • navigation based on linearised eq.of motion(exemplary solutions, yaw stability) • manoeuvring test (constraint & unconstraint motion) • slender body approximation <p>Learning Outcomes</p> <p>Introduction into basic concepts for the assessment and prognosis ship manoeuvrabilit.</p> <p>Ability to develop methods for analysis of manoeuvring behaviour of ships.</p>
Literature	<ul style="list-style-type: none"> • 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 Fluidodynamik 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 fundamentals 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 phenomena 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	<ol style="list-style-type: none"> 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	<ul style="list-style-type: none"> • 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 Conference 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, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	<p>Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica 1.17.0.</p> <ul style="list-style-type: none"> • 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	<p>[1] Modelica Association: "Modelica Language Specification - Version 3.5", Linköping, Sweden, 2021.</p> <p>[2] OpenModelica: OpenModelica 1.17.0, https://www.openmodelica.org (siehe Download), 2021.</p> <p>[3] M. Tiller: "Modelica by Example", https://book.xogeny.com, 2014.</p> <p>[4] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</p> <p>[5] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</p> <p>[6] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</p>

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, Dr. Johannes Brunnemann
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	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - Vorlesungsskript als Blattsammlung (auch als pdf-download oder CD verfügbar) - Übungsaufgaben mit Lösungsweg - Literaturliste

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

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

Courses			
Title	Typ	Hrs/wk	CP
Module Responsible	NN		
Admission Requirements	None		
Recommended Previous Knowledge	See selected module according to FSPO		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	See selected module according to FSPO		
<i>Skills</i>	See selected module according to FSPO		
Personal Competence			
<i>Social Competence</i>	See selected module according to FSPO		
<i>Autonomy</i>	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					
<i>Knowledge</i>	See selected module according to FSPO				
<i>Skills</i>	See selected module according to FSPO				
Personal Competence					
<i>Social Competence</i>	See selected module according to FSPO				
<i>Autonomy</i>	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 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				
<i>Knowledge</i>	Students can			
	<ul style="list-style-type: none"> • 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. 			
<i>Skills</i>	Students can			
	<ul style="list-style-type: none"> • 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				
<i>Social Competence</i>	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.			
<i>Autonomy</i>	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	20 min			
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory			

Course L0637: Marine Diesel Engine Plants	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	SoSe
Content	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • D. Woodyard: Pounder's Marine Diesel Engines • H. Meyer-Peter, F. Bernhardt: Handbuch der Schiffsbetriebstechnik • K. Kuiken: Diesel Engines • Mollenhauer, Tschöke: Handbuch Dieselmotoren • Projektierungsunterlagen der Motorenhersteller

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

Module M0721: Air Conditioning				
Courses				
Title	Typ	Hrs/wk	CP	
Air Conditioning (L0594)	Lecture	3	5	
Air Conditioning (L0595)	Recitation Section (large)	1	1	
Module Responsible	Prof. Arne Speerforck			
Admission Requirements	None			
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	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.			
<i>Skills</i>	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				
<i>Social Competence</i>	In lectures and exercises, the students can use many examples and experiments to discuss in small groups in a goal-oriented manner, develop a solution and present it. Within the exercises, the students can independently develop further questions and work out targeted solutions.			
<i>Autonomy</i>	Students are able to define tasks independently, to develop the necessary knowledge themselves based on the knowledge they have received, and to use suitable means for implementation. In the exercises, the students discuss the methods taught in the lectures using complex tasks and critically analyze the results.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 min			
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory			

Course L0594: Air Conditioning	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Arne Speerforck, Prof. Gerhard Schmitz
Language	DE
Cycle	SoSe
Content	<p>1. Overview</p> <p>1.1 Kinds of air conditioning systems</p> <p>1.2 Ventilating</p> <p>1.3 Function of an air condition system</p> <p>2. Thermodynamic processes</p> <p>2.1 Psychrometric chart</p> <p>2.2 Mixer preheater, heater</p> <p>2.3 Cooler</p> <p>2.4 Humidifier</p> <p>2.5 Air conditioning process in a Psychrometric chart</p> <p>2.6 Desiccant assisted air conditioning</p> <p>3. Calculation of heating and cooling loads</p> <p>3.1 Heating loads</p> <p>3.2 Cooling loads</p> <p>3.3 Calculation of inner cooling load</p> <p>3.4 Calculation of outer cooling load</p> <p>4. Ventilating systems</p> <p>4.1 Fresh air demand</p> <p>4.2 Air flow in rooms</p> <p>4.3 Calculation of duct systems</p> <p>4.4 Fans</p> <p>4.5 Filters</p> <p>5. Refrigeration systems</p> <p>5.1. compression chillers</p> <p>5.2 Absorption chillers</p>
Literature	<ul style="list-style-type: none"> • Schmitz, G.: Klimaanlageanlagen, Skript zur Vorlesung • VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013 • Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009 • Recknagel, H.; Sprenger, E.; Schrammek, E.-R.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013

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

Module M1161: Turbomachinery				
Courses				
Title		Typ	Hrs/wk	CP
Turbomachines (L1562)		Lecture	3	4
Turbomachines (L1563)		Recitation Section (large)	1	2
Module Responsible	Prof. Markus Schatz			
Admission Requirements	None			
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can <ul style="list-style-type: none"> distinguish the physical phenomena of conversion of energy, understand the different mathematic modelling of turbomachinery, calculate and evaluate turbomachinery. 			
<i>Skills</i>	The students are able to <ul style="list-style-type: none"> - understand the physics of Turbomachinery, - solve excersises self-consistent. 			
Personal Competence				
<i>Social Competence</i>	The students are able to <ul style="list-style-type: none"> discuss in small groups and develop an approach. 			
<i>Autonomy</i>	The students are able to <ul style="list-style-type: none"> develop a complex problem self-consistent, analyse the results in a critical way, have an qualified exchange with other students. 			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory			

Course L1562: Turbomachines	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Markus Schatz
Language	DE
Cycle	SoSe
Content	<p>Topics to be covered will include:</p> <ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • "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	<p><i>Knowledge</i></p> <p>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.</p> <p><i>Skills</i></p> <p>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.</p> <p>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.</p> <p>Personal Competence</p> <p><i>Social Competence</i></p> <p>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.</p> <p><i>Autonomy</i></p> <p>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.</p>			
<i>Knowledge</i>				
<i>Skills</i>				
Personal Competence				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	No	5 %	Exercices	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 International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Dolezal, R.: Dampferzeugung. Springer-Verlag, 1985 • Thomas, H.J.: Thermische Kraftanlagen. Springer-Verlag, 1985 • Steinmüller-Taschenbuch: Dampferzeuger-Technik. Vulkan-Verlag, Essen, 1992 • Kakaç, Sadik: 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	<ul style="list-style-type: none"> • "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	<p><i>Knowledge</i></p> <p>VBT/Combustion Engineering</p> <p>The students outline the thermodynamic and chemical fundamentals of combustion processes and the main characteristics of various fuels. They gain basic knowledge in reaction kinetics and fundamentals of furnace design. The students are able to describe the formation of emissions and the primary reduction measures, and evaluate the impact of regulations and allowable limit levels.</p> <p>KWK/Combined Heat and Power</p> <p>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.</p> <p>Storage Technologies</p> <p>The students present the layout, design and operation of electrical and heat storage technologies and are able to classify these in regards of their optimum operating range and conditions in power plants and complex energy systems. They evaluate the environmental effects of the storage technologies.</p> <p><i>Skills</i></p> <p>The students will be able to identify optimization possibilities due to combined power and heat production and the usage of short, medium and long-term storage technologies. The detailed understanding of the complete energy conversion chain, starting with the combustion of a fuel, the conversion of the primary energy into heat and power, storage and discharge of the storage enables the students to evaluate the efficiency and economics of the processes and to holistically consider energy utilisation. Examples from practical experience, such as the CHP energy supply facility of the TUHH and the district heating network of Hamburg will be used, to highlight the potential from electricity generation plants with simultaneous heat extraction and storage.</p> <p>Within the framework of the exercises the students deepen their knowledge based on examples from the industries.</p> <p>Personal Competence</p> <p><i>Social Competence</i></p> <p>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.</p> <p><i>Autonomy</i></p> <p>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.</p>			
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.
	No	10 %	Written elaboration	Anhand der gelehnten Inhalte werden Kurzfragen gestellt und Projektaufgaben bearbeitet und präsentiert
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 International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory			

Course L0216: Combined Heat and Power and Combustion Technology	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Dr. Kristin Abel-Günther
Language	DE
Cycle	SoSe
Content	<p>Part 1: Combustion Engineering</p> <ul style="list-style-type: none"> • Thermodynamic and chemical fundamentals • Fuels • Reaction kinetics • Premixed flames • Systematik of flames and combustion chambers • Combustion Chamber design • Reduction of Emissions <p>Part 2: Energy Storage</p> <p>1.Motivation: Why is Energy storage essential ?</p> <p>2.Storage of electrical energy</p> <ul style="list-style-type: none"> • Condensers • Akkumulators • Hydro power stations • Short term storage with fly wheels • Compressed air energy storage CAES • Economics <p>3.Heat Storage</p> <ul style="list-style-type: none"> • Sensible heat storage • Latent heat storage • Thermocheical heat storage • Economics <p>4.Sector coupling and Power to X</p> <ul style="list-style-type: none"> • PtG • PTL • Research on PtX <p>Part 3: "Combined Heat and Power":</p> <ul style="list-style-type: none"> • Layout, design and operation of Combined Heat and Power plants • District heating plants with back-pressure steam turbine and condensing turbine with pressure-controlled extraction tapping • District heating plants with gas turbine • District heating plants with combined steam and gas turbine • District heating plants with motor engine • Combined cooling heat and power (CCHP) • Layout of the key components • Regulatory framework and allowable limits • Economic significance and calculation of the profitability of district CHP plant
Literature	<p>Bezüglich des Themenbereichs "Kraft-Wärme-Kopplung":</p> <ul style="list-style-type: none"> • W. Piller, M. Rudolph: Kraft-Wärme-Kopplung, VWEV 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 <p>und für die Grundlagen der "Verbrennungstechnik":</p> <ul style="list-style-type: none"> • 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	<p><i>Knowledge</i> 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 structural components and the entire hull girder; they understand the effect of exciting forces of the propeller and main engine and methods for their determination</p> <p><i>Skills</i> 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</p> <p>Personal Competence</p> <p><i>Social Competence</i> The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.</p> <p><i>Autonomy</i> Students are able to detect vibration-prone components on ships, to model the structure, to select suitable calculation methods and to assess the results</p>		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	3 hours		
Assignment for the Following Curricula	Energy Systems: Specialisation Marine Engineering: Elective Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Compulsory Ship and Offshore Technology: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory		

Course L1528: Ship Vibration	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Rüdiger Ulrich Franz von Bock und Polach
Language	EN
Cycle	WiSe
Content	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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 Energy Systems (L0023)	Lecture	3	5	
Thermal Energy Systems (L0024)	Recitation Section (large)	1	1	
Module Responsible	Prof. Arne Speerforck			
Admission Requirements	None			
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	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.			
<i>Skills</i>	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				
<i>Social Competence</i>	In lectures and exercises, the students can use many examples and experiments to discuss in small groups in a goal-oriented manner, develop a solution and present it. Within the exercises, the students can independently develop further questions and work out targeted solutions.			
<i>Autonomy</i>	Students are able to define tasks independently, to develop the necessary knowledge themselves based on the knowledge they have received, and to use suitable means for implementation. In the exercises, the students discuss the methods taught in the lectures using complex tasks and critically analyze the results.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 min			
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory			

Course L0023: Thermal Energy Systems	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Arne Speerforck, Prof. Gerhard Schmitz
Language	DE
Cycle	WiSe
Content	<p>1. Introduction</p> <p>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</p> <p>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</p> <p>4. Thermal treatment 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</p> <p>5. Laws and standards 5.1 Buildings 5.2 Industrial plants</p>
Literature	<ul style="list-style-type: none"> • Schmitz, G.: Klimalanlagen, 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 Energy Systems	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Arne Speerforck
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Thesis

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

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

Module M1801: Master thesis (dual study program)	
Courses	
Title	Typ Hrs/wk CP
Module Responsible	Professoren der TUHH
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
<i>Knowledge</i>	Dual students ... <ul style="list-style-type: none"> ... use the specialised knowledge (facts, theories and methods) from their field of study and the acquired professional knowledge confidently to deal with technical and practical professional issues. ... can explain the relevant approaches and terminologies in depth in one or more of their subject's specialist areas, describe current developments and take a critical stance. ... formulate their own research assignment to tackle a professional problem and contextualise it within their subject area. They ascertain the current state of research and critically assess it.
<i>Skills</i>	Dual students ... <ul style="list-style-type: none"> ... can select suitable methods for the respective subject-related professional problem, apply them and develop them further as required. ... assess knowledge and methods acquired during their studies (including practical phases) and apply their expertise to complex and/or incompletely defined problems in a solution- and application-oriented manner. ... acquire new academic knowledge in their subject area and critically evaluate it.
Personal Competence	
<i>Social Competence</i>	Dual students ... <ul style="list-style-type: none"> ... can present a professional problem in the form of an academic question in a structured, comprehensible and factually correct manner, both in writing and orally, for a specialist audience and for professional stakeholders. ... answer questions as part of a professional discussion in an expert, appropriate manner. They represent their own points of view and assessments convincingly.
<i>Autonomy</i>	Dual students ... <ul style="list-style-type: none"> ... can structure their own project into work packages, work through them at an academic level and reflect on them with regard to feasible courses of action for professional practice. ... work in-depth in a partially unknown area within the discipline and acquire the information required to do so. ... apply the techniques of academic work comprehensively in their own research work when dealing with an operational problem and question.
Workload in Hours	Independent Study Time 900, Study Time in Lecture 0
Credit points	30
Course achievement	None
Examination	Thesis
Examination duration and scale	According to General Regulations
Assignment for the Following Curricula	Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Data Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Computer Science in Engineering: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory International Management and Engineering: Thesis: Compulsory Logistics, Infrastructure and Mobility: Thesis: Compulsory Aeronautics: Thesis: Compulsory

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