Module Handbook
Master “Wind Engineering”

Last updated Oktober 2017

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- 2 Electives

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Module number [1]: Scientific and Technical Writing

Course	Master of Science – Wind Engineering
Module name	Scientific and Technical Writing
Abbreviation (if applicable)	
Subtitle (if applicable)	
Seminar (if applicable)	
Semester	Winter semester
Person in charge of module	Peter Missfeld, University of applied sciences Flensburg
Lecturer/s	Peter Missfeld, University of applied sciences Flensburg
Status within the curriculum	Master Course Wind Engineering mandatory course
Language	English
Type of course and hours per week	2 h lectures, 2 h writing laboratory
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	English language skills according to admission requirements
Aims of the module, acquired skills	• The students learn how to write academic texts using technical vocabulary and are able to structure texts • They are able to define research questions • After finishing the module the students are able to quote sources correctly • They gain the knowledge of drafting, revising and editing academic texts
Subjects covered	• Formats for scientific and technical writing • Arguing • Structuring texts • Introduction, summary, and abstracts for own written texts • Various citation styles • Presentation of results
Form of examination	Written report
Media used	Powerpoint presentation, Blackboard
Recommended literature	• Alred, G. J., Brusaw, C. T., Oliu W. E.: Handbook of Technical Writing, Bedford/St. Martin's, 2009 • Glasman-Deal, H.: Science Research Writing for non-native speakers of English, Imperial College London, UK, 2010 • Sheffield, N.: Scientific Writing: Clarity, Conciseness, and Cohesion, Institute for Genome Sciences and Policy, Duke University, 2011 • Rogers, S.M.: Mastering Scientific and Medical Writing-A Self-help Guide. Springer, 2007

Module number [2]: Global Wind industry and environmental conditions

Course	Master of Science – Wind Engineering
Module name	Global Wind industry and environmental conditions
Abbreviation (if applicable)	
Subtitle (if applicable)	
Seminar (if applicable)	
Semester	Winter semester
Person in charge of module	Dr. rer. nat. Hermann van Radecke, University of applied sciences Flensburg Prof. h.c. Dr. Klaus Rave, University of applied sciences Flensburg
Lecturer/s	Dr. rer. nat. Hermann van Radecke, University of applied sciences Flensburg Prof. h.c. Dr. Klaus Rave, University of applied sciences Flensburg et. al.
Status within the curriculum	Master Course Wind Engineering mandatory course
Language	English
Type of course and hours per week	4 h lectures with exercises
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	None
Aims of the module, acquired skills	• This course gives an overview of global wind energy networks and standard energy and environmental calculations of wind parks. • It provides an insight into the actual state of the global wind energy market with global institutions, organisations, networks and associations. Students will learn about the different regulatory regimes and their effects on the wind industry. The influence of policy making and the implementation of policies are outlined. • It deals with the financing of wind farms, the bankability of projects and the strategies for project development. • An analysis of the relationship between R&D, legislation, different climates and onshore and offshore installations will provide students with valuable experience for future careers. • The students learn the fundamentals of energy meteorology and through study of the impact of wind energy plants on the environment gain knowledge of types and levels of emissions. • They will understand and be able to calculate the physical, technical and legal aspects of wind energy parks with regard to their energy production and emissions within the frame of site assessment.
Subjects covered	• Overview of the global wind industry • The onshore and offshore markets, general trends • Energy policies and regulatory frameworks • Global drivers of the markets

	• Finance, bankability, project developments • Energy meteorology, wind systems, boundary layers, profile, turbulence, WAsP, mesoscale models, wind atlas, technical directives, short and long-term measurement • Emissions and influences on the environment, noise measurement and calculation, shadow, turbulence, optical impact, IEC standards • Calculation of energy and emissions (Program modules Windpro, Windfarmer, WAsP, et al.)
Form of examination	Written examination (120 min)
Media used	black board, power point presentation,
Recommended literature	• Manwell, J. F., McGowan, J. G., Rogers, A. L.: Wind Energy Explained. Wiley, Chichester, 2009 • Troen, I. and E. L. Petersen: European Wind Atlas. Risø National Laboratory, Roskilde, 1989 • CEwind, Hrsg.: Einführung in die Windenergietechnik. Carl Hanser Verlag, München, 2012 • CEwind, ed.: Understanding Wind Energy Technology. Wiley, 2014 i.p. • IEC 61400 International Electrotechnical Commission • Technische Richtlinien (FGW-Richtlinien) • Manuals programs WindPRO and Windfarmer

Module number [3]: Wind farm project management and GIS

Course	Master of Science – Wind Engineering
Module name	Wind farm project management and GIS
Abbreviation (if applicable)	
Subtitle (if applicable)	
Seminar (if applicable)	Wind energy project management and planning
Semester	Winter semester
Person in charge of module	Prof. Dr. Bernd Möller, Europa-Universität Flensburg
Lecturer/s	Prof. Dr. Bernd Möller, Europa-Universität Flensburg
Status within the curriculum	Master Course Wind Engineering Mandatory course
Language	English
Type of course and hours per week	4 h lectures
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	none
Aims of the module, acquired skills	• Acquisition of general knowledge about all phases of developing onshore wind energy projects, from the first idea of realisation, acquisition, business model, choice of location, infrastructural planning, approval planning and financing, to site management during building phase. • The students learn about political, social, technical and legal aspects of wind energy planning and management • The students gain practical skills of using geographical information systems for wind energy project management and planning.
Subjects covered	• Wind energy planning and policy review • Social acceptance and environmental aspects of wind energy • Legal characteristics of planning, implementation and operation • Basic types of projects (greenfield, compression, repowering) • Identification of suitable areas and preliminary location analysis • Assessing the local wind potential • Financial analysis and feasibility studies • Budget planning and calculation of profitability • Urban and rural land-use planning • Seeking approval and preliminary planning • Site management • Introduction to the use of GIS software for engineers and planners • Acquisition and application of geospatial data and information
Form of examination	Lab exercise portfolio
Media used	white board, power point presentation, beamer, Lab with ArcGIS and relevant geodata.
Recommended literature	• Erich Hau: Wind Turbines – Fundamentals, Technologies, Applications, Economics. Springer, 2013 (German or English edition)

	• De Smith, Longley and Goodchild: Geospatial Analysis – A Comprehensive Guide. Available online: http://spatialanalysisonline.com/ • Collins and Law: Getting to know ArcGIS for Desktop. Third edition. ESRI Press, 2013. • Booth and Mitchell: Getting started with ArcGIS. Various versions, ESRI Press, 1999-2011. • GIS for Renewable Energy. GIS Best Practices series, ESRI 2010. • Tore Wizelius: Wind Power Project Management. Gotland University, 2006. • Selected scientific papers made available by the lecturer.

Module number [4]: Advanced Engineering Mathematics

Course	Master of Science – Wind Engineering
Module name	Advanced Engineering Mathematics
Abbreviation (if applicable)	AdvMath
Subtitle (if applicable)	
Seminar (if applicable)	
Semester	Winter semester
Person in charge of module	Prof. Dr. Alois Peter Schaffarczyk, University of applied sciences Kiel
Lecturer/s	Dr. Falk Scharnberg, University of applied sciences Flensburg Additional lecturers
Status within the curriculum	Master Course Wind Engineering mandatory course
Language	English
Type of course and hours per week	4 h lectures
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	Sound Knowledge of undergraduate Mathematic
Aims of the module, acquired skills	• The students will be introduced into the classical methods of advanced engineering calculus. • Besides learning classical methods of advanced engineering calculus the students will also be able to apply the methods to fluid mechanics
Subjects covered	• Advanced topics of linear algebra • Space Curves • Vector differential calculus: grad, div, curl(rot) • Vector integral calculus: integral theorems • Fourier Analysis • Linear partial differential equations
Form of examination	Written examination (120 min)
Media used	black board, power point presentation, internet
Recommended literature	• E. Kreyszig, Advanced Engineering Mathematics, 10th Ed, J. Wiley and Sons, 2011, ISBN 978-0-470-64613-7 • Many others

Module number [5]: Mechanical Engineering for Electrical Engineers

Course	Master of Science – Wind Engineering
Module name	Mechanical Engineering for Electrical Engineers
Abbreviation (if applicable)	
Subtitle (if applicable)	
Seminar (if applicable)	
Semester	Winter semester
Person in charge of module	Dr. rer. nat. Hermann van Radecke, University of applied sciences Flensburg
Lecturer/s	Dr. rer. nat. Hermann van Radecke, University of applied sciences Flensburg Prof. Dr. Jacqueline Bridge, UWI
Status within the curriculum	Master Course Wind Engineering mandatory course
Language	English
Type of course and hours per week	4 h lectures with practical exercises
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	none
Aims of the module, acquired skills	• This course provides a bridging opportunity for students who have completed a Bachelor of Science (Electrical/Electrotechnical Engineering). • Goal: To prepare students to utilize FEM-based computational tools. • First, the students are introduced to basic mechanics concepts: applied loads (forces, bending moments and torques), the resulting internal loads and the generation of stresses. Point loads, uniformly distributed loads and parabolic load distributions will be analysed. • This forms the foundation for the development of simple models which can be analysed using FEA techniques e.g. beams in bending must have at least 3 layers of elements: the neutral layer, one in tension, one in compression. • In this manner, students will be prepared for laboratory experiments with FEM software in the computer lab.
Subjects covered	• Introduction: The finite element method, types of finite elements and what they can calculate, a motivation of what the students have to learn. • Axioms, principles and sign conventions in mechanics. • Statics: Resolution of forces, static equilibrium systems, calculation of support reactions. • Mechanics of Materials: Mechanical stress, Hooke’s law, normal and shear stresses, axial loads and torsion. • Strength calculation: The voltage analogue;comparison of voltage manipulation with the determination of stresses due to

	tension/compression, bending and torsion of prismatic straight bars. • Kinematics and Kinetics of (a) point masses and (b) rigid bodies in pure rotation. • Beam model, concentrated and distributed loads, shear force, bending moment and torque curves. • Application to the modelling of FEM systems.
Form of examination	Written examination (120 min)
Media used	Whiteboard, PC and video projector, e-learning platform, in-class experiments, numerical simulations, lecture notes, drilled exercises
Recommended literature	• Beer, F., Johnston, E.R., deWolf, J., Mazurek, D: Mechanics of Materials. McGraw Hill, 6th edition, 2011 • Gere, J.M., Goodno, B.J.: Mechanics of Materials, CEngage Learning, 8th edition, 2012 • Popov, E.: Engineering Mechanics of Solids.", Prentice Hall, 2nd edition, 1998 • Buchanan, G.: Mechanics of Materials. HRW.

Module number [6]: Electrical Engineering for Mechanical Engineers

Course	Master of Science – Wind Engineering
Module name	Electrical Engineering for Mechanical Engineers
Abbreviation (if applicable)	EE for ME
Subtitle (if applicable)	
Seminar (if applicable)	
Semester	Winter semester
Person in charge of module	Prof. Dr.-Ing. Peter Sahner, University of applied sciences Flensburg
Lecturer/s	Prof. Dr.-Ing. Peter Sahner, University of applied sciences Flensburg
Status within the curriculum	Master Course Wind Engineering mandatory course
Language	English
Type of course and hours per week	4 h lectures
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	Bachelor degree in an engineering discipline or in physics
Aims of the module, acquired skills	• The course allows the students to understand the basics of electrical engineering • They are able to apply the learned basics to observed electrical phenomena
Subjects covered	• Ohm’s law • Kirchhoff’s law • DC circuit: current in resistor, current in inductor, voltage at capacitor • AC circuits: calculation of steady states in AC circuits using complex number calculation • Electric and magnetic field
Form of examination	Written examination (120 min)
Media used	black board, power point presentation, internet
Recommended literature	• Ose, R.,Elektrotechnik für Ingenieure, Fachbuchverlag Leipzig • Zastrow, D.;Elektrotechnik, Vieweg, Braunschweig • Weisgerber, W.;Elektrotechnik für Ingenieuere Bd. 1 + 2,Vieweg, Braunschweig

Module number [7]: German for foreign students

Course	Master of Science – Wind Engineering
Module name	German for foreign students
Abbreviation (if applicable)	
Subtitle (if applicable)	Basic knowledge of German language
Seminar (if applicable)	German for foreigners
Semester	Winter semester
Person in charge of module	Sybille Kähler, University of applied sciences Flensburg
Lecturer/s	Sybille Kähler, University of applied sciences Flensburg
Status within the curriculum	Master Course Wind Engineering elective course
Language	German
Type of course and hours per week	4 h lectures
Student workload	attendance: 60 h private study: 90 h
Credit points	5ECTS
Preconditions according to examination regulations	none
Aims of the module, acquired skills	• basic language skills corresponding to A1 (breakthrough or beginner) or A2 (waystage or elementary) of the Common European Framework of Reference for Languages (CEF) depending on the students' preknowledge
Subjects covered	• A1: after completion of this course students can - understand and use familiar everyday expressions and very basic phrases related to particular concrete situations - introduce themselves and others - ask and answer questions about personal details - interact in a simple way • A2: after completion of this course students can: - understand and use sentences and frequently used expressions related to areas of most immediate relevance - communicate in simple and routine tasks - exchange information on familiar and routine matters - describe in simple terms aspects of their background, immediate environment and matters in areas of immediate need
Form of examination	Oral and written examination (90 min.)
Media used	white board, beamer, hand-outs
Recommended literature	• Krenn, W., Puchta, H.: Motive A1: Kompaktkurs DaF. Deutsch als Fremdsprache. Hueber Verlag, München. • Krenn, W., Puchta, H.: Motive A2: Kompaktkurs DaF. Deutsch als Fremdsprache. Hueber Verlag, München.

Module number [8]: English for engineers

Course	Master of Science – Wind Engineering
Module name	English for engineers
Abbreviation (if applicable)	ENGL
Subtitle (if applicable)	
Seminar (if applicable)	
Semester	Winter semester
Person in charge of module	John Ward, University of applied sciences Flensburg
Lecturer/s	John Ward, University of applied sciences Flensburg
Status within the curriculum	Master Course Wind Engineering elective course
Language	English
Type of course and hours per week	4 h lectures
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	none
Aims of the module, acquired skills	• Students have the general and specialized language foundations for the formulation of scientific and technical matters. • Students are particularly aware of collocations and linguistic twists and know typical verb-noun and adjective-noun combinations which are used in technical communication
Subjects covered	• Controlled formulating • Exercises for easy and accurate conversion of facts into language. • Basic technical terms and their linguistic description in definitions: circuit, conductance, conductivity, efficiency, machine, magnitude, resistance, resistor, power, quantity, speed, switch, velocity, ...) • Technical communication: complaints, damage reports, technical reports, invitation to seminar, ... • Treatment of selected topics: disturbance and errors; velocity; modernization; naming and defining, building, design and construction; the environment; quality;
Form of examination	Written Examination (120 min)
Media used	black board, power point presentation, internet
Recommended literature	Bonamy, D.: Technical English 3. Pearson Longman, 2011 ISBN: 978-1-4082-2947-7

Module number [9]: Energy Economics

Course	Master of Science – Wind Engineering
Module name	Energy Economics
Abbreviation (if applicable)	EE
Subtitle (if applicable)	
Seminar (if applicable)	
Semester	Winter semester
Person in charge of module	Prof. Dr. Olav Hohmeyer, University Flensburg
Lecturer/s	Prof. Dr. Olav Hohmeyer, University Flensburg
Status within the curriculum	Master Course Wind Engineering elective course
Language	English
Type of course and hours per week	4 h lectures
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	Admission to the M.Sc. Wind Engineering
Aims of the module, acquired skills	• Students are introduced to the fundamental problems and the overall contexts of the economics of energy. • Students will learn about the different parts of energy demand and the different ways of energy supply. • An understanding of the limitations of non-renewable energy sources and the difficulties of their substitution by renewable and often intermittent energy sources is taught. • The differences in the markets for grid-bound fuels are taught. • At the end of the seminar, each student is able to understand the basic relationships of the various energy markets and classify the contribution of different energy sources, fuels and technologies in the context of the total energy system and sustainable development.
Subjects covered	• Why is energy a subject of economics? • Energy as a resource; • Energy consumption and sustainable development; • Energy and the environment; Social costs of energy; • General aspects of energy markets; Prices in energy markets; • The coal market; The crude oil market; The natural gas market; The electricity market; The market for district heating; • Energy demand by sector; Industry, Households, Commercial sector, Transport, • Potentials, costs and limits of renewable energy sources, • Solar energy for electricity, Solar energy for low temperature heat, Wind energy, Energy from biomass, Hydropower, Geothermal energy, Wave and tidal energy, • Potentials, costs and limits of the rational use of energy by sector, Industry, Households, Commercial Sector, Transport, • Scenarios of sustainable long term energy systems

Form of examination	Presentation of the different teams and a final written report by each team
Media used	Group work and lectures with projector based presentations
Recommended literature	• Hensing, I. et.al. (1998): Energiewirtschaft. Einführung in Theorie und Politik. R. Oldenbourg Verlag, München. • Banks, Ferdinand B.: Energy Economics: A Modern Introduction. Kluewer Academic Publishers, Boston • BP (see most recent year): World Energy Report. Internet • Bundesministerium für Wirtschaft und Arbeit (see most recent year): Energie Daten 201x. Nationale und internationale Entwicklung. (Internet BMWi)

Module number [10]: Introduction to Windturbine Aerodynamics

Course	Master of Science – Wind Engineering
Module name	Introduction to Windturbine Aerodynamics
Abbreviation (if applicable)	IntroAero
Subtitle (if applicable)	Basic knowledge of Wind Turbine Aerodynamics
Seminar (if applicable)	
Semester	Summer semester
Person in charge of module	Prof. Dr. Alois Peter Schaffarczyk, University of applied sciences Kiel
Lecturer/s	Prof. Dr. Alois Peter Schaffarczyk, University of applied sciences Kiel
Status within the curriculum	Master Course Wind Engineering mandatory course
Language	English
Type of course and hours per week	4 h lectures
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	Sound Knowledge of undergraduate Mathematic
Aims of the module, acquired skills	• Introduction into the classical methods of low-speed aerodynamics and blade-element and momentum theory. Students then are able to understand and use standard BEM Codes l
Subjects covered	• Integral and differential methods of fluid dynamics • 2D Airfoils • Simple Momentum-theory of Wind-Turbine, The Betz Limit • General Momentum Theory • Vortex-Theory of Wind-Turbine • The Blade Element Momentum Theory • Outlook: Computational Fluid Dynamics
Form of examination	Written Examination (120 min)
Media used	black board, power point presentation, internet
Recommended literature	• A. P. Schaffarczyk, Introduction to Wind Turbine Aerodynamics, Springer Verlag, 2014, ISBN 978-3-642-36408-2 • J. Katz and A. Plotkin, Low-Speed Aerodynamics, CUP, 2001; ISBN, 0-521-66552-3

Module number [11]: Certification, load assumptions and simulations

Course	Master of Science – Wind Engineering
Module name	Certification, load assumptions and simulations
Abbreviation (if applicable)	CERT
Subtitle (if applicable)	Basic knowledge about loads, certification, standards and guidelines of wind turbines
Seminar (if applicable)	
Semester	Summer semester
Person in charge of module	Prof. Dr. -Ing. Torsten Faber, University of applied sciences Flensburg
Lecturer/s	Prof. Dr. -Ing. Torsten Faber, University of applied sciences Flensburg Andreas Manjock, University of applied sciences Flensburg/DNV GL
Status within the curriculum	Master Course Wind Engineering mandatory course
Language	English
Type of course and hours per week	2 h lectures, 2 h exercises
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	General knowledge in undergraduate mechanics, general ability to use computers, basic experience in the use of engineering software
Aims of the module, acquired skills	• Knowledge and understanding of general items about loads, standards and guidelines, type and project certification • Possibility to connect this knowledge about loads and certification with practical background of the person who is teaching this course • Introduction to load simulation for wind turbines. • The students will understand and learn about the design processes of wind turbines. They will be able to understand the importance of dynamic load simulations for wind turbines and can calculate different load cases.
Subjects covered	• General Items • Extreme and fatigue load calculations • Standards and Guidelines • Type Certification: o Numbering systems o Certification Report o Statement of Compliance o Type Certificate: - Design Assessment - Quality Management - IPE - Prototype Testing • Project Certification: o Site Assessment o Site Specific Design Assessment o Manufacturing Surveillance

	o Surveillance of Transport, Installation and Commissioning
	• Physics and Aerodynamic Principles
	• Guidelines and Standards
	• Wind Turbine Design Process
	  ○ Load Case Definitions
	  ○ Turbine Design
	  ○ Load case simulation
	• Extreme Loads (for Example DLC 1.3)
	Fatigue Loads

Form of examination	Written Examination (120 min) or Oral examination (depending on the number of students)
Media used	black board, power point presentation, projector, PC
Recommended literature	• Understanding Wind Energy Technology, Wiley, 2014 (expected) • Hau, E.: Windkraftanlagen. Springer Verlag, Berlin, 2008 • Manwell, J.F. et.al.: Wind Energy Explained. Wiley Ltd, Chichester, 2009 • Heier, S.: Windkraftanlagen im Netzbetrieb, Vieweg u. Teubner Verlag, Wiesbaden, 2009 • Gasch, R., Twele, J.: Windkraftanlagen. Vieweg u. Teubner Verlag, Wiesbaden, 2010 • CEwind eG, Alois Schaffarczyk: Einführung in die Windenergietechnik, Carl Hanser Verlag, München, 2012 • Guideline for the Certification of Wind Turbines On- and Offshore • DIBt Regulations • Germanischer Lloyd, Guideline for the Certification of Wind Turbines, Edition 2003/2004 • Germanischer Lloyd, Guideline for the Certification of Wind Turbines, Edition 2010 • IEC 61400-1:1999 (Edition 2) • IEC 61400-1:2005 (Edition 3) + Amendement 2010 • DIN EN 61400-1:2006 / DS EN 61400-1:2006 (Denmark) • DIBt, German Typenprüfung TAPS2000 (India)

Module number [12]: Control and automation of wind power plants

Course	Master of Science – Wind Engineering
Module name	Control and automation of wind power plants
Abbreviation (if applicable)	CSAWPP
Subtitle (if applicable)	
Seminar (if applicable)	
Semester	Summer semester
Person in charge of module	Prof. Dr.-Ing. Reiner Schütt, University of applied sciences Westküste
Lecturer/s	Prof. Dr.-Ing. Reiner Schütt, University of applied sciences Westküste
Status within the curriculum	Master Course Wind Engineering mandatory course
Language	English
Type of course and hours per week	4h lectures, exercises, project work
Student workload	attendance: 60 h private study: 90 h
Credit points	5ECTS
Preconditions according to examination regulations	general knowledge of undergraduate mathematics, general knowledge of automation and control, general knowledge of electrical drives and power electronics, admission to the M.Sc. in Wind Engineering
Aims of the module, acquired skills	• The students know and understand the control systems for pitch, azimuth, speed and power adjustment, the automation as well as the possibilities of process control, remote control and maintenance systems. • They can layout and optimize the subsystems. They can judge, which can be fulfilled tasks in which automation level and with which characteristics.
Subjects covered	• Introduction: defining control systems and automation, basics in wind energy conversion systems, their definition and standards • Feedback control systems: objectives and strategies, system description, application to motion control systems • Feedback control in wind energy conversion systems: overview, generator systems, yaw-, pitch-, rotor-power- and speed-control, dc-voltage-control and electrical power control • Process management: open loop control, operating states, supervisory control, grid integration management, communication systems • Summary
Form of examination	Oral or written examination (120 min)
Media used	Blackboard, overhead, beamer, internet
Recommended literature	• Heier, Siegfried: Grid Integration of WECS, John Wiley & Sons, 2008 • Hau, Erich: Wind Turbines, Springer Verlag, 2006 • Gasch, Robert: Wind Power Plants, Springer Verlag, 2006 2008 • CEwind: Understanding Wind Power Technology, John Wiley & Sons, 2014

	• Garcia-Sanz, Mario: Wind Energy Systems Control Engineering Design, Taylor & Francis, 2012 • Schütt, Reiner: Control Systems and Automation of Wind Power Plants, lecture notes, 2013 • Leonhard, Werner: Control of Electr. Drives, Springer Verlag, 2001

Module number [13]: Tower and rotor structures

Course	Master of Science – Wind Engineering
Module name	Tower and rotor structures
Abbreviation (if applicable)	ToRo
Subtitle (if applicable)	Basic knowledge about towers and rotor blades of wind turbines
Seminar (if applicable)	
Semester	Summer semester
Person in charge of module	Prof. Dr. -Ing. Torsten Faber, University of applied sciences Flensburg Prof. Dr. Alois Peter Schaffarczyk, University of applied sciences Kiel
Lecturer/s	Prof. Dr. -Ing. Torsten Faber, University of applied sciences Flensburg Prof. Dr. Alois Peter Schaffarczyk, University of applied sciences Kiel
Status within the curriculum	Master Course Wind Engineering mandatory course
Language	English
Type of course and hours per week	2 h lectures, 2 h exercises
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	none
Aims of the module, acquired skills	• Knowledge and understanding of general items about structures of towers and rotorblades • Possibility to connect this knowledge about loads and certification with practical background of the person who is teaching this course
Subjects covered	• General items • Relevant standards & materials used • Tower and rotor types • Safety Concept and design calculation • Detail calculations • Modal Analysis
Form of examination	Written examination (120 min) and Oral examination (depending on the number of students)
Media used	black board, power point presentation, beamer
Recommended literature	• Understanding Wind Energy Technology, Wiley, 2014 (expected) • Guideline for the Certification of Wind Turbines On- and Offshore • DIBt Regulations

Module number [14]: Mechanical drive train

Course	Master of Science – Wind Engineering
Module name	Mechanical drive train
Abbreviation (if applicable)	MDT
Subtitle (if applicable)	
Seminar (if applicable)	
Semester	Summer semester
Person in charge of module	Prof. Dipl.-Ing. P. Quell, University of applied sciences Kiel
Lecturer/s	Prof. Dipl.-Ing. P. Quell, University of applied sciences Kiel
Status within the curriculum	Master Course Wind Engineering mandatory course
Language	English
Type of course and hours per week	4 h lectures / exercises
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	none
Aims of the module, acquired skills	• The students have a profound knowledge of the general set-up, tasks and functionalities of wind turbine drive trains and their components. • They do understand the technological and economical aspects of different solutions and are able to select preferred technical concepts for given conditions and demands. • The students are able to describe the operational und environmental conditions and their impact on the wind turbine drive trains. • They know the methods and processes of calculating and designing the main components and to integrate them in the drive train system. • The students do understand the operation and maintenance requirements and the applied processes to achieve a successful and economical efficient operation throughout the whole life-cycle. • In parallel they know how to analyze and solve specific tasks and assignments given to them within a team. They know how to present their results effectively and convincingly.
Subjects covered	• Tasks and functionalities of wind turbine drive trains • Variants, technology and economics of drive trains • Design of gearboxes • Geared and directly driven generators • Rotor bearing solutions • Rotor shafts and joins • Couplings, brakes, shaft-hub-joints • Operation and maintenance
Form of examination	Assignments with presentation and written examination (90 min.)
Media used	Blackboard, beamer,

Recommended literature	• Germanischer Lloyd (GL): Guideline for the Certification of Wind Turbines, 2010 • EN 61400-1: Design Requirements for Wind Turbines, 2011 • Schaffarczyk, A.: Introduction to Wind Energy Technology, 2013, Wiley • Gasch, R.: Wind Power Plants, 2011, Springer-Verlag • Hau, E.: Wind Turbines, Springer-Verlag, 2013

Module number [15]: Electrical Engineering for wind turbines

Course	Master of Science – Wind Engineering
Module name	Electrical Engineering for wind turbines
Abbreviation (if applicable)	EE for WT
Subtitle (if applicable)	
Seminar (if applicable)	
Semester	Summer semester
Person in charge of module	Prof. Dr. Frank Hinrichsen, University of applied sciences Flensburg
Lecturer/s	Prof. Dr. Frank Hinrichsen, University of applied sciences Flensburg
Status within the curriculum	Master Course Wind Engineering mandatory course
Language	English
Type of course and hours per week	4 h lectures
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	Bachelor degree in an electrical engineering biased discipline, or successful completion of Module “Electrical engineering for mechanical engineers”
Aims of the module, acquired skills	• Understanding the electrical issues related to wind turbines • Getting to know the electrical components of a wind turbine power plant
Subjects covered	• Basics application of electric machines and power electronics used in wind turbines: generators, transformers, motors, rectifiers, frequency converters, softstarters in power circuit and in auxiliary equipment • Pitch and yaw systems • Cables of different voltage levels and for different purposes in wind turbines and wind parks • Switch gear (contactors, circuit breakers, fuses, relays) • Safety issues in electric installations • Lightning protection in wind turbines • Controller hardware, communication systems and other microelectronics used in wind turbines • Condition monitoring • Reading and understanding wiring diagrams
Form of examination	Written examination (120 min)
Media used	black board, power point presentation,
Recommended literature	Burton, T. et al.: “ Wind Energy Handbook”, 2nd Ed., Wiley, Mai 2011 Ackermann, T.: “Wind Power in Power Systems”, Wiley-Blackwell, Mai 2012 Stiebler, M.: “Wind Energy Systems for Electric Power Generation: Green Energy and Technology”, Springer, 2010 Heier, S.: “Grid Integration of Wind Energy: Onshore and Offshore Conversion Systems”, Wiley, 2014

Module number [16]: FE & Fatique Analysis

Course	Master of Science – Wind Engineering
Module name	FE & Fatique Analysis
Abbreviation (if applicable)	FFA
Subtitle (if applicable)	
Seminar (if applicable)	
Semester	Winter semester
Person in charge of module	Ulf Karnath, k2 E+C GmbH Rainer Osthorst, aerodyn Energiesysteme GmbH
Lecturer/s	Ulf Karnath, k2 E+C GmbH Rainer Osthorst, aerodyn Energiesysteme GmbH
Status within the curriculum	Master Course Wind Engineering mandatory-optional course
Language	English
Type of course and hours per week	2 h lectures 2 h exercises
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	none
Aims of the module, acquired skills	• basic use of ANSYS Workbench • performing a static linear FE Analysis • validation of mesh quality • validation of stress results • Using FKM guideline for fatigue analyses • Performing fatigue analyses of forged steel and cast iron for wind turbine components
Subjects covered	• linear static analyses • influence of mesh quality at regions with high stress gradients • comparison of FEM stress results with stresses calculated with analytical approach • minimize stresses at hot spots by modifying local geometry definitions • calculation of stress concentration factor on the basis of FEM results • introduction to fatigue analyses • calculation of synthetic SN curves according FKM guideline for wind turbine rotor shaft • influences of size, mean stress, roughness and notches on SN curves • using the safety factors of FKM and DNV GL guidelines • analysing the damage sum according to Plamgren/Miner and safety margin or stress reserve factor • fatigue analyses of different materials like forged steel with different strength and nodular cast iron
Form of examination	documentation of FE Analysis of main shaft WEC "Optimus"
Media used	black board, power point presentation, PC, beamer

Recommended literature	• FKM - Analytical Strength Assessment of Components Edition-6/2012, VDMA • DNVGL-ST-0361-2016-09 - Machinery for wind turbines DNV GL Hamburg

Module number [17]: Machinery components & rotor blades

Course	Master of Science – Wind Engineering
Module name	Machinery components & rotor blades
Abbreviation (if applicable)	
Subtitle (if applicable)	
Seminar (if applicable)	
Semester	Winter semester
Person in charge of module	Prof. Dr. Alois Peter Schaffarczyk, University of applied sciences Kiel
Lecturer/s	Prof. Dr. Alois Peter Schaffarczyk, University of applied sciences Kiel (2 SWS) Prof. Dr.-Ing. Michael Thiemke, University of applied sciences Flensburg (1 SWS) Helmut Petrin , AVL (1 SWS)
Status within the curriculum	Master Course Wind Engineering mandatory course
Language	English
Type of course and hours per week	4h lectures/practice
Student workload	attendance: 36 h private study: 114 h
Credit points	5 ECTS
Preconditions according to examination regulations	none
Aims of the module, acquired skills	• The students learn how to calculate and to develop the machinery components of wind turbines: - mechanical drive train - gear boxes - the stress distributions (normal and shear stresses) in different structures under combined loads - natural frequencies and vibrations of structures - the life cycle behaviour of structures - calculation methods (analytical, numerical) • The students will be able, to calculate the stresses and safety factors under dynamic wind loads in wind energy converters. • Students finally should be able to read relevant literature in this subject and understand the foundations of aero-elastic codes to a preliminary structural design of wind turbine blade
Subjects covered	• Basics of 1 and 2 DOF systems • Rotating reference systems • Dynamical equations in Lagrange’s formulation • Natural frequencies, Campbell-Diagram • Life cycle calculation methods • Analytical calculation methods: beam theory, plates • Numerical calculation methods: General mathematical simulation methods, FEM, condensation of FEM models, multi body simulations
Form of examination	Written examination (120 minutes)
Media used	black board, power point presentation, PC, beamer

Recommended literature	• Schaffarczyk (Ed.) Understanding Wind Power Technology: Theory, Deployment and Optimization, Wiley, 2014 • Germanischer Lloyd: Wind Turbines, 2003 • Germanischer Lloyd: Regulations for the Certification of Wind Energy Conversion Systems. Germanischer Lloyd, 1999 • IEC 61400-1: Wind Turbine Generator Systems, 2006 • Roark: Formulas of Stress and Strain, 1975 • Szilard: Theory and Analysis of Plates, 1978 • International Organization For Standardization: ISO 6336 - Calculation of load capacity of spur and helical gears 2006 • Deutsches Institut für Normung e.V.: Calculation of load capacity of cylindrical gears; introduction and general influence factors, 1987

Module number [18]: Electrical machines, power electronics and control

Course	Master of Science – Wind Engineering
Module name	Electrical machines, power electronics and control
Abbreviation (if applicable)	
Subtitle (if applicable)	
Seminar (if applicable)	
Semester	Winter semester
Person in charge of module	Prof. Dr.-Ing. Frank Hinrichsen, University of applied sciences Flensburg
Lecturer/s	Prof. Dr.-Ing. Frank Hinrichsen, University of applied sciences Flensburg
Status within the curriculum	Master course Wind Engineering mandatory-optional course
Language	English
Type of course and hours per week	4 h lectures
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	Basic knowledge in electrical engineering, especially electrical energy engineering
Aims of the module, acquired skills	• To have basic knowledge on steady state performance of three phase AC mains, induction generators, synchronous generators and power electronic converters for AC machines as used in wind power stations and be able to calculate their performance.
Subjects covered	• Three phase AC mains • Induction generators • Synchronous generators • Power electronic converters for AC machines
Form of examination	Written examination (120 min)
Media used	Black board, power point presentation, beamer
Recommended literature	• Schaffarczyk, J (Editor).: *Understanding Wind Power Technology – Theory, Deployment and Optimization*, Wiley, 2012 • Schaffarczyk, J (Hrsg.).: *Einführung in die Windenergietechnik*, Hanser Verlag, 2012 • Heier, S.: *Grid Integration of Wind Energy – Onshore and Offshore Conversion Systems,* 3rd Edition, Wiley, 2014 • Heier, S.: *Windkraftanlagen: Systemauslegung, Netzintegration und Regelung* , Teubner + Vieweg Verlag, 2009 • Stiebler, M.: *Green Energy and Technology: Wind Energy Systems for Electric Power Generation*, Springer, 2012

Module number [19]: Grid Integration

Course	Master of Science – Wind Engineering,
Module name	Grid Integration
Abbreviation (if applicable)	GI
Subtitle (if applicable)	Mutual effects between wind turbines and power systems
Seminar (if applicable)	seminar
Semester	Winter semester
Person in charge of module	Prof. Dr. Clemens Jauch, University of applied sciences Flensburg
Lecturer/s	Prof. Dr. Clemens Jauch, University of applied sciences Flensburg
Status within the curriculum	Master Course Wind Engineering mandatory-optional course
Language	English
Type of course and hours per week	4 h lectures
Student workload	attendance: 60 h private study: 90 h
Credit points	5ECTS
Preconditions according to examination regulations	none
Aims of the module, acquired skills	• understanding the fundamental principles of power systems • understanding the behaviour of grid connected wind turbines • understanding the effects grid connected wind turbines have on power systems • understanding the effects transient and dynamic events in power systems have on wind turbines
Subjects covered	• power system basics o basic characteristics and quantities o flicker o power system stability • power system simulation • wind farms in power systems • interactions between wind turbines and power systems o long term effects o feed-in management o inertial response o flicker o low voltage ride through and and other transient events • harmonics
Form of examination	Written examination (120 minutes)
Media used	beamer based presentation, blackboard
Recommended literature	• B.M. Weedy, B.J. Cory; Electric Power Systems; John Wiley • S. Heier; Grid Integration of Wind Energy Conversion Systems; John Wiley & Sons

Module number [20]: Tower and sub-structure design and dimensioning

Course	Master of Science – Wind Engineering
Module name	Tower and sub-structure design and dimensioning simulation
Abbreviation (if applicable)	TSDD
Subtitle (if applicable)	In-depth knowledge about tower design and dimensioning
Seminar (if applicable)	
Semester	Winter semester
Person in charge of module	Prof. Dr. -Ing. Torsten Faber, University of applied sciences Flensburg
Lecturer/s	Prof. Dr. -Ing. Torsten Faber, University of applied sciences Flensburg
Status within the curriculum	Master Course Wind Engineering Mandatory-optional course
Language	English
Type of course and hours per week	2 h lectures, 2 h exercises
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	• Certification and load assumptions • Tower and rotor structures
Aims of the module, acquired skills	Students • know to design, dimension and optimise the (sub-)structures of a wind turbine and tower in consideration of structural safety, serviceability and economic efficiency • know what materials can be used (steel, reinforced concrete, GRP, wood etc.) • can evaluate what materials are applicable under specific conditions
Subjects covered	• Design Calculation • Verification against Material Failure • Verification against Stability Failure • Verification against Fatigue Failure • Verification of Serviceability • Detail Calculation • FEM Calculation • Prevention of Resonance • Internal resistance – Dimensioning of concrete and reinforcement steel • External resistance – Assessment of soil, respective interaction between soil and foundation • Dynamic behaviour – Validation of natural frequencies which were assumed within load calculation
Form of examination	Written examination (120 min) or Oral examination (depending on the number of students)
Media used	black board, power point presentation, beamer and FEM Lab

Recommended literature	• Guideline for the Certification of Wind Turbines On- and Offshore • DIBt Regulations • Civil Engineering DIN-Standards • Eurocodes for civil engineering

Module number [21]: Project: Development of a wind turbine

Course	Master of Science – Wind Engineering
Module name	Project: Development of a wind turbine
Abbreviation (if applicable)	P_WT
Subtitle (if applicable)	Focus: A Mechanical engineering B Electrical engineering C Structures
Seminar (if applicable)	project
Semester	Winter semester
Person in charge of module	Prof. Peter Quell, University of applied sciences Kiel
Lecturer/s	A) Prof. Dr. Alois Schaffarczyk, University of applied sciences Kiel B) Prof. Dr. Rajesh Saiju, University of applied sciences Flensburg C) Prof. Dr. Torsten Faber, University of applied sciences Flensburg D) Dipl.-Ing. Andreas Manjock, DNV-GL E) Prof. Peter Quell, University of applied sciences Kiel
Status within the curriculum	Master Course Wind Engineering Mandatory-optional course
Language	English
Type of course and hours per week	3 h project discussion 17 h self-dependent project work
Student workload	attendance: 30 h private study: 270 h
Credit points	10 ECTS
Preconditions according to examination regulations	none
Aims of the module, acquired skills	• Project work in an R&D process • Identification of the components needed to build a wind turbine with the consideration of varying site conditions • Dimensioning and designing the relevant mechanical, electrical or constructional components of a wind turbine (based on the team focus) • Gaining in-depth knowledge about the current market situation of wind turbines • Understanding the importance of interface management in a project and being able to implement interface management to any project • Efficiently working and communicating an interdisciplinary team
Subjects covered	• Project planning and project management • Interdisciplinary project team work interacting between mechanics team, electrics team and structures team A • Conception of the mechanical drive train • Designing the rotor bearing, gearbox, couplings and brakes • Aerodynamical and structural design of the rotor blades B • Conception of the electrical system • Dimensioning transformer, generator, converter and cable system for the wind turbine • Conception of the control system C • Load simulation and calculation

		• Conception of the tower and foundation • Designing and dimensioning tower and foundation
Form of examination	Presentation and project report	
Media used	-	
Recommended literature	• Schaffarczyk, Alois: Understanding Wind Power Technology, Wiley, 2014, ISBN: 978-1118647516 • Hau, Erich: Wind Turbines, Springer, 2013, ISBN: 978-3642271502 • S. Heier; Grid Integration of Wind Energy Conversion Systems; John Wiley & Sons • DNV-GL: Guideline for the Certification of Wind Turbines, 2010 DIN EN 61400: Wind turbines, 2010	

Module number [22]: Advanced Wind Farm Planning and Turbine Measurements

Course	Master of Science – Wind Engineering
Module name	Advanced Wind Farm Planning and Turbine Measurements
Abbreviation (if applicable)	
Subtitle (if applicable)	
Seminar (if applicable)	
Semester	Winter semester
Person in charge of module	Dr. rer. nat. Hermann van Radecke, University of applied sciences Flensburg Marko Ibsch, DNV GL
Lecturer/s	Dr. rer. nat. Hermann van Radecke, University of applied sciences Flensburg Marko Ibsch, DNV GL
Status within the curriculum	Master Course Wind Engineering elective course
Language	English
Type of course and hours per week	2 h practical laboratory exercises, attended course of lectures 2 h lecture
Student workload	Attendance: 60 h Private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	Basics in wind properties Basics in wind energy theory Basics in wind turbine systems
Aims of the module, acquired skills	Working in the computer lab the students will learn to use the two most important wind park planning programs. At predefined projects with extended lab manuals students are lead trough annual energy yield productions with WAsP and other methods, the use of short time wind measurements at a site, the calculation of noise and shadow emission and their assessment, visual impact and photomontage, electrical grid lay out, optimisation and other procedures. In the lab the students use the planning programs WindPRO, Windfarmer and WAsP and other tools. The students will be able to evaluate prognoses of wind-energy potential. They will be able to calculate and evaluate emissions. Knowledge and understanding of general items about the respective standards and the different types of measurements Characteristics of wind turbines Market relevance Possibility to learn from the experience of the lecturers, who come from one of the leading testing companies worldwide
Subjects covered	• Energy meteorology, annual energy production calculations, met-tower, short-term long-term measurements, own and public wind resources, wake models, programs Windpro, Windfarmer, WAsP et al. • Emissions and influences on the environment, noise, shadow, programs Windpro, Windfarmer et al • Visual impact, visibility, photomontage, programs Windpro, Windfarmer et al.

	• Electrical layout of windpark, programs Windpro, Windfarmer et al. • Optimisation of a windpark layout, programs Windpro, Windfarmer • Evaluation of economic efficiency of a windpark • General overview • Standards and Guidelines for Turbine Measurements • Prototype testing • Power Performance • Loads • Acoustics • Power Quality • Test of Turbine Behaviour
Form of examination	Laboratory report Written examination (120 min)
Media used	Computer lab, laboratory experiments, whiteboard, PC and video projector, e-learning platform, lecture notes, program manuals Power Point Presentations
Recommended literature	• Troen, I. and E.L. Petersen: European Wind Atlas. Risø National Laboratory, Roskilde, 1989 • Manwell, J.F., McGowan, J.G., Rogers, A.L.: Wind Energy Explained. Wiley, Chichester, 2009 • CEwind, Hrsg.: Einführung in die Windenergietechnik. Carl Hanser Verlag, München, 2012. • CEwind, ed.: Understanding Wind Energy Technology. Wiley, 2014 i.p. • IEC 61400 International Electrotechnical Commission • Technische Richtlinien (FGW-Richtlinien) • Manual program Windpro • Manual program Windfarmer • Wind Turbines - Fundamentals, Technologies, Application, Economics - 2nd edition • E Hau, Springer 2006, Hardcover XVIII, 783 p. 552 • Gasch, R., Twele, J.: Wind Power Plants - Fundamentals, Design, Construction and Operation. James and James, 2005, Softcover 416pp ISBN 9781902916385 • Wind Power in Power Systems, Edited by Thomas Ackermann, Wiley January 2005 , Hardcover 742 pp ISBN 0470855088 • Wind Energy - The Facts, European Wind Energy Association (EWEA), Earthscan, March 2009, Hardback, 488 pages, ISBN: 978184407710 • Aerodynamics of Wind Turbines (2nd Edition), Martin O.L. Hansen, Earthscan, Hardcover 192pp ISBN 9781844074389 • Wind Energy Explained: Theory, Design and Application

Module number [23]: Offshore wind energy: Operation and Maintenance

Course	Master of Science – Wind Engineering
Module name	Offshore wind energy: Operation and Maintenance
Abbreviation (if applicable)	OWE; O&M
Subtitle (if applicable)	
Seminar (if applicable)	
Semester	Winter semester
Person in charge of module	Dr.-Ing. Axel Birk, Hanseatic Renewable Consulting GmbH
Lecturer/s	Dr.-Ing. Axel Birk, Hanseatic Renewable Consulting GmbH
Status within the curriculum	Master Course Wind Engineering elective course
Language	English
Type of course and hours per week	4 h lectures
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	none
Aims of the module, acquired skills	• The students have a profound knowledge of the general set up and the functionalities of offshore wind wind power plants (OWPP) • They understand the market, the potential and the economics of offshore wind energy. They are able to select technical solutions based on a balanced evaluation of yield and costs. • The students are able to describe the operational und environmental conditions offshore and their impact on the OWPP. • They know the different types of offshore foundations and are able to select the best solution for given environmental conditions. • The students are able to describe the logistical processes for construction, transport, installation and servicing of OWPPs. • The Module will create general understanding to manage processes to operate and maintain wind turbines • The competence to use planning methods for intervention (scheduled and unscheduled) will be teached • The students will learn to create documentation and use life cycle management techniques • In the course the ability to identify and influence main cost elements of O&M phase will be explained
Subjects covered	• Differences between onshore and offshore applications • Offshore markets and potential • Economics of offshore wind parks • Operational and environmental conditions offshore • Types of fixed foundations • Construction and installation of offshore WECs • business process O&M (elements, interfaces) • scheduled interventions (ressources, timing and cost)

	• unscheduled intervention (ressources, timing and cost) • Health and Safety • Documentation needs for Life Cycle Management • Spare part management for tear and wear parts or regular spares • work instructions for O&M • RDS-PP as tool to describe wind power plants
Form of examination	Oral examination
Media used	Beamer based presentation
Recommended literature	• Heier, S.: Grid Integration of WIND ENERGY CONVERSION SYSTEMS. 2nd Edition, John Wiley & Sons Ltd. Chichester, New York, Weinheim, Brisbane, Singapore, Toronto, 2006. Translated by Rachel Waddington, Swadlincote, UK • Lesny, Kerstin: Foundations for Offshore Wind Turbines, VGE, 2010 • Det Norske Veritas (DNV): Regulations for the Design of Offshore Wind Turbine Structures, 2005 • Praxishandbuch Schnittstellenmanagement Offshore Wind EEHH, Maritimes Cluster ISBN: 978-3-00-05402024-0

Module number [24]: Computational Fluid Dynamics

Course	Master of Science – Wind Engineering, elective
Module name	Computational Fluid Dynamics
Abbreviation (if applicable)	CFDLS
Subtitle (if applicable)	Introduction to Computational Fluid Dynamics with OpenFOAM
Seminar (if applicable)	
Semester	Winter semester
Person in charge of module	Prof. Dr. Alois Peter Schaffarczyk, University of applied sciences Kiel
Lecturer/s	Prof. Dr. Alois Peter Schaffarczyk, University of applied sciences Kiel
Status within the curriculum	Master Course Wind Engineering elective course
Language	English
Type of course and hours per week	short introduction with large amounts of practice (2)
Student workload	attendance: 60 h private study: 90 h
Credit points	5 ECTS
Preconditions according to examination regulations	Sound Knowledge of Wind Turbine Aerodynamics, helpful: basic knowledge of Linux, C++
Aims of the module, acquired skills	• The module is an introduction to CFD. The students will learn how to use CFD and how to apply it to wind turbine aerodynamics • Additionally the students will get to know and learn how to use OpenFOAM and other open source codes
Subjects covered	• What is CFD? • Understanding and working with Linux and C++ • Understanding and working with OpenFOAM • Meshing, Solving, Post-Processing • Solving Problem 1: laminar and turbulent flat-plate boundary layer • Solving Pr. 2: 2D Wind Turbine Airfoil DU-W-300-mod • Solving Pr. 3: Actuator Disk-Model of the MEXICO Rotor • Solving Pr. 4: Full 3D Wind Turbine Wing (Mexico)
Form of examination	Oral examination
Media used	PC, power point presentation
Recommended literature	• A. P. Schaffarczyk, Introduction to Wind Turbine Aerodynamics, Springer Verlag, 2014, ISBN 978-3-642-36408-2 • CAJ Fletcher, Computaional Techniques for Fluid Dynamics, 2 Vol. Springer, 1991 • OpenFOAM User Guide 2.2.1, June 2013 • G. Schepers et al, Final report of IEA Task 29, Mexnext (Phase 1): Analysis of Mexico wind tunnel measurements, ECN-E-12-004, Petten, NL, 202

Module number [25]: Modelling & Simulation of Wind Turbines

Course	Master of Science – Wind Engineering
Module name	Modelling & Simulation of Wind Turbines
Abbreviation (if applicable)	MaS
Subtitle (if applicable)	Modelling wind turbines in a commonly used simulation environment for simulating the general behaviour of wind turbines during normal operation
Seminar (if applicable)	seminar
Semester	Winter semester
Person in charge of module	Prof. Dr. Clemens Jauch, Flensburg University of Applied Sciences
Lecturer/s	Prof. Dr. Clemens Jauch, Flensburg University of Applied Sciences
Status within the curriculum	Master Course Wind Engineering elective course
Language	English
Type of course and hours per week	2 h lectures 2 h laboratory exercise
Student workload	attendance: 60 h private study:90 h
Credit points	5 ECTS
Preconditions according to examination regulations	General knowledge in undergraduate mathematics, general ability to use computers, basic experience in the use of engineering software
Aims of the module, acquired skills	• The students learn the general functionality of a wind turbine system: The interrelation between wind speed, pitch angle, rotor speed, torque and power in a wind turbine are discussed to the extent so the students can apply this knowledge in the laboratory • The lab exercise comprises modelling a general wind turbine system with the simulation tool Matlab/Simulink. • Goal of the lab exercise is a running simulation model in Matlab/Simulink that reproduces the response of a wind turbine in terms of pitch angle, rotor speed, torque and power, when subject to variations in the wind speed and variations in grid quantities
Subjects covered	An Introduction to Modelling and Simulation • Fields of Application and Advantages of Modelling and Simulation • Simulation Environments for Engineering • Time-Invariant and Time-Variant Systems • Linear and Non-Linear Systems • Differential Equations • Numerical Integration • Block Diagram Representation • Transfer Functions and State Space Approach • Per Unit Representation • Initialisation • Anti-Windup of Integrators • Lookup Function

	Modelling Wind Turbines
	• Models of Wind Turbine Subsystems
	    o Wind Model
	    o Aerodynamics
	    o Drive Train
	    o Tower
	    o Generator and Converter
	    o Control System
	    o Interface to Power System
	• Block Diagrams of Different Wind Turbine Systems

Form of examination	Written examination (120 minutes)
Media used	Beamer based presentation, blackboard, computer laboratory with Matlab/Simulink software
Recommended literature	• Documentations and examples on the Matlab homepage http://www.mathworks.de/support/

Module number [26]: Wind Engineering Challenge Project

Course	Master of Science – Wind Engineering
Module name	Wind Engineering Challenge Project
Abbreviation (if applicable)	WEP
Subtitle (if applicable)	. a) Mechanical & Electrical Engineering . b) System Design (Modeling & Optimization) . c) Physical Prototyping . d) Project Management
Seminar (if applicable)	project
Semester	Winter semester
Person in charge of module	Prof. Dr. Torsten Faber, Rasmus Borrmann, Robert Rudolf, University of applied sciences Flensburg
Lecturer/s	Robert Rudolf, Rasmus Borrmann
Status within the curriculum	optional
Language	English
Type of course and hours per week	2h project discussion 2h project work
Student workload	Attendance: 60h Private study: 90h
Credit points	5 ECTS
Preconditions according to examination regulations	None
Aims of the module, acquired skills	Acquire practical R&D experience by participating in a wind-specific engineering competition or challenge
Subjects covered	Design Theory • Practical aerodynamic design (Rotor design tradeoffs, surface finish effects, fairing design, manufacturing) • Project-specific theory (e.g. competition) Virtual Prototyping • CFD: 2D boundary layer code (XFoil), 3D panel method (XFLR5), and rotor BEM (QBlade) • Performance Modeling • Numerical Optimization Physical Prototyping • Geometric Dimensioning and Tolerancing (GD&T) • CNC machining (Hot wire cutting, milling, 3D printing) Measurement • System characterization (Friction, Drag, etc.) • Wind tunnel testing • Site assessment • Performance measurement • Optional: telemetry
Form of examination	Periodic design reviews (33%), simulation report (33%), physical prototype (34%)
Media used	n/a

Recommended literature	• Gaunaa, M., Øye, S. & Mikkelsen, R. (2009). *Theory and Design of Flow Driven Vehicles Using Rotors for Energy Conversion.* In EWEC 2009 Proceedings online. Brussels: EWEC • Manwell, J., McGowan, J. & Rogers, A. (2009). *Wind Energy Explained: Theory, Design and Application*. Chichester: John Wiley & Sons Ltd. • Marten, D., Wendler, J., Pechlivanoglou, G., Nayeri, C. & Paschereit, C. (2009). QBlade: An open source tool for Design and Simulation of horizontal and vertical axis wind turbines. *International Journal of Emerging Technology and Advanced Engineering 3 (Special Issue* 3), 264-269. • Meschia, F. (2008). Model analysis with XFLR5. *Radio Controlled Soaring Digest 25(2),* 27-51. • Competition-/challenge-specific material (TBD)

Module number [27]: Master thesis

Course	Master of Science – Wind Engineering,
Module name	Master thesis
Abbreviation (if applicable)	-
Subtitle (if applicable)	-
Seminar (if applicable)	-
Semester	4^{th} semester (or 3^{rd} for students having been registered for the 2nd semester of the programme immediately)
Person in charge of module	2 professors of the course of study
Lecturer/s	-
Status within the curriculum	Master Course Wind Engineering mandatory course
Language	English, German (if an application is filed accordingly)
Type of course and hours per week	• Writing of final thesis • Preparation and realisation of colloquium • The thesis is to be produced in a time period of five months.
Student workload	attendance: - private study: 900 h
Credit points	30 ECTS
Preconditions according to examination regulations	For students having been registered for the 2nd semester of the programme immediately, pursuing the programme as a three-semester course of study, a minimum of 45 credit points (CP) is the prerequisite for admission to the thesis. For students having started with the first semester of the programme, pursuing the programme as a four-semester course of study, a minimum of 75 credit points (CP) is the prerequisite for admission to the thesis.
Aims of the module, acquired skills	• With the Master's thesis the students show that they are able to independently compose a comprehensive work that complies with high methodological, conceptual and scientific demands. • They are also able to present the results in written and oral form.
Subjects covered	The topic of the thesis has to be related to one of the taken modules of the study and has to be supervised by at least one professor of the study program. Subjects covered: • Conception of a work plan • Independent study of related literature and methodology • Application of methodology • Compilation of the thesis • Presentation of results • Colloquium
Form of examination	The colloquium is scheduled to take 60 minutes for each candidate. The grade of the master’s thesis is made up of the grade for the written thesis counting 70% and the grade for the colloquium counting 30%.
Media used	-
Recommended literature	-