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**Modulhandbuch**  
**Engineering Physics - Master's Programme**  
**im Sommersemester 2022**  
erstellt am 05/04/22

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## Pflichtmodule

### phy611 - Theoretical Methods

<b>Module label</b>	Theoretical Methods
<b>Module code</b>	phy611
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( attendance: 56 hrs, self study: 124 hrs )
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Pflichtmodule</li> </ul>
<b>Responsible persons</b>	<p>Cocchi, Caterina (Module responsibility)</p> <p>Anemüller, Jörn (Authorized examiners)</p> <p>Cocchi, Caterina (Authorized examiners)</p> <p>Doclo, Simon (Authorized examiners)</p> <p>Hartmann, Alexander (Authorized examiners)</p> <p>Kühn, Martin (Authorized examiners)</p> <p>Lücke, Jörg (Authorized examiners)</p> <p>Kunz-Drolshagen, Jutta (Authorized examiners)</p> <p>Neu, Walter (Authorized examiners)</p> <p>Peinke, Joachim (Authorized examiners)</p> <p>Poppe, Björn (Authorized examiners)</p> <p>Schmidt, Thorsten (Authorized examiners)</p> <p>Stoevesandt, Bernhard (Authorized examiners)</p> <p>Strybny, Jann (Authorized examiners)</p>
<b>Prerequisites</b>	Theory modules in Bachelor, e.g., Mathematical Methods; Quantum Structure of Matter
<b>Skills to be acquired in this module</b>	<p>Computational Fluid Dynamics (CFD I &amp; II)</p> <ul style="list-style-type: none"> <li>• Deeper understanding of the fundamental equations of fluid dynamics.</li> <li>• Overview of numerical methods for the solution of the fundamental equations of fluid dynamics.</li> <li>• Confrontation with complex problems in fluid dynamics.</li> <li>• To become acquainted with different, widely used CFD models that are used to study complex problems in fluid dynamics.</li> <li>• Ability to apply these CFD models to certain defined problems and to critically evaluate the results of numerical models.</li> </ul> <p><b>Computerorientierte Physik</b>            Extension and complement of qualification in theoretical physics through the acquisition of solid and deep knowledge of advanced concepts and methods in theoretical physics. Depending on the selected course the students acquire knowledge in the fields of basis numerical methods of theoretical physics, algorithms and data structures in scientific computing, code debugging. They obtain skills for a confident application of modern methods of theoretical physics such as diagram generation, Molecular Dynamics and Monte Carlo simulations and quantitative analysis of advanced problems of theoretical physics and in further development of the physical intuition. They enhance their competences to effectively deal with sophisticated problems of theoretical physics, to independently develop approaches to current issues of theoretical physics, and to comprehend common concepts and methods of theoretical physics and the natural sciences, in general.</p> <p><b>Modelling and Simulation</b>            The students attending successful the course acquire an advanced understanding of the conceptual design of models in the field of engineering sciences. Special emphasis is on identifying the significant physical processes and the choice of the most efficient modelling type. The interaction of numerical simulations with field measurements and laboratory measurements including the theory of similarity will be discussed. To meet the needs of renewable energy, laser technology, environmental sciences and marine sciences the practical focus is on the modelling and simulation of fluid dynamics in small scales and close to structures.</p>

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## Module contents

### Computational Fluid Dynamics (CFD I & II)

- CFD I: The Navier-Stokes equations, filtering / averaging of Navier-Stokes equations, introduction to numerical methods, finite-differences, finite-volume methods, linear equation systems, NS-solvers, RANS, URANS, LES, DNS, turbulent flows, incompressible flows, compressible flows, efficiency and accuracy.
- CFD II: Introduction to different CFD models, such as OpenFOAM and PALM. Application of these CFD models to defined problems from rotor aerodynamics and the atmospheric boundary layer.

### Computerorientierte Physik

- Debugging
- Data structures
- Algorithms
- Random number generation
- Data analysis
- Percolation
- Monte Carlo simulation
- Finite size scaling
- Quantum Monte Carlo
- Molecular dynamics simulations
- Event-driven simulations
- Graphs and algorithms
- Genetic algorithms
- optimization problems

### Modelling and Simulation

- Understanding of advanced fluid dynamics including three-dimensional, transient and compressible processes
- Identifying the significant physical processes, defining the dimensionality and relevant scales in time and space
- Theory of similarity, range of dimensionless numbers
- Potential Theory
- Numerical Algorithms and possibilities of independent coding of simplest mathematical models
- Limitations of numerical models, risk of empirical approaches included in numerical models
- Introduction of a complete chain of Open-Source-CFD-Tools, considering preprocessing, processing and postprocessing tools
- Need and availability of appropriate measurement techniques for the steering, calibration and verification of models
- Contactless high-resolving measuring techniques in the fluid dynamics
- Limits of accuracy of different modelling and simulation concepts

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## Reader's advisory

- Computational Fluid Dynamics (CFD I & II)

J.H. Ferziger, M. Peric, Computational Methods for Fluid Dynamics, Springer, 2002.  
C. Hirsch, Numerical Computation of Internal and External Flows: Introduction to the Fundamentals of CFD, Vol 1: Fundamentals of Computational Fluid Dynamics, 2nd edition, Butterworth-Heinemann, Amsterdam.  
P. Sagaut, Large Eddy Simulation for Incompressible Flows, Springer, Berlin, 1998.  
J. Fröhlich, Large Eddy Simulationen turbulenter Strömungen, Teubner, Wiesbaden, 2006. (in German)

- Computerorientierte Physik

T. H. Cormen, S. Clifford, C.E. Leiserson, und R.L. Rivest: Introduction to Algorithms. MIT Press, 2001.  
K. Hartmann: Practical guide to computer simulation. World-Scientific, 2009.  
J. M. Thijssen: Computational Physics. Cambridge University Press, 2007.  
M. Newman, G. T. Barkema: Monte Carlo Methods in Statistical Physics. Oxford University Press, 1999.

- Modelling and Simulation

Versteeg, K.H. & Malalasekera, W.: An Introduction to Computational Fluid Dynamics. Prentice Hall, 2nd rev. Ed., 2007.

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## Links

<b>Languages of instruction</b>	German, English
<b>Duration (semesters)</b>	1 Semester
<b>Module frequency</b>	halbjährlich

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<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>				
<b>Modulart / typ of module</b>	je nach Studiengang Pflicht oder Wahlpflicht			
<b>Lehr-/Lernform / Teaching/Learning method</b>	Lecture: 3hrs/week; Excercises: 1hrs/week			
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Time of examination		Type of examination	
<b>Final exam of module</b>	According selected course			
Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				56 h

## phy631 - Advanced Metrology

<b>Module label</b>	Advanced Metrology			
<b>Module code</b>	phy631			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> <li>• Master's Programme Engineering Physics (Master) &gt; Pflichtmodule</li> </ul>			
<b>Responsible persons</b>	<p>Huke, Philipp (Module responsibility)</p> <p>Huke, Philipp (Authorized examiners)</p> <p>Huke, Philipp (Module counselling)</p>			
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>	<p>The course in Advanced Metrology sets up a high level route enabling the students to acquire skills to allow them to operate effectively in the majors of Engineering Physics. This is achieved by provision of state-of-the-art technical and physical approaches covering broad aspects of advanced metrology within the context of Laser&amp;optics, Biomedical physics &amp; acoustics, and renewable energies.</p> <p>Demonstrate systematic knowledge across appropriate advanced metrology technologies, management and environmental issues to provide solutions for international industries and/or research organisations</p>			
<b>Module contents</b>	<p>The module combines theory and practical applications of the fundamentals of metrology in all majors.</p> <ul style="list-style-type: none"> <li>• Fundamentals of Metrology</li> <li>• Dimensional Measurement Systems</li> <li>• Basic metrology operators including Association and Filtration.</li> <li>• Optical Metrology and Instrumentation</li> <li>• Surface and Nanometrology</li> <li>• Machine Tool and Large Volume Metrology</li> <li>• Process Measurement and Control</li> <li>• Individual Project</li> </ul>			
<b>Reader's advisory</b>	T. Yoshizawa (Ed.): Handbook of Optical Metrology: Principles and Applications, 2nd rev. ed., Crc Pr Inc., 2015 Recent publications on specific topics			
<b>Links</b>				
<b>Language of instruction</b>	English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>	halbjährlich			
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	je nach Studiengang Pflicht oder Wahlpflicht			
<b>Lehr-/Lernform / Teaching/Learning method</b>	Lecture: 4 hrs/week first, 2 hrs/week second half of semester Experimental /Seminar work: 0 hrs/week first, 2 hrs/week second half of semester			
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Time of examination	Type of examination		
<b>Final exam of module</b>		1 written exam or 1 presentation or 1 oral exam or 1 seminar paper		
Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Course selection (Specialization Biomedical Physics)		4	WiSe	56
Course selection (Specialization Acoustics)		2	WiSe	28
Course selection (Specialization Renewable Energies)		2	WiSe	28
Course selection (Specialization Laser & Optics)		2	WiSe	28
<b>Total time of attendance for the module</b>				140 h



## phy640 - Seminar Advanced Topics in EP

<b>Module label</b>	Seminar Advanced Topics in EP	
<b>Module code</b>	phy640	
<b>Credit points</b>	3.0 KP	
<b>Workload</b>	90 h ( Attendance: 28 hrs, Self study: 62 hrs )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Pflichtmodule</li> </ul>	
<b>Responsible persons</b>	Koch, Sandra (Authorized examiners)  Neu, Walter (Authorized examiners)  Neu, Walter (Module responsibility)	
<b>Prerequisites</b>	Participation: 1st -3rd semester. Presentation: Master thesis work in progress or finished; at least one successfully completed specialization module.	
<b>Skills to be acquired in this module</b>	The students are enabled to demonstrate the ability to communicate clearly, both orally and in writing, to specialist and non-specialist audiences. Demonstrate knowledge, fundamental understanding and critical awareness of current research fields in the student's master projects. Personal development through practice of communication, presentation, time management, teamwork, problem solving, project management, critical evaluation, numeracy, and IT skills.	
<b>Module contents</b>	Current seminar topics	
<b>Reader's advisory</b>	M. Alley: The Craft of Scientific Presentations, Springer, 2nd ed., 2013 Publications according to seminar topics	
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	halbjährlich	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	je nach Studiengang Pflicht oder Wahlpflicht	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Seminar: 2 hrs/week	
<b>Vorkenntnisse / Previous knowledge</b>	Participation: 1st - 3rd semester. Presentation: Master thesis work in progress or finished; at least one successfully completed specialization module.	
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		max 1h oral presentation and written report or oral exam (1 hour and regular active and documented participation in the seminar spread over the first three semesters.
<b>Course type</b>	Seminar	
<b>SWS</b>	2	
<b>Frequency</b>	--	
<b>Workload attendance</b>	28 h	

## phy681 - Tools and Skills for Scientific Engineering

<b>Module label</b>	Tools and Skills for Scientific Engineering			
<b>Module code</b>	phy681			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Attendance: 28 hrs, Self study: 152 hrs )			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Pflichtmodule</li> </ul>			
<b>Responsible persons</b>	<p>Huke, Philipp (Module responsibility)</p> <p>Doclo, Simon (Authorized examiners)</p> <p>Brückner, Hans Josef (Authorized examiners)</p> <p>Huke, Philipp (Authorized examiners)</p> <p>Koch, Sandra (Authorized examiners)</p> <p>Neu, Walter (Authorized examiners)</p> <p>Petrovic, Vlaho (Authorized examiners)</p> <p>Poppe, Björn (Authorized examiners)</p> <p>Reck, Martin (Authorized examiners)</p> <p>Schellenberg, Markus (Authorized examiners)</p> <p>Schmidt, Jonas (Authorized examiners)</p> <p>Schüning, Thomas (Authorized examiners)</p> <p>Struve, Bert (Authorized examiners)</p> <p>Teubner, Ulrich (Authorized examiners)</p>			
<b>Prerequisites</b>	Acc. selected course			
<b>Skills to be acquired in this module</b>	<p>This module aims to raise the students understanding of the strategic, leadership, and technical aspects of project management and their role in adding competitive advantage to any enterprise. Concepts and techniques for programme and project management are introduced, developed and applied, with the aid of relevant case material.</p> <p>The students learn to consider specific key instrument types in current usage. This will be delivered in a project study format with each instrument being evaluated in terms of operating principle, design, and signal processing.</p>			
<b>Module contents</b>	Acc. selected course			
<b>Reader's advisory</b>	Acc. selected course			
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>	halbjährlich			
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM-PB (Professionalisierungsbereichsmodul im Master)			
<b>Modulart / typ of module</b>	je nach Studiengang Pflicht oder Wahlpflicht			
<b>Lehr-/Lernform / Teaching/Learning method</b>	Seminar: 2hrs/week; Excercise: 2hrs/week			
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Time of examination		Type of examination	
<b>Final exam of module</b>	Acc. selected course			
Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28

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Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Exercises		2	SoSe oder WiSe	28
Practical training		1	SoSe oder WiSe	14
<b>Total time of attendance for the module</b>				<b>98 h</b>

# Advanced Physics

## phy602 - Advanced Nuclear & Particle Physics

<b>Module label</b>	Advanced Nuclear & Particle Physics	
<b>Module code</b>	phy602	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Advanced Physics</li> </ul>	
<b>Responsible persons</b>	<p>Poppe, Björn (Module responsibility)</p> <p>Poppe, Björn (Authorized examiners)</p> <p>Drolshagen, Gerhard (Authorized examiners)</p> <p>Looe, Hui Khee (Authorized examiners)</p>	
<b>Prerequisites</b>	Basic lectures in physics / engineering	
<b>Skills to be acquired in this module</b>	<p><b>High-Energy Radiation Physics:</b> Basic understanding of the physical basics of high-energy radiation physics (in the energy sector from approx. 106 eV). Students should understand the universal approaches of the physical description of the generation, acceleration, interaction and detection of high-energy radiation across disciplines.</p> <p><b>Space Environment:</b> Basic understanding of the main components of the near-Earth space environment. The students shall become familiar with die different types of radiation and particles in space, their physical characteristics and their effects on hardware and humans in space. The interdisciplinary nature of these topics shall become clear.</p>	
<b>Module contents</b>	<p><b>High-Energy Radiation Physics:</b> Fundamentals of high-energy radiation physics, types of radiation in the environment, cosmos and medicine, cosmic rays, fundamentals of astroparticle physics, terrestrial and cosmic accelerators, interaction of radiation with matter, detection mechanisms and dosimetry, technical realizations for acceleration and detection.</p> <p><b>Space Environment:</b> Overview of radiation and particles in space and their energy ranges. The upper Earth atmosphere, the spectrum of the sun and its variability, plasma, solar- terrestrial interactions, the radiation belts of Earth, cosmic rays, meteoroids and meteors, near-Earth objects, space debris. Effects and potential protection measures.</p>	
<b>Reader's advisory</b>	<p>H. Krieger: Strahlungsmessung und Dosimetrie, Springer Verlag, Wiesbaden, 2013; Grupen: Astroparticle Physics, Springer Verlag, Heidelberg, 2005; Falkenburg, Rhode (Eds.): From Ultra Rays to Astroparticles, Springer Verlag, Heidelberg, 2012</p>	
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	jährlich	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	2 Vorleseungen: 2 SWS + 2 SWS	
<b>Vorkenntnisse / Previous knowledge</b>	Basic lectures in physics / engineering	
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>	written exam Max. 180 min. or oral exam 30 min.	
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

## phy603 - Fluid Dynamics

<b>Module label</b>	Fluid Dynamics	
<b>Module code</b>	phy603	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 84 hrs, Self study: 96 hrs )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Advanced Physics</li> </ul>	
<b>Responsible persons</b>	Peinke, Joachim (Module responsibility)  Lukassen, Laura (Authorized examiners)  Peinke, Joachim (Authorized examiners)	
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>	Fundamental knowledge and comprehension on the movement of fluids	
<b>Module contents</b>	Fluid Dynamics I: Basic equations: Navier-Stokes-equation, Continuity- equation, Bernoulli- equation; Vortex- equation { and Energy balance equations; laminar flows and stability analysis; exact solutions, application of basic equations  Fluid Dynamics II: Reynolds-equation, "closing problem" of turbulence: Turbulence models: Cascade models, Stochastic models	
<b>Reader's advisory</b>	J. Spurk, N. Aksel: Fluid Mechanics, Springer D. J. Tritton: Physical Fluid dynamics. Clarendon Press, Oxford, 2003 G. K. Batchelor: An introduction to fluid dynamics. Cambridge University Press, Cambridge, 2002 U. Frisch: Turbulence: the legacy of A. N. Kolmogorov. Cambridge University Press, Cambridge, 2001 J. Mathieu, J. Scott: An introduction to turbulent flow. Cambridge University Press, Cambridge, 2000 P.A. Davidson: turbulence Oxford 2004	
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Reference text</b>	Unterrichtssprache: English. German on demand, if no international students participate	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Lecture: 2hrs/week; Excercise: 2hrs/week	
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Time of examination	Type of examination
<b>Final exam of module</b>	KL	
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	



## phy607 - Selected Topics in Advanced Physics

<b>Module label</b>	Selected Topics in Advanced Physics	
<b>Module code</b>	phy607	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Overall workload of 180 h )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Advanced Physics</li> </ul>	
<b>Responsible persons</b>	<p>Neu, Walter (Module responsibility)</p> <p>Gülker, Gerd (Authorized examiners)</p> <p>Lienau, Christoph (Authorized examiners)</p> <p>Nilius, Niklas (Authorized examiners)</p>	
<b>Prerequisites</b>	Related to selected course/s	
<b>Skills to be acquired in this module</b>	The aim of this module is, to give students further access to also small courses (3 CP) which address the specific interest of the student and deliver unique in-depth knowledge or the opportunity to train specific physics skills.	
<b>Module contents</b>	Photonics, Optics, Metrology,	
<b>Reader's advisory</b>	Related to selected course/s	
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	Sommer- oder Wintersemester	
<b>Module capacity</b>	unlimited	
<b>Reference text</b>	This module offers special as well as advanced courses in Advanced Physics. The list of eligible courses will be updated each academic year. Please refer to the courses listed for this module in Stud.IP.	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Related to selected course/s	
<b>Vorkenntnisse / Previous knowledge</b>	Related to selected course/s	
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>	Related to selected course/s	
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

## phy633 - Optics

<b>Module label</b>	Optics	
<b>Module code</b>	phy633	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Advanced Physics</li> </ul>	
<b>Responsible persons</b>	Teubner, Ulrich (Module responsibility)  Teubner, Ulrich (Authorized examiners)	
<b>Prerequisites</b>	Electrodynamics	
<b>Skills to be acquired in this module</b>	The students acquire broad theoretical and experimental knowledge of optics together with the necessary physical background. In the laboratory they acquire practical skills during application of their knowledge from lecture. The module prepares the students to work in the field of optical science and engineering in general, and yields the base for all further specialisations within the field of optics and laser technology.	
<b>Module contents</b>	Fundamental and advanced concepts of optics. Topics include: reflection and refraction, optical properties of matter, polarisation, dielectric function and complex index of refraction, evanescent waves, dispersion and absorption of light, Seidel's aberrations, Sellmeier's equations, optical systems, wave optics, Fourier analysis, wave packets, chirp, interference, interferometry, spatial and temporal coherence, diffraction (Huygens, Fraunhofer, Fresnel), focussing and optical resolution, brilliance, Fourier optics, optics at short wavelengths (extreme UV and X-rays)	
<b>Reader's advisory</b>	Born and Wolf: Principles of Optics (Cambridg Press); E. Hecht: Optics (Addison-Wesley); Pedrotti and Pedrotti: Introduction to Optics (Prentice- Hall); Saleh and Teich, Fundamentals of Photonics (Wiley); all those books are also available in German	
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	Wintersemester	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Lecture plus Lab Part: 4 hrs/week	
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>	max 180 min written exam or 30 min oral exam or Lab work with report	max. 2hr written examination or max 1h oral examination or experimental work and laboratory reports or presentation or homework
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

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## phy617 - Fourier Methods

Module label	Fourier Methods
Module code	phy617
Credit points	6.0 KP
Workload	180 h ( Attendance: 56hrs, Self Study: 124 hrs )
Applicability of the module	<ul style="list-style-type: none"><li>Master's Programme Engineering Physics (Master) &gt; Advanced Physics</li></ul>
Responsible persons	Teubner, Ulrich (Module responsibility)  Teubner, Ulrich (Authorized examiners)
Prerequisites	

### Skills to be acquired in this module

#### Physics with ultrashort pulses:

Students will get competences on the special aspects on ultrashort laser pulses which do not play a role in standard optics or laser physics. Starting from basics, the module yields advanced knowledge of the physics of femtosecond light pulses and their interaction with matter, as well as the physics of femtosecond lasers. The students will obtain skills to work with such lasers, in particular, on generation, handling, measurement, application of femtosecond pulses.

#### Fourier methods:

The students acquire deeper knowledge on Fourier mathematics and its applications within physics. They will learn related definitions, properties, theorems. Many examples will be presented. The students should be able to apply Fourier technology for physical and technical problems, in particular with relation of spatial and temporal domain to (spatial) frequency domain. They will get deepened insight on physical procedures by analysis within frequency domain.

### Module contents

The course consists of two parts, both strongly related to Fourier physics:

#### 1) Physics with ultrashort pulses:

Linear and non-linear optics of ultrashort pulses such as: amplitude, phase and spectral phase of the electric field, chirp, phase and group velocity, dispersion, group velocity dispersion, pulse compression, self focusing, self phase modulation, frequency conversion, multi photon effects; femtosecond laser pulse generation and amplification with various schemes, measurement of ultrashort pulses; applications

#### 2) Fourier methods:

Motivation: Application of Fourier transformation within physics. Examples of Fourier pairs; properties of Fourier transformation; symmetries; important theorems; displacement, differentiation, convolution, uncertainty relation; examples to convolution theorem, frequency comb, Hilbert transformation, auto correlation function methods of time/frequency analysis, Wigner distribution; Fourier transformation in higher dimensions: tomography; discrete Fourier transformation, sampling theorem; applications

### Reader's advisory

Physics with ultrashort pulses:

C. Rullière: Femtosecond Laser Pulses. Springer, Berlin, 2004

J.-C. Diels, W. Rudolph: Ultrashort Laser Pulse Phenomena. Academic Press, Amsterdam, 2006

K. Jesse: Femtosekundenlaser. Springer, Berlin, 2005

A.M. Weiner: Ultrafast Optics, Wiley

Fouriertechniken in der Physik:

R. Bracewell: "The Fourier Transform and its Applications", McGraw-Hill, 3. Auflage (1999)

T. Butz: "Fouriertransformation für Fußgänger", Vieweg+Teubner, 7. Auflage (2011)

D. W. Kammler: "A First Course in Fourier Analysis", Cambridge University Press (2008)

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M. Wollenhaupt, A. Assion and T. Baumert: "SpringerHandbook of Lasers and Optics", Springer, Chapter 12, 2.Auflage (2012)

L. Cohen: "Time Frequency Analysis", Prentice Hall(1995)

Weitere spezielle Literatur wird in der Vorlesung bekannt gegeben.

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**Links**

<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	jährlich	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	lecture: 4 SWS	
<b>Vorkenntnisse / Previous knowledge</b>	Basics of Optics and Laser Physics	
Examination	Time of examination	Type of examination
<b>Final exam of module</b>	2 * 3 hours written or 2 * 30 minutes oral exams	
<b>Course type</b>	Lecture	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	28 h	

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## phy950 - Audiologie und Akustik

<b>Module label</b>	Audiologie und Akustik	
<b>Module code</b>	phy950	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Advanced Physics</li> </ul>	
<b>Responsible persons</b>	van de Par, Steven (Module responsibility)  Kollmeier, Birger (Module responsibility)	
<b>Prerequisites</b>	Einführendes Akustik Modul	
<b>Skills to be acquired in this module</b>	Die Studierenden erwerben theoretische Grundlagen und fortgeschrittene Methoden der Psychophysik, Audiologie und Akustik. Sie erlangen Fertigkeiten zum sicheren und selbstständigen Umgang mit modernen Konzepten und Methoden der Angewandten Physik.	
<b>Module contents</b>	<p><i>Psychophysik und Audiologie</i></p> <p>- Physiologie: Überblick über Hörsystem, Außenohr, Virtuelle Akustik, Mittelohr, Stapediusreflex, Innenohrfunktion, Cochleamodelle, Makro und Mikromechanik der Cochlea., Otoakustische Emissionen (Theorie), Innere Haarzellen, Auditorischer Nerv, Hirnstamm, Tonotopie, binaurale Verschaltung, Periodizitätentuning, Cortex (A1), Evozierte Felder (MEG) und Potentiale (EEG).</p> <p>- Audiologie: Audiogramm, BERA, Schalleitungs- und Schallempfindungsstörungen, Tinnitus, Otoakustische Emissionen (Diagnostisch), Stapediusreflex-audiometrie, Impedanzaudiometrie</p> <p>- Psychophysik: Wahrnehmungsgrößen, JNDs, Weber-Fechnersches Gesetz, Schwellen, Signaldetektion, dprime/ROC, Lautheit, Tonhöhe, Stevenssches Gesetz, Zeitliche und spektrale Maskierung, Modulationswahrnehmung, auditorische Szenenanalyse, effektive Signalverarbeitungs-Modelle</p> <p><i>Akustik</i></p> <p>Schwingungen und Wellen, physikalische Grundlagen der Akustik, Erzeugung und Ausbreitung von Schall, Messung und Bewertung von Schall, Verarbeitung und Analyse akustischer Signale, Akustik von Stimme und Sprache, Sprachpathologie, Schalldämmung und -dämpfung, Raum- und Bauakustik, Elektroakustik, Musikalische Akustik, Stoßwellen, ausgesuchte Kapitel der Akustik, der Vibrationen und des Ultraschalls.</p>	
<b>Reader's advisory</b>	B. Kollmeier: Skriptum Physikalische, technische und medizinische Akustik, Universität Oldenburg;  H. Kuttruff, Akustik: Eine Einführung, 2004;  P. Damaske, Acoustics and Hearing, Springer, 2008;  M. Heckl, G. Müller: Taschenbuch der technischen Akustik, Springer-Verlag, 2012	
<b>Links</b>		
<b>Language of instruction</b>	German	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	jährlich	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Vorlesung: 3 SWS, Übung: 1 SWS	
<b>Vorkenntnisse / Previous knowledge</b>	Einführendes Akustik Modul	
<b>Examination</b>	Time of examination	Type of examination

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Examination	Time of examination	Type of examination
<b>Final exam of module</b>		one or two examination, totaling to 180 min. written exam or 30 min. oral exam
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

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# Schwerpunkt: Biomedical Physics

## bio279 - Basic Concepts in Animal Physiology

<b>Module label</b>	Basic Concepts in Animal Physiology	
<b>Module code</b>	bio279	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master of Education Programme (Special Needs Education) Biology (Master of Education) &gt; Mastermodule</li> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Biomedical Physics</li> </ul>	
<b>Responsible persons</b>	<p>Heyers, Dominik (Module responsibility)</p> <p>Köppl, Christine (Module counselling)</p> <p>Dedek, Karin (Module counselling)</p> <p>Heyers, Dominik (Authorized examiners)</p> <p>Köppl, Christine (Authorized examiners)</p> <p>Dedek, Karin (Authorized examiners)</p>	
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>	<p>++ biological knowledge          ++ knowledge of biological working methods          + biologically relevant knowledge in the natural sciences and mathematics          + statistics &amp; scientific programming          ++ abstract, logical, analytical thinking          + deepened expertise in biological specialist field          ++ independent learning and (research-based) working          + teamwork</p> <p>Basic knowledge on physiological processes and their underlying mechanisms with a focus on human physiology. Performing, analysing and documenting physiological experiments.</p>	
<b>Module contents</b>	<p>The lecture (Vorlesung: 5.02.271 - Physiologie der Tiere und des Menschen) covers topics such as cell physiology, sensory physiology, neurophysiology, functions of the vegetative system, blood physiology/immune response, blood cycle, respiration and digestion. Emphasis will be on human physiology. In the following lab exercises, students get the opportunity to perform physiological experiments linking to topics from the lecture. By performing experiments on themselves and computer simulations students will gain insight into the underlying physiological principles.</p>	
<b>Reader's advisory</b>	<p>Klinke, Pape, Kurtz, Silbernagl: Physiologie, Aufl. 6, 2010          Schmidt, Lang, Heckmann: Physiologie des Menschen mit Pathophysiologie, Aufl. 31, 2011          (if available: Wehner, Gehring: Zoologie)</p>	
<b>Links</b>		
<b>Language of instruction</b>	German	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	jährlich	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>		
<b>Modulart / typ of module</b>	je nach Studiengang Pflicht oder Wahlpflicht	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Time of examination	Type of examination
<b>Final exam of module</b>	within a few weeks after the winter term lecture period	written exam (100%)
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>		

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**Workload attendance**

56 h

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## phy614 - Personalized Medicine

<b>Module label</b>	Personalized Medicine	
<b>Module code</b>	phy614	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( attendance: 56 hrs, self study: 124 hrs )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Biomedical Physics</li> </ul>	
<b>Responsible persons</b>	Schmidt, Thorsten (Module responsibility)  Schmidt, Thorsten (Authorized examiners)	
<b>Prerequisites</b>	Statistics, Computing	
<b>Skills to be acquired in this module</b>	Students should understand current high-throughput methods used in research and clinics. They should be aware of the advantages and challenges and should be able to judge and interpret the results. In addition, the students should accomplish a sound understanding of basic algorithms which are used to analyze big and complex data sets. They should be able to choose, use and interpret appropriate tools and methods. Finally, students should be able to address the limitations and prospects of big-data analyses in complex systems.	
<b>Module contents</b>	The lecture aims to provide an overview about current experimental high-throughput methods and bioinformatic algorithms to address the challenges of exponentially growing amounts of data. In addition to basic algorithms and methods like alignments, hidden markov models, Viterbi, graphs or protein-protein interaction networks, the lecture aims to give an introduction to a data-driven view of disease biology	
<b>Reader's advisory</b>	<p>Genomic and Personalized Medicine:</p> <p>V1-2 Huntington F. Willard, Geoffrey S. Ginsburg; Academic Press; 2. Edition. (30. Oktober 2012);</p> <p>Cancer Genomics:</p> <p>From Bench to Personalized Medicine; Graham Dellaire, Jason Berman; Academic Press; 1. Edition (17. January 2014);</p> <p>Systems Biology:</p> <p>A Textbook; Eda Klipp et al (2009); Wiley-VCH Verlag GmbH, Co. KGaA; Auflage: 1. Edition;</p>	
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	jährlich	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	EB (Ergänzungsbereich / Complementary)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Lecture: 4 hrs/week	
<b>Vorkenntnisse / Previous knowledge</b>	Statistics, Computing	
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>	KL	
<b>Course type</b>	Lecture	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	28 h	

## phy678 - Processing and analysis of biomedical data

<b>Module label</b>	Processing and analysis of biomedical data	
<b>Module code</b>	phy678	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Biomedical Physics</li> </ul>	
<b>Responsible persons</b>	<p>Poppe, Björn (Module responsibility)</p> <p>Brand, Thomas (Authorized examiners)</p> <p>Ewert, Stephan (Authorized examiners)</p> <p>Hohmann, Volker (Authorized examiners)</p> <p>Uppenkamp, Stefan (Authorized examiners)</p>	
<b>Prerequisites</b>	Basic signal processing, algebra knowledge	
<b>Skills to be acquired in this module</b>	This course introduces basic concepts of statistics and signal processing and applies them to real-world examples of bio-medical data. In the second part of the course, recorded datasets are noise-reduced, analyzed, and discussed in views of which statistical tests and analysis methods are appropriate for the underlying data. The course forms a bridge between theory and application and offers the students the means and tools to set up and analyze their future datasets in a meaningful manner.	
<b>Module contents</b>	Normal distributions and significance testing, Monte- Carlo bootstrap techniques, Linear regression, Correlation, Signal-to-noise estimation, Principal component analysis, Confidence intervals, Dipole source analysis, Analysis of variance Each technique is explained, tested and discussed in the exercises.	
<b>Reader's advisory</b>	Kirkwood B.R. and Sterne A.C., Essential Medical Statistics: 2nd edition. Blackwell Science, Oxford, 2003; Cho, Z.H. and Singh J. P. J.M.: Foundations of Medical Imaging. John Wiley, New York, 1993; Kutz, J.N. Data-Driven Modeling and Scientific Computation: Methods for complex systems and Big Data. Oxford University Press, Oxford, 2013	
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	Wintersemester	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Lecture: 2hrs/week; Exersise: 2hrs/week	
<b>Vorkenntnisse / Previous knowledge</b>	Basic signal processing, algebra knowledge	
Examination	Time of examination	Type of examination
<b>Final exam of module</b>	Exam or presentation or oral exam or homework or practical report	
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

## phy685 - Advanced Engineering Topics in Biomedical Physics & Acoustics

<b>Module label</b>	Advanced Engineering Topics in Biomedical Physics & Acoustics	
<b>Module code</b>	phy685	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Overall workload of 180 h )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Biomedical Physics</li> </ul>	
<b>Responsible persons</b>	<p>Doclo, Simon (Module responsibility)</p> <p>Poppe, Björn (Module responsibility)</p> <p>Anemüller, Jörn (Authorized examiners)</p> <p>Blau, Matthias (Authorized examiners)</p> <p>Brand, Thomas (Authorized examiners)</p> <p>Dietz, Mathias (Authorized examiners)</p> <p>Doclo, Simon (Authorized examiners)</p> <p>Ewert, Stephan (Authorized examiners)</p> <p>Hohmann, Volker (Authorized examiners)</p> <p>Kollmeier, Birger (Authorized examiners)</p> <p>Lücke, Jörg (Authorized examiners)</p> <p>Meyer, Bernd (Authorized examiners)</p> <p>Oetjen, Arne (Authorized examiners)</p> <p>Poppe, Björn (Authorized examiners)</p> <p>Siedenburg, Kai (Authorized examiners)</p> <p>Uppenkamp, Stefan (Authorized examiners)</p> <p>van de Par, Steven (Authorized examiners)</p>	
<b>Prerequisites</b>	Related to selected course/s	
<b>Skills to be acquired in this module</b>	The aim of this module is, to give students further access to also small courses (3 CP) which address the specific interest of the student and deliver unique in-depth knowledge or the opportunity to train specific engineering skills.	
<b>Module contents</b>	Photonics, Optics, Metrology,	
<b>Reader's advisory</b>	Related to selected course/s	
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	Sommer- oder Wintersemester	
<b>Module capacity</b>	unlimited	
<b>Reference text</b>	This module offers special as well as advanced engineering courses in Biomedical Physics and Acoustics. The list of eligible courses will be updated each academic year. Please refer to the courses listed for this module in Stud.IP.	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Related to selected course/s	
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Time of examination	Type of examination

Examination		Time of examination	Type of examination	
<b>Final exam of module</b>			Related to selected course/s	
Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		4	SoSe oder WiSe	56
Seminar		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
Practical training		1	SoSe oder WiSe	14
<b>Total time of attendance for the module</b>				126 h

## phy686 - Advanced Topics in Biomedical Physics & Acoustics

<b>Module label</b>	Advanced Topics in Biomedical Physics & Acoustics			
<b>Module code</b>	phy686			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Overall workload of 180 h )			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Biomedical Physics</li> </ul>			
<b>Responsible persons</b>	<p>Anemüller, Jörn (Authorized examiners)</p> <p>Blau, Matthias (Authorized examiners)</p> <p>Brand, Thomas (Authorized examiners)</p> <p>Dietz, Mathias (Authorized examiners)</p> <p>Doclo, Simon (Authorized examiners)</p> <p>Ewert, Stephan (Authorized examiners)</p> <p>Hohmann, Volker (Authorized examiners)</p> <p>Kollmeier, Birger (Authorized examiners)</p> <p>Lücke, Jörg (Authorized examiners)</p> <p>Meyer, Bernd (Authorized examiners)</p> <p>Oetjen, Arne (Authorized examiners)</p> <p>Poppe, Björn (Authorized examiners)</p> <p>Siedenburg, Kai (Authorized examiners)</p> <p>Uppenkamp, Stefan (Authorized examiners)</p> <p>van de Par, Steven (Authorized examiners)</p> <p>Doclo, Simon (Module responsibility)</p> <p>Poppe, Björn (Module responsibility)</p>			
<b>Prerequisites</b>	Related to selected course/s			
<b>Skills to be acquired in this module</b>	The aim of this module is, to give students further access to also small courses (3 CP) which address the specific interest of the student and deliver unique in-depth knowledge or the opportunity to train specific engineering skills.			
<b>Module contents</b>	Photonics, Optics, Metrology,			
<b>Reader's advisory</b>	Related to selected course/s			
<b>Links</b>				
<b>Language of instruction</b>	English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>	Sommer- oder Wintersemester			
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>	Related to selected course/s			
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Time of examination	Type of examination		
<b>Final exam of module</b>	Related to selected course/s			
Course type	Comment	SWS	Frequency	Workload of compulsory attendance

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Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		4	SoSe oder WiSe	56
Seminar			SoSe oder WiSe	0
<b>Total time of attendance for the module</b>				<b>56 h</b>

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## phy698 - Selected Topics on Medical Radiation Physics

<b>Module label</b>	Selected Topics on Medical Radiation Physics
<b>Module code</b>	phy698
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )
<b>Applicability of the module</b>	<ul style="list-style-type: none"><li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Biomedical Physics</li></ul>
<b>Responsible persons</b>	Looe, Hui Khee (Authorized examiners)  Poppe, Björn (Authorized examiners)  Ruehmann, Antje (Authorized examiners)  Poppe, Björn (Module responsibility)
<b>Prerequisites</b>	
<b>Skills to be acquired in this module</b>	<p>5.04.4242:</p> <p>Neben den aktuellen Themen der Strahlenphysik erlernen die Studierenden den Umgang mit meist englischsprachigen Fachzeitschriften aus dem Bereich. Darüber hinaus werden Präsentationstechniken durch eigene Vorträge erlernt. Parallel zu der Veranstaltung wird die Verwendung eines Monte-Carlo Strahlungstransport-Codes (EGS) erlernt und somit die Fähigkeit vertieft, komplexe physikalische Modelle in eine Software umzusetzen.</p> <p>5.04.4642:</p> <p>Der Kurs vermittelt die Fähigkeit zum Verständnis grundlegender Anwendungen der Strahlenphysik in der Medizin. Die Studierenden erweitern somit ihre Kompetenzen im Hinblick auf die Bewertung fächerübergreifender Zusammenarbeit unterschiedlicher Disziplinen. Sie erlernen zudem den selbständigen Umgang mit fremdsprachlicher Literatur.</p>
<b>Module contents</b>	<p>5.04.4242:</p> <p>Aktuelle Themen aus der Medizinischen Strahlenphysik wie: IMRT, NMR, PET, SPECT usw.;</p> <p>5.04.4642:</p> <p>Grundlagen der Strahlentherapie, Dosimetrie, Einführung in die Strahlentherapie, Wechselwirkung von Strahlung mit Materie, Elektronen, Photonen und Teilchenstrahlung,  mathematische Beschreibung von Dosisverteilungen in Absorbern, Detektoren und dosimetrische Protokolle, Grundlagen der Bestrahlungsplanung sowie Brachytherapie.</p>
<b>Reader's advisory</b>	<p>5.04.4242:</p> <p>Aktuelle Themen aus der Medizinischen Strahlenphysik wie: IMRT, NMR, PET, SPECT usw.;</p> <p>5.04.4642:</p> <p>Grundlagen der Strahlentherapie, Dosimetrie, Einführung in die Strahlentherapie, Wechselwirkung von Strahlung mit Materie, Elektronen, Photonen und Teilchenstrahlung, mathematische Beschreibung von Dosisverteilungen in Absorbern, Detektoren und dosimetrische Protokolle, Grundlagen der Bestrahlungsplanung sowie Brachytherapie.</p>

<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	jährlich	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Vorlesung: 4 SWS, Übung: 2 SWS	
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Time of examination	Type of examination
<b>Final exam of module</b>	KL	
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	



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## phy959 - Medizinische Strahlenphysik II

<b>Module label</b>	Medizinische Strahlenphysik II	
<b>Module code</b>	phy959	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h	
<b>Applicability of the module</b>	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Biomedical Physics	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	28 h	

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## phy955 - Medizinische Strahlenphysik I

<b>Module label</b>	Medizinische Strahlenphysik I	
<b>Module code</b>	phy955	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h	
<b>Applicability of the module</b>	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Biomedical Physics	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

## phy964 - Advanced Computing

<b>Module label</b>	Advanced Computing			
<b>Module code</b>	phy964			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Biomedical Physics</li> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		4	SoSe oder WiSe	56
Exercises		4	SoSe oder WiSe	56
<b>Total time of attendance for the module</b>				112 h

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## phy954 - Imaging and Data Analysis

<b>Module label</b>	Imaging and Data Analysis	
<b>Module code</b>	phy954	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h	
<b>Applicability of the module</b>	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Biomedical Physics	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	28 h	

# Schwerpunkt: Laser and Optics

## phy608 - Biomedical Optics

<b>Module label</b>	Biomedical Optics			
<b>Module code</b>	phy608			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( 180 h (Präsenzzeit 56h, Selbststudium: 124h) )			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>			
<b>Responsible persons</b>	Neu, Walter (Authorized examiners)			
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>	Vermittlung fortgeschrittener Kenntnisse im Bereich der medizinischen Optik und optischer Technologien in der Medizin sowie deren theoretischem Hintergrund und der experimentellen Methoden. Die Studierenden werden wissenschaftlich kompetent positioniert, um aktuelle Entwicklungen kritisch zu verfolgen und die Gestaltung (Entwicklung und Design) innovativer optischer Applikationen in der Medizin zu initiieren.			
<b>Module contents</b>	Physiologie und Psychophysik des Sehens, Theorie von Abbildungssystemen, Ophthalmologische Optik, Lichttechnik, Photometrie, Sehen am Arbeitsplatz und im Verkehr, optische Messungen am Patienten, diagnostische und therapeutische Laseranwendungen, Strahlenschutz (Infrarot, UV, Laser), Mikroskopie, Beugungs- und subbeugungsbegrenzte Verfahren, optische Spektroskopie, Fluoreszenzverfahren			
<b>Reader's advisory</b>	<p>Bille, J., Schlegel, W.: Medizinische Physik 3. Medizinische Laserphysik. Springer, Berlin, 2005. ISBN: 3540266305</p> <p>Faller, A., Schünke, M.: Der Körper des Menschen. Thieme Verlag, 2004.</p> <p>Glaser, R.: Biophysics. Springer-Verlag, 2001 Dössel, O.: Bildgebende Verfahren in der Medizin. Springer-Verlag, 2000.</p> <p>Hoppe, W., Lohmann, W., Markl, H., Ziegler, H. (Hrsg.): Biophysik. Springer-Verlag 1982</p> <p>J. Kiefer: Biological Radiation Effects, Springer Verlag 1990</p>			
<b>Links</b>				
<b>Language of instruction</b>	English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>	jährlich			
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>	Vorlesung: 4 SWS			
<b>Vorkenntnisse / Previous knowledge</b>	Medizin für Naturwissenschaftler, Optik, Laserphysik			
<b>Examination</b>	Time of examination	Type of examination		
<b>Final exam of module</b>		KL		
Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				56 h

## phy632 - Spectrophysics

<b>Module label</b>	Spectrophysics	
<b>Module code</b>	phy632	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( 180 h (Präsenzzeit 56h, Selbststudium: 124h) )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>	
<b>Responsible persons</b>	<p>Koch, Sandra (Authorized examiners)</p> <p>Neu, Walter (Authorized examiners)</p> <p>Schellenberg, Markus (Authorized examiners)</p>	
<b>Prerequisites</b>	Atomic and Molecular Physics, Optical systems	
<b>Skills to be acquired in this module</b>	Students gain in depth theoretical as experimental knowledge on advanced optical spectroscopy applied to atomic and molecular systems. They are qualified in setting up innovative methods and measurement devices based on their expert competence in up-to-date research and development areas. The module prepares the students to work in the field of optical science and engineering in general, and yields the base for all further specialisations within the field of optics and laser technology	
<b>Module contents</b>	Atomic structure and atomic spectra, molecular structure and molecular spectra, emission and absorption, width and shape of spectral lines, radiative transfer and transition probabilities, elementary plasma spectroscopy, experimental tools in spectroscopy, dispersive and interferometric spectrometers, light sources and detectors, laser spectroscopy, nonlinear spectroscopy, molecular spectroscopy, time resolved spectroscopy, coherent spectroscopy	
<b>Reader's advisory</b>	<p>A. Thorne, U. Litzen, S. Johansson: Spectrophysics. Principles and Applications. Springer, 1999. ISBN 978-3540651178;</p> <p>J.M. Hollas, M.J. Hollas: Modern Spectroscopy. Wiley, 2003. ISBN 978 0470844168;</p> <p>S. Svanberg: Atomic and molecular spectroscopy. Basic aspects and practical applications. Springer, 2001.;</p> <p>W. Demtröder, Laser Spectroscopy Vol. 1 and 2, Springer, 5th ed. 2014 and 4th ed., 2008;</p> <p>Saleh and Teich, Fundamentals of Photonics (Wiley); Recent publications on specific topic</p>	
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	jährlich	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Vorlesung: 3 SWS, Labor: 1 SWS	
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

## phy634 - Biophotonics and Spectroscopy

<b>Module label</b>	Biophotonics and Spectroscopy			
<b>Module code</b>	phy634			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>			
<b>Responsible persons</b>	<p>Koch, Sandra (Authorized examiners)</p> <p>Neu, Walter (Authorized examiners)</p> <p>Schellenberg, Markus (Authorized examiners)</p>			
<b>Prerequisites</b>	Basics in optics and laser physics, in particular, fundamentals of optics and photonics; atomic and molecular physics; spectrophysics			
<b>Skills to be acquired in this module</b>	The students thoroughly deepen their knowledge on concepts of spectroscopy as well as on biophotonics. This module provides the theoretical background for analytical applications involving UV-Visible spectroscopy, atomic absorption, emission and laser based spectroscopies. The students develop a sound understanding of the principles and instrumentation of atomic and molecular spectroscopy with in depth applications to a wide range of environments e.g. analytical, biological, industrial, pharmaceutical, environmental. The students develop problem solving skills with reasoning based on theory underlying spectroscopy and photonics in biosciences and medicine thus providing a background to practical laboratory training.			
<b>Module contents</b>	Application of atomic and molecular spectroscopy at a wide range of fields, e.g. industrial, biosciences, microscopy, pharmaceutical, environmental, trace analysis: 1. Explain the mechanisms of and fundamental distinctions between molecular and atomic spectroscopy 2. Recognise the issues regarding sensitivity and selectivity of molecular and atomic spectroscopy 3. Evaluate the limitations and analytical issues associated with each method 3. Demonstrate analytical application of these atomic and molecular absorption and emission techniques 4. Discriminate the analytical challenges that can be appropriately solved by these spectroscopic techniques			
<b>Reader's advisory</b>	R. Noll: Laser-Induced Breakdown Spectroscopy. Fundamentals and Applications. Springer, Berlin, 2012. ISBN: 978-3-642-20667-2; S. Musazzi, U. Perini (Eds.): Laser-Induced Breakdown Spectroscopy. Theory and Applications. Springer Series in Optical Sciences, Berlin, 2014. ISBN: 978-3-642-45084-6; Braun, M., Gilch, P., Zinth, W.: Ultrashort Laser Pulses in Biology and Medicine. Springer Berlin; 2007. ISBN-13: 978-3540735656; S. Svanberg: Atomic and molecular spectroscopy. Basic aspects and practical applications. Springer, 2004.; W. Demtröder, Laser Spectroscopy Vol. 1 and 2, Springer, 5nd ed. 2014 and 4th ed., 2008; B. Di Bartolo, John Collins (Eds.): Biophotonics: Spectroscopy, Imaging, Sensing, and Manipulation. Springer Netherlands, 2011. ISBN: 978-90-481-9976-1; W. Fritzsche, J. Popp (Eds.): Optical Nano- and Microsystems for Bioanalytics. Springer Series on Chemical Sensors and Biosensors, Berlin, 2012. ISBN: 978-3-642-25497-0; Recent publications on specific topics			
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>	Sommer- oder Wintersemester			
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>	Lecture: 2 hrs/week, Seminar: 2hrs/week			
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				56 h

## phy637 - Laser Design and Beam Guiding

<b>Module label</b>	Laser Design and Beam Guiding	
<b>Module code</b>	phy637	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>	
<b>Responsible persons</b>	Struve, Bert (Authorized examiners)  Neu, Walter (Module responsibility)	
<b>Prerequisites</b>	basic knowledge on optics and laser physics	
<b>Skills to be acquired in this module</b>	Students acquire advanced knowledge for the design of lasers and laser systems, they also understand the propagation of laser beams and their forming.	
<b>Module contents</b>	design of different laser types; physics of active and passive laser components; beams and resonators; lab work	
<b>Reader's advisory</b>	G. Reider, Photonics, 2016, Springer Verlag, Berlin; W. Koechner, Solid-State Laser Engineering, 6th. rev. 2006, Springer Verlag, Berlin; B. Struve, Einführung in die Lasertechnik, 2009, VDEVerlag, Berlin; Additional literature given in the lecture	
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	Sommersemester	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Lecture: 4 hrs/week , practical applications included in lecture	
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	



## phy638 - Laser material processing

<b>Module label</b>	Laser material processing	
<b>Module code</b>	phy638	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( 180 h (Präsenzzeit 56h, Selbststudium: 124h) )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>	
<b>Responsible persons</b>	<p>Schüning, Thomas (Authorized examiners)</p> <p>Neu, Walter (Module responsibility)</p>	
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>	Fundamental knowledge of the characteristics of the laser beam, Knowledge of laser sources for industrial applications, knowledge of procedures of the material processing with laser beams Knowledge of the physical-technical procedures of the individual manufacturing processes with laser beams; Ability for the estimation of favorable working parameters; The participants should be able to understand the procedures of the material processing with laser beams and evaluate the tasks of manufacturing.	
<b>Module contents</b>	Overview of the interactions between laser beams and materials in laser material processing. Allocation of the processes in relation to production technology with the laser beam as a tool. Intensive treatment of the manufacturing processes with laser beams in terms of quality, speed and costs. The processes of cutting, joining, surface treatment and generative manufacturing are dealt with intensively using examples from industrial production. Within the framework of lecture-accompanied project work, the application technologies are processed, optimized and evaluated by the students in the laser laboratory.	
<b>Reader's advisory</b>	<p>Script</p> <p>William M. Steen: Laser Material Processing, Springer, 2010</p> <p>J. Down, W. Schulz: The Theory of Laser Materials Processing, Springer, 2017</p>	
<b>Links</b>		
<b>Languages of instruction</b>		
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	jährlich	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Vorlesung: 4 SWS	
<b>Vorkenntnisse / Previous knowledge</b>	Knowledge in physics, optics, production engineering	
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

## phy682 - Advanced Engineering Topics in Laser and Optics

<b>Module label</b>	Advanced Engineering Topics in Laser and Optics			
<b>Module code</b>	phy682			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Overall workload of 180 h )			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>			
<b>Responsible persons</b>	Brückner, Hans Josef (Authorized examiners)  Neu, Walter (Authorized examiners)  Teubner, Ulrich (Authorized examiners)  Neu, Walter (Module responsibility)			
<b>Prerequisites</b>	Related to selected course/s			
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>	Related to selected course/s			
<b>Reader's advisory</b>	Related to selected course/s			
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>	Sommer- oder Wintersemester			
<b>Module capacity</b>	unlimited			
<b>Reference text</b>	This module offers special as well as advanced engineering courses in Laser and Optics. The list of eligible courses will be updated each academic year. Please refer to the courses listed for this module in Stud.IP.			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>	Related to selected course/s			
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		4	SoSe oder WiSe	56
Seminar		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
Practical training		1	SoSe oder WiSe	14
<b>Total time of attendance for the module</b>				126 h

## phy683 - Advanced Topics in Laser and Optics

<b>Module label</b>	Advanced Topics in Laser and Optics	
<b>Module code</b>	phy683	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( 180 h )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>	
<b>Responsible persons</b>	Neu, Walter (Module responsibility)  Lienau, Christoph (Authorized examiners)  Neu, Walter (Authorized examiners)	
<b>Prerequisites</b>	Related to selected course/s	
<b>Skills to be acquired in this module</b>	The aim of this module is, to give students further access to also small courses (3 CP) which address the specific interest of the student and deliver unique in-depth knowledge or the opportunity to train specific engineering skills.	
<b>Module contents</b>	Photonics, Optics, Metrology	
<b>Reader's advisory</b>	   Related to selected course/s	
<b>Links</b>		
<b>Languages of instruction</b>	English , German	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	Sommer- oder Wintersemester	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Related to selected course/s	
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

## phy965 - Engineering Scientific Instrumentation

<b>Module label</b>	Engineering Scientific Instrumentation			
<b>Module code</b>	phy965			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>

## phy966 - Intense Light Physics

<b>Module label</b>	Intense Light Physics	
<b>Module code</b>	phy966	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( 180 h (Präsenzzeit 56h, Selbststudium: 124h) )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>	
<b>Responsible persons</b>	Teubner, Ulrich (Module responsibility)	
<b>Prerequisites</b>	Basics in optics and laser physics, in particular, Fundamentals of Optics and Photonics; Atomic Physics, Electrodynamics	
<b>Skills to be acquired in this module</b>	The students acquire broad experimental knowledge of the application of intense light from femtosecond and high power laser systems. They should be acquainted with the interaction of intense light with matter in general and with respect to important scientific and technical applications (in industry) such as laser material processing, high field physics (i.e. laser matter interaction at high intensity), laser generated particle and radiation sources of ultrashort duration and/or ultrashort wavelength etc	
<b>Module contents</b>	Femtosecond and high power laser systems and its application, absorption of intense laser light, basics of laser matter interaction at high intensity, diagnostics, applications in micro machining, laser generated ultrashort radiation such as high-order laser harmonics and femtosecond K-a-sources and keV and MeV electron and ion sources and their application to micro fabrication micro and nano analysis.; atto physics, strong field physics	
<b>Reader's advisory</b>	E.Gamaly; Femtosecond Laser-Matter Interactions(Pan Stanford); P.Gibbon: Short pulse laser interactions with matter (Imperial College Press); D.Bäuerle: Laser Processing and Chemistry (Springer); Further literature according indication during course	
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	jährlich	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Vorlesung und Labor: 4 SWS	
<b>Vorkenntnisse / Previous knowledge</b>	Basics in optics and laser physics, in particular, Fundamentals of Optics and Photonics; Atomic Physics, Electrodynamics	
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>	experimental work and laboratory reports or max. 2hr written examination or max 1h oral	
<b>Course type</b>	Lecture	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	28 h	

## phy600 - Photonics

<b>Module label</b>	Photonics	
<b>Module code</b>	phy600	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>	
<b>Responsible persons</b>	Brückner, Hans Josef (Authorized examiners)  Struve, Bert (Authorized examiners)	
<b>Prerequisites</b>	Basic knowledge on optics, electrodynamics and atomic physics	
<b>Skills to be acquired in this module</b>	Starting from basics, the module yields advanced knowledge of the physics of lasers, of interaction of optical radiation with matter, optoelectronic principles and components as, e.g. laser beams, different laser types, light emitters, detectors, modulators. The students acquire skills in working with lasers and optoelectronic components.	
<b>Module contents</b>	Fundamentals of lasers (optical gain, optical resonator, laser beams), laser types, laser safety; electronic bandstructures in matter, semiconductor junctions, radiation laws, light emitting diodes, photodetectors, solar cells	
<b>Reader's advisory</b>	C. Breck Hitz, J. J. Ewing, J. Hecht, Introduction to Laser Technology, 2012, Wiley Press; G. Reider, Photonics, 2016, Springer Verlag; B. Struve, Einführung in die Lasertechnik, 2009, VDE Verlag; Saleh, Teich: Fundamentals of Photonics, John Wiley and Sons; Ebeling: Integrierte Optoelektronik, Springer Verlag; Original literature according indication during course	
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	jährlich	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Lecture: 4 hrs/week , practical applications included in lecture	
<b>Vorkenntnisse / Previous knowledge</b>	Basic knowledge on optics, electrodynamics and atomic physics	
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>	2 hr written examination or 30 min oral examination or experimental work or homework or presentation	
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

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# Schwerpunkt: Renewable Energies

## inf511 - Smart Grid Management

<b>Module label</b>	Smart Grid Management
<b>Module code</b>	inf511
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h
<b>Applicability of the module</b>	<ul style="list-style-type: none"><li>• Master's Programme Business Informatics (Master) &gt; Akzentsetzungsmodule der Informatik</li><li>• Master's Programme Computing Science (Master) &gt; Angewandte Informatik</li><li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li><li>• Master's Programme Environmental Modelling (Master) &gt; Mastermodule</li><li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li></ul>
<b>Responsible persons</b>	Lehnhoff, Sebastian (Module responsibility)  Lehrenden, Die im Modul (Authorized examiners)
<b>Prerequisites</b>	
<b>Skills to be acquired in this module</b>	<p>After successful completion of the course the students should be able to understand the existing structures and technical basis of energy systems to produce, transfer and distribute electricity and their interaction and dependency on each other. They should have developed an understanding for necessary IT- and process control technology components, methods and processes to control and operate electrical energy systems. The students are able to estimate and evaluate the requirements and challenges of ICT and computer science which are caused by the development and integration of unforeseeable fluctuations of decentralised plants. The students will be able to estimate the influence of distributed control concepts and algorithms for decentralised plants and consumers in the so called Smart Grid energy systems. Regarding the requirements the students will be able to analyse the safety, reliability, realtime capability and flexibility of Smart Grid energy systems.</p> <p><b>Professional competence</b> The students:</p> <ul style="list-style-type: none"><li>• understand the existing structures and the technical basis of energy systems producing, transferring and distributing electricity and their interaction and dependency on each other.</li><li>• develop an understanding for necessary IT- and process control technology components, methods and processes to control and operate electrical energy systems.</li><li>• estimate and evaluate the requirements and challenges of ICT and computer science which are caused by the development and integration of unforeseeable fluctuations of decentralised plants.</li><li>• estimate the influence of distributed control concepts and algorithms for decentralised plants and consumers in the so called Smart Grid energy systems.</li></ul> <p><b>Methodological competence</b> The students:</p> <ul style="list-style-type: none"><li>• analyse the safety, reliability, realtime capability and flexibility of Smart Grid energy systems</li><li>• use advanced mathematical methods to calculate networks</li></ul> <p><b>Social competence</b> The students:</p> <ul style="list-style-type: none"><li>• create solutions in small teams</li><li>• discuss their solutions</li></ul> <p><b>Self-competence</b> The students:</p> <ul style="list-style-type: none"><li>• reflect their own use of electricity as a limited resource</li></ul>

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<b>Module contents</b>	<p>Content of the Module: In this course information technology, economical energy industry and technical basic knowledge and methods are analysed by using concrete Smart Grid approaches. The basic calculation methods for an intelligent grid management are introduced.</p> <p>This module deals with the technical and economical framework for a permissible electrical network as well as mathematical modelling and calculation methods to analyse conditions of electrical energy networks (in stationary conditions).</p>
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These are:

- The organisation of the EU energy market (regulatory framework, responsibility in liberalisation of electrical energy systems)
- Establishment and operation of electrical energy supply networks (network topology, statutory duties of supply, supply quality/system services, malfunctions and protection systems)
- Network calculation (complex vector representation, effective/idle power, mathematical performance models/net model, transformation: node performance to node voltage and electricity, calculation of conductive current, current flow, fix-point-iteration, Newton-Raphson-Method, voltage drop, transformer model)
- Intelligent network management (Smart Grids), aggregation forms, machine learning approaches)

**Reader's advisory**

**Suggested reading:**

- Crastan V.: "Elektrische Energieversorgung II", Springer 2004
- Heuck K., Dettman K. D., Schulz D.: "Elektrische Energieversorgung I", 7. Aufl., Vieweg 2007
- Konstantin, P.: "Praxisbuch Energiewirtschaft", Springer 2006
- Schwab, A.: "Elektroenergiesysteme, Springer 2009

**Links**

<b>Language of instruction</b>	English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>	jährlich			
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	AS (Akzentsetzung / Accentuation)			
<b>Modulart / typ of module</b>	je nach Studiengang Pflicht oder Wahlpflicht			
<b>Lehr-/Lernform / Teaching/Learning method</b>	V+Ü			
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Time of examination		Type of examination	
<b>Final exam of module</b>	At the end of the semester		Oral exam	
Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		3	SuSe	42
Exercises		1	SuSe	14
<b>Total time of attendance for the module</b>				56 h



## phy609 - Photovoltaic Physics

<b>Module label</b>	Photovoltaic Physics			
<b>Module code</b>	phy609			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> <li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li> </ul>			
<b>Responsible persons</b>	Kühn, Martin (Module responsibility)  Gütay, Levent (Authorized examiners)			
<b>Prerequisites</b>	Solid-state-Physics, semi-conductor Physics, Module Renewable Energy Technologies I			
<b>Skills to be acquired in this module</b>	describe schematically the events around the pn-junction under bias in the dark and under illumination, calculate the width of the space charge region, use solar cell data sheets in their professional career, discuss the concepts of solar cell materials, design and optimization, choose a PV technology for a given project			
<b>Module contents</b>	This specialization module covers the physics of photovoltaics. The behaviour of solar cells is discussed from a fundamental physical point of view to explain the differences in performance and limits of various photovoltaic materials. Students learn how solar cells function, are designed and optimized, Optical and electrical properties of semiconductors, light absorption, Charge carrier generation/recombination/life time, Charge carrier transport across the pn-junction in equilibrium and under light and voltage bias, Transport equations, Current-voltage characteristics, efficiency, Quantum efficiency, Design concepts to optimize the efficiency, Overview of the most important PV technologies			
<b>Reader's advisory</b>	S. Hegedus, A. Luque, Handbook of Photovoltaic Science and Engineering, published John Wiley and Sons (2nd Edition 2011); Christiana Honsberg and Stuart Bowden, PVCDROM, <a href="http://www.pveducation.org/pvcdrom/instructions">http://www.pveducation.org/pvcdrom/instructions</a> , Access date 2.10.2014; lecture notes for the respective courses			
<b>Links</b>				
<b>Language of instruction</b>	English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>	Sommersemester			
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>	Vorlesung: 4 SWS, Übung: 2 SWS			
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Time of examination		Type of examination	
<b>Final exam of module</b>			1 Exam	
Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				56 h

## phy616 - Computational Fluid Dynamics 1 / 2

<b>Module label</b>	Computational Fluid Dynamics 1 / 2	
<b>Module code</b>	phy616	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> <li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li> </ul>	
<b>Responsible persons</b>	Lukassen, Laura (Authorized examiners)  Stoevesandt, Bernhard (Authorized examiners)  Lukassen, Laura (Module responsibility)	
<b>Prerequisites</b>	Fluid Dynamics I	
<b>Skills to be acquired in this module</b>	Deeper understanding of the fundamental equations of fluid dynamics. Overview of numerical methods for the solution of the fundamental equations of fluid dynamics. Confrontation with complex problems in fluid dynamics. To become acquainted with different, widely used CFD models that are used to study complex problems in fluid dynamics. Ability to apply these CFD models to certain defined problems and to critically evaluate the results of numerical models.	
<b>Module contents</b>	CFD I: The Navier-Stokes equations, filtering / averaging of Navier- Stokes equations, introduction to numerical methods, finite- differences, finite-volume methods, linear equation systems, NS-solvers, RANS, URANS, LES, DNS, turbulent flows, incompressible flows, compressible flows, efficiency and accuracy. CFD II: Introduction to different CFD models, such as OpenFOAM and PALM. Application of these CFD models to defined problems from rotor aerodynamics and the atmospheric boundary layer.	
<b>Reader's advisory</b>	J.H. Ferziger, M. Peric, Computational Methods for Fluid Dynamics, Springer, 2002; C. Hirsch, Numerical Computation of Internal and External Flows: Introduction to the Fundamentals of CFD, Vol 1: Fundamentals of Computational Fluid Dynamics, 2nd edition, Butterworth-Heinemann, Amsterdam; P. Sagaut, Large Eddy Simulation for Incompressible Flows, Springer, Berlin, 1998; J. Fröhlich, Large Eddy Simulationen turbulenter Strömungen, Teubner, Wiesbaden, 2006 (in German)	
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	Sommersemester	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Pflicht / Mandatory	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Lecture: 2hrs/week, Excercise: 2hrs/week	
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Time of examination	Type of examination
<b>Final exam of module</b>	<ul style="list-style-type: none"> <li>• 1 Klausur oder</li> <li>• 1 Referat oder</li> <li>• 1 mündliche Prüfung oder</li> <li>• 1 fachpraktische Übung</li> </ul>	
<b>Course type</b>	Course selection ( Vorlesungen oder Praktikum oder Seminar )	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

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## phy641 - Energy Ressources & Systems

<b>Module label</b>	Energy Ressources & Systems
<b>Module code</b>	phy641
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self-study: 124 hrs )
<b>Applicability of the module</b>	<ul style="list-style-type: none"><li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li><li>• Master's Programme European Master in Renewable Energy (EUREC) (Master) &gt; Mastermodule</li><li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li></ul>
<b>Responsible persons</b>	Knipper, Martin (Authorized examiners)  Torio, Herena (Authorized examiners)  Knipper, Martin (Module responsibility)  Agert, Carsten (Module responsibility)
<b>Prerequisites</b>	
<b>Skills to be acquired in this module</b>	After successful completion of the module students should be able to: <ul style="list-style-type: none"><li>• characterize the global energy system and analyze the structure and constraints of today's energy system,</li><li>• explain the availability and connection between solar and wind energy,</li><li>• identify the problems and challenges of energy supply due to fluctuating energy resources with varying and seasonal load profiles,</li><li>• relate the solar irradiance conversion process as well as the atmospheric radiation balance of the earth to Wind Energy Meteorology.</li></ul>
<b>Module contents</b>	<p>This module will give an overview on the global energy system and the challenges of energy supply due to fluctuating energy resources with varying and seasonal load profiles.</p> <p>Energy Meteorology (Lecture - 90 h workload)</p> <p>Section I: Solar Irradiance</p> <ul style="list-style-type: none"><li>• Radiation laws,</li><li>• Solar geometry,</li><li>• Interaction of solar irradiance with the atmosphere,</li><li>• Radiation climatology,</li><li>• Solar radiation model,</li><li>• Statistical properties of solar irradiance,</li><li>• Measuring devices to ascertain solar radiation balance,</li><li>• Satellite-supported data acquisition to assess solar irradiance,</li></ul> <p>Section II: Wind Flow</p> <ul style="list-style-type: none"><li>• Origin and potential of atmospheric energy movements, Heat balance of the atmosphere,</li><li>• Physical laws of atmospheric flow,</li><li>• Wind circulation in the atmosphere, local winds,</li><li>• Wind flow in atmospheric layers (vertical structure, Ekman Layer),</li><li>• Assessment of wind potential (European Wind Atlas: model, concept,</li><li>• Wind Measurements,</li></ul> <p>Energy Systems (Lecture - 90 h workload)</p> <ul style="list-style-type: none"><li>• Definitions, separation electrical - thermal energy use,</li><li>• Resources and reserves,</li><li>• Energy system analysis: Efficiencies at various levels of the energy chain; Exergy analysis,</li><li>• Energy scenarios,</li><li>• Climate change,</li><li>• Advanced (power plant) technologies for conventional fuels,</li><li>• Electric power systems with large shares of renewables</li></ul>
<b>Reader's advisory</b>	Energy Meteorology: <ul style="list-style-type: none"><li>• IEA World Energy Outlook (<a href="http://wordenergyoutlook.org/">http://wordenergyoutlook.org/</a>)</li><li>• Iqbal, M. 1984: An Introduction to Solar Radiation, Academic Press, Toronto</li></ul>

- Liou, K.-N. 2002: An Introduction to Atmospheric Radiation, Academic Press: 2nd edition, Page 2 of 39
- Peixoto, J.P. and Oort A.H. 2007: Physics of Climate Book, Surge Publishing
- Rasmussen, B. 1988: Wind Energy, 2, Routledge: 1st edition
- Sathyajith, M. 2006: Wind energy: fundamentals, resource analysis and economics, Springer
- Stull, R.B. 1988: An Introduction to Boundary Layer Meteorology, Springer 1st edition

Energy Systems:

- Ramage, J.: Energy: A Guide Book (Oxford University Press, 1997)
- Boyle, G. et al. (Eds.): Energy Systems and Sustainability (Oxford University Press, 2003)
- Blok, K.: Introduction to Energy Analysis (Technische Universiteit Delft, 2007)
- Houghton, J.: Global Warming: The Complete Briefing, 5th Ed. (Cambridge University Press, 2015)
- UNDP (Ed.): World Energy Assessment: Energy and the Challenge of Sustainability (2000/2004), <http://www.undp.org/energy/weapub2000.htm>
- GEA: Global Energy Assessment { Toward a Sustainable Future (Cambridge University Press and International Institute for Applied System Analysis, Laxenburg, 2012), [www.iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/Chapters\\_Home.en.html](http://www.iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/Chapters_Home.en.html) - Goldemberg, J. et al.: Energy for a Sustainable World (Wiley Eastern, 1988)
- Nakicenovic, N., A. Grübler and A. McDonald (Eds.): Global Energy Perspectives (Cambridge University Press, Cambridge, 1998) - Khartchenko, N.V.: Advanced Energy Systems (Taylor and Francis, 1998)
- IEA (International Energy Agency): World Energy Statistics and Balances 2015 - BP: Statistical Review of World Energy 2016 (<http://www.bp.com/en/global/corporate/energy-economics.html>)
- EIA: International Energy Outlook 2016 ([www.eia.doe.gov/forecasts/ieo/](http://www.eia.doe.gov/forecasts/ieo/))
- United Nations: 2013 Energy Statistics Yearbook (2016) ([unstats.un.org/unsd/energy/yearbook/](http://unstats.un.org/unsd/energy/yearbook/))

Links		
Language of instruction	English	
Duration (semesters)	1 Semester	
Module frequency	Winter semester	
Module capacity	unlimited	
Modullevel / module level	MM (Mastermodul / Master module)	
Modulart / typ of module	Pflicht / Mandatory	
Lehr-/Lernform / Teaching/Learning method	Vorlesung: 2 SWS, Vorlesung: 2 SWS	
Vorkenntnisse / Previous knowledge		
Examination	Time of examination	Type of examination
Final exam of module		written exam
	At the end of the lecture period	
Course type		
Course type	Lecture	
SWS		
SWS	4	
Frequency		
Frequency	SoSe oder WiSe	
Workload attendance		
Workload attendance	56 h	

## phy644 - Wind Energy Physics, Data & Analysis

<b>Module label</b>	Wind Energy Physics, Data & Analysis
<b>Module code</b>	phy644
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( attendance: 2*28 hrs, self-study: 124 hrs )
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> </ul>
<b>Responsible persons</b>	<p>Heinemann, Detlev (Authorized examiners)</p> <p>Kühn, Martin (Authorized examiners)</p> <p>Lukassen, Laura (Authorized examiners)</p> <p>Peinke, Joachim (Authorized examiners)</p>
<b>Prerequisites</b>	The module starts in the winter term: Wind Energy Physics has to be taken before participating in Wind Physics Measurement Project
<b>Skills to be acquired in this module</b>	<p>After successful completion of the module students should be able to:</p> <ul style="list-style-type: none"> <li>Evaluate wind energy related measurements,</li> <li>Interprete such measurements gained in the field of wind energy applications,</li> <li>Critically evaluate measured data</li> </ul>
<b>Module contents</b>	<p>The winter term lecture teaches the basic knowledge in wind energy physics. Physical properties of fluids, wind characterization and anemometers, aerodynamic aspects of wind energy conversion, dimensional analysis, (pitheorem), and wind turbine performance, design of wind turbines, electrical systems.</p> <p>The sequentially following WPhyMPr addresses problems based on real wind data, which will be solved on at least four important aspects in wind physics. The course will comprise lectures and assignments as well as self-contained work in groups of 3 persons. The content consist of the following four main topics, following the chronological order of the work process:</p> <p>Data handling (measurements, measurement technology, handling of wind data, assessment of measurement artefacts in wind data, preparation of wind data for further processing); Energy Meteorology (geographical distribution of winds, wind regimes on different time and length scales, vertical wind profile, distribution of wind speed, differences between onshore and offshore conditions); Measure - Correlate - Predict (MCP) (averaging of wind data, bin-wise averaging of wind data, long term correlation and long term correction of wind data, sources of long term wind data); LIDAR (analyses and conversion of data from LIDAR measurements)</p>
<b>Reader's advisory</b>	<p>R. Gasch , J. Twele : Wind Power Plants Fundamentals, Design, Construction and Operation, 2nd Ed., Springer Verlag, 2012, ISBN: 978 3 642 22937 4</p> <p>S. Emeis : Wind Energy Meteorology: Atmospheric Physics for Wind Power Generation, Springer, 2012</p> <p>Evaluation of site specific wind conditions; MEASNET Guideline; Version 1; November 2009; free available in the internet: <a href="http://www.measnet.com/wpcontent/uploads/2012/04/Measnet_SiteAssessment_V10.pdf">http://www.measnet.com/wpcontent/uploads/2012/04/Measnet_SiteAssessment_V10.pdf</a></p> <p>IEC 61400 12 1:2005 Power performance measurements of electricity producing wind turbines; guideline</p>
<b>Links</b>	
<b>Language of instruction</b>	English
<b>Duration (semesters)</b>	1 Semester
<b>Module frequency</b>	Sommer- und Wintersemester
<b>Module capacity</b>	unlimited
<b>Reference text</b>	The module starts in the winter term: Wind Energy Physics has to be taken before participating in Wind Physics Measurement Project
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)
<b>Modulart / typ of module</b>	Wahlpflicht / Elective
<b>Lehr-/Lernform / Teaching/Learning method</b>	Seminar: 2 SWS, Seminar: 2 SWS
<b>Vorkenntnisse / Previous knowledge</b>	

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Examination	Time of examination	Type of examination
<b>Final exam of module</b>		1 Exam
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

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## phy646 - Wind Physics Student's Lab

<b>Module label</b>	Wind Physics Student's Lab
<b>Module code</b>	phy646
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )
<b>Applicability of the module</b>	<ul style="list-style-type: none"><li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li></ul>
<b>Responsible persons</b>	Schmidt, Andreas Hermann (Authorized examiners)  Kühn, Martin (Module responsibility)
<b>Prerequisites</b>	Basic computer knowledge; mechanics; mathematical methods for physics and engineering; basic knowledge of wind energy utilization; previous knowledge of metrology, basic knowledge of aerodynamics
<b>Skills to be acquired in this module</b>	The "Wind Physics Student's Lab" aims to foster the learning process by own research activities of the students in wind physics and additionally to build up skills for scientific and experimental work and scientific writing. Therefore, this course is also intended as preparation for the master thesis. The course is organized as seminar with integrated work in the laboratory. The students will investigate an individual, self-formulated research question and will be guided by the supervisors through the research-based learning process. The work in groups and discussion of solutions aims to improve skills in team working. In order to introduce the students to current wind energy research, the course is offered in three versions. These versions represent the work of the three research groups at ForWind - University Oldenburg.
<b>Module contents</b>	<p>Content of Wind2Grid-Seminar</p> <p>The seminar consists of three main phases with different learning steps:</p> <p>1st phase:</p> <p>Class-room seminar building up basic competences</p> <p>identification of the technical tasks</p> <p>introduction to current research</p> <p>introduction to the learning platform</p> <p>investigating standard situations and functional interaction by means of the experimental system</p> <p>defining an own research question</p> <p>defining an experimental strategy</p> <p>planning the experiment</p> <p>2nd phase: Laboratory work (1 week)</p> <p>set-up, execution, data acquisition and decommissioning of the experiment</p> <p>3rd phase: Evaluation and documentation evaluating the experiment</p> <p>documentation with a short report (paper) presentation</p> <p>The seminar "Wind turbine rotor in turbulent inflow" is connected to the scientific work of the research group Turbulence, Wind Energy and Stochastics (TWIST).</p> <p>In this seminar, turbulent wind fields and their effects on wind turbines will be investigated. Students learn how turbulence can be described, investigated and evaluated for different purposes. The students gain a deep understanding of the phenomenon of turbulence. They learn to work with measured data from the open field and perform own experiments with an active turbulence grid and a model of a wind turbine in a turbulent wind tunnel. They learn to establish their own research questions and are encouraged to develop own methods. The seminar consists of three main phases with different learning steps:</p> <p>1st phase: Class-room seminar</p> <ul style="list-style-type: none"><li>- building up basic competences</li><li>- identification of the technical and/or scientific tasks</li><li>- introduction to current research</li><li>- introduction to the experiment related to the seminar</li></ul> <ul style="list-style-type: none"><li>• investigating standard situations and functional interaction by means of the experimental system</li><li>• defining own research questions</li><li>• defining an experimental strategy</li><li>• planning the experiment</li></ul> <p>2nd phase: Laboratory work</p> <ul style="list-style-type: none"><li>• set-up, execution, data acquisition and decommissioning of the experiment</li></ul> <p>3rd phase: Evaluation and documentation</p> <ul style="list-style-type: none"><li>• evaluating the experiment</li><li>• documentation with a short report (paper)</li><li>• presentation</li></ul>

<b>Reader's advisory</b>	<p>English Language: Robert Gasch, Wind Power Plants - Fundamentals, Design, Construction and Operation, 2nd Ed., 2012, Springer-Verlag; ISBN: 978-3-642-22937-4  German Language: Robert Gasch, Windkraftanlagen - Grundlagen und Entwurf, 9th Ed., 2016, Springer + Vieweg; ISBN: 978-3-658-12360-4  German Language: CEwind eG / Alois Schaffarczyk, Einführung in die Windenergietechnik; 1st Ed. 2012, Carl Hanser Verlag, Munich  English Language: Erich Hau, Wind Turbines: Fundamentals, Technologies, Application, Economics, 3rd Ed., 2013, Springer-Verlag; ISBN 978-3-642-27151-9  German Language: Erich Hau, Windkraftanlagen. Grundlagen, Technik, Einsatz, Wirtschaftlichkeit. 5th Ed., 2014, Springer-Verlag; ISBN: 978-3-642-28877-7</p>	
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	Sommer- und Wintersemester	
<b>Module capacity</b>	unlimited	
<b>Reference text</b>	Each seminar offered within the module holds for 6 credit points. Thus, students have to register for only one of the offered seminars within the module.	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Seminar with laboratory experiments for research oriented learning / Seminar mit Blockpraktikum zum forschungsbasierten Lernen: 4 hrs/week	
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Time of examination	Type of examination
<b>Final exam of module</b>		Portfolio
<b>Course type</b>	Seminar	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	



## phy647 - Future Power Supply Systems

<b>Module label</b>	Future Power Supply Systems	
<b>Module code</b>	phy647	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> <li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li> </ul>	
<b>Responsible persons</b>	Agert, Carsten (Authorized examiners)	
<b>Prerequisites</b>	Knowledge from module RE technology I, Mathematics	
<b>Skills to be acquired in this module</b>	<p>After successful completion of the module students should be able to</p> <ul style="list-style-type: none"> <li>• explain the management, power balancing and the provision of ancillary services within future electricity grid configurations with high shares of fluctuating and distributed generation</li> <li>• perform power system simulation with related software tools</li> <li>• describe different grid-designs, including mini- and microgrids</li> <li>• compare different markets for electricity (Futures' Market, Day-Ahead-Market, Intraday-Market, Balancing Power Market, Self-Consumption) and assess the suitability of these concepts for promoting the implementation of higher shares of fluctuating distributed power generation within the electricity grid.</li> <li>• explain the technical principles and resulting limiting factors of concepts and components required for power control within "Smart City", "Smart Grid", and "Smart Home" concepts</li> </ul>	
<b>Module contents</b>	<p>Future Power Supply Systems:</p> <ul style="list-style-type: none"> <li>• Technology and characteristics of conventional power plants based e. g. on coal, gas, and nuclear,</li> <li>• Fundamentals, structure, technologies and operation of (AC-) electricity grids (incl. balancing power, voltage management, etc.),</li> <li>• Fluctuating distributed generation: Characteristics and solutions on the transmission and distribution grid levels, incl. storage, vehicle-to-grid-concepts, smart inverters, heat pumps / CHP, etc,</li> <li>• Interactions between technology and economics: The different electricity markets (Futures Market, Day-Ahead-Market, Intraday-Market, Balancing Power Market, Self-Consumption) and their links to the physical world, - "Smart City", "Smart Grid", "Smart Home", - Mini- and Micro-Grids,</li> <li>• Energy scenarios and modelling,</li> <li>• Chemical energy carriers in the energy system: power-to-gas (e.g. methane) and power-to-liquids (e.g. methanol)</li> </ul>	
<b>Reader's advisory</b>	<p>Future Power Supply Systems: Buchholz, B.M., Styczynski Z. (2014). Smart Grids - Fundamentals and Technologies in Electricity Networks. Springer Ed.,            Khartchenko, N. et al. (2013). Advanced Energy Systems, Second Edition (Energy Technology). CRC Press Inc.            Hemami, A. (2015). Electricity and Electronics for Renewable Energy Technology: An Introduction (Power Electronics and Applications) CRC Press,            Schlögl, R. (2013) Ed., Chemical Energy Storage, De Gruyter</p>	
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	Sommersemester	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Lecture and Seminar: 4 hrs/week	
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>	Report (presentation: 50 min, Term-paper: 5 pp.) or Exercises (8 Exercises). In addition, active participation is required. The criteria to fulfil the requirement of the active participation are	

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Examination	Time of examination	Type of examination
		announced at the beginning of the term.
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

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## phy648 - Wind Resources and its Applications

<b>Module label</b>	Wind Resources and its Applications
<b>Module code</b>	phy648
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( Attendance: 72 hrs, Self study: 108 hrs )
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> <li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li> </ul>
<b>Responsible persons</b>	<p>Heinemann, Detlev (Authorized examiners)</p> <p>Waldl, Hans-Peter (Authorized examiners)</p> <p>Kühn, Martin (Module responsibility)</p>
<b>Prerequisites</b>	Knowledge in Basics Wind Energy, Fluid Dynamics I, Matlab
<b>Skills to be acquired in this module</b>	<p>assess different aspects of wind energy farms by modelling, comparison, explanation of wind energy potential, wind energy farm's output, power curves, wind energy project development, assess in detail in uences of meteorological/ climatological aspects on the performance of wind power systems, summarize physical processes governing atmospheric wind flows,</p> <p>value atmospheric boundary layer flow relevant for wind power conversion, argue methods for wind resource assessment and forecasting</p>
<b>Module contents</b>	<p>Advanced Wind Energy Meteorology (Lecture -90 h workload)</p> <p>Atmospheric Boundary Layer (turbulence, vertical structure, special BL effects)</p> <p>Atmospheric Flow Modelling: Linear models, RANS and LES models</p> <p>Wind farm modelling</p> <p>Offshore-Specific Conditions</p> <p>Resource Assessment and Wind Power Forecasting</p> <p>Wind Measurements and Statistics</p> <p>Wind Energy Applications - from Wind Resource to Wind Farm Operations (Lecture - 90 h workload)</p> <p>Evaluation of Wind Resources</p> <p>Weibull Distribution</p> <p>Wind velocity measurements to determine energy yield</p> <p>Basics of Wind Atlas Analysis and Application Program (WAsP) Method, Partial models using WAsP</p> <p>Measure-Correlate-Predict (MCP) Method of long term corrections of wind measurement data in correlation to long term reference data</p> <p>Conditions for stable, neutral and instable atmospheric conditions</p> <p>Wind yield from wind distribution and the power curve Basics in appraising the yearly wind yield from a wind turbine.</p> <p>Wake Effect and Wind Farm</p> <p>Recovery of original wind fields in the downstream of wind turbines</p> <p>Basics of Riso Models</p> <p>Spacing and efficiency in wind farms</p> <p>Positive and Negative Effects of Wind Farms</p> <p>Wind Farm Business</p> <p>Income from the energy yield from wind farms</p> <p>Profit optimization by increase of energy production</p> <p>Wind farm project development</p> <p>Wind farm operation and Surveillance of power production vs. wind climate, power curves, and turbine availability</p>
<b>Reader's advisory</b>	<p>Advanced Wind Energy Meteorology</p> <p>Holton, J.R. and G. J. Hakim, 2013: An Introduction to Dynamic Meteorology, 5th Edition, Academic Press, New York</p> <p>Stull, R.B., 1988: An Introduction to Boundary Layer Meteorology. Kluwer Academic Pub. Wind Energy Applications - from Wind Resource to Wind Farm Operations Burton, T., N. Jenkins, D. Sharpe and E. Bossanyi, 2011: Wind Energy Handbook, Second Edition, John Wiley. Gasch, R. and J. Twele, 2012: Wind Power Plants: Fundamentals, Design, Construction and Operation; Second Edition, Springer</p> <p><a href="http://www.av8n.com/how/htm/airfoils.html">http://www.av8n.com/how/htm/airfoils.html</a>, Last access: 4/2016</p> <p><a href="http://www.windpower.org/en/">http://www.windpower.org/en/</a>, Last access: 4/2016</p>
<b>Links</b>	
<b>Language of instruction</b>	English
<b>Duration (semesters)</b>	1 Semester
<b>Module frequency</b>	Sommersemester
<b>Module capacity</b>	unlimited

<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Vorlesung: 4 SWS	
<b>Vorkenntnisse / Previous knowledge</b>	Knowledge in Basics Wind Energy, Fluid Dynamics I, Matlab	
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>	1 Exam	
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

## phy649 - Design of Wind Energy Systems

<b>Module label</b>	Design of Wind Energy Systems
<b>Module code</b>	phy649
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( Attendance: 72 hrs, Self study: 108 hrs )
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> <li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li> </ul>
<b>Responsible persons</b>	<p>Kühn, Martin (Authorized examiners)</p> <p>Kühn, Martin (Module responsibility)</p>
<b>Prerequisites</b>	Basics in Wind Energy Utilisation
<b>Skills to be acquired in this module</b>	<p>Design of Wind Energy Systems: The students attending the course will have the possibility to expand and sharpen of their knowledge about wind turbine design from the basic courses. The lectures include topics covering the whole spectrum from early design phase to the operation of a wind turbine. Students will learn in exercises how to calculate and evaluate design aspects of wind energy converters.</p> <p>At the end of the lecture, they should be able to: estimate the site specific energy yield, calculate the aerodynamics of wind turbines using the blade element momentum theory, model wind fields to obtain specific design situations for wind turbines, estimate the influence of dynamics of a wind turbine, especially in the context of fatigue loads, transfer their knowledge to more complex topics such as simulation and measurements of dynamic loads, calculate the economic aspects of wind turbine</p> <p>Aeroelastic Simulation of Wind turbines: student who has met the objectives of the course will be able to: understand the basic concept of an aero-servo-elastic computer code to determine the unsteady aerodynamic loads, derive and validate the required parameters to model the aero-hydro-elastic response of a wind turbine, identify and interpret the required empirical parameters to correct the blade element momentum (BEM) method with respect to dynamic in flow, unsteady airfoil aerodynamics (dynamic stall), yawed flow, dynamic wake modeling, explain the effects of the different models on the resulting time series and validate the code, interpret design standards for on- and offshore wind turbines, select the required load cases according to sitespecific environmental data, identify the dimensioning load cases and calculate design loads for different main components of a wind turbine.</p>
<b>Module contents</b>	<p>Design of Wind Energy Systems Introduction to industrial wind turbine design, rotor aerodynamics and Blade Element Momentum (BEM) theory, dynamic loading and system dynamics, wind field modelling for fatigue and extreme event loading, design loads and design aspects of onshore wind turbines, simulation and measurements of dynamic loads, design of offshore wind turbines, power quality and grid integration on wind turbines.</p> <p>Aeroelastic Simulation of Wind turbines: The course focuses on the practical implications and hands-on experience of the aero-hydro-servo-elastic modelling and simulation of wind turbines. The subjects are similar but the treatment is complementary to the parallel course 'Design of Wind Energy Systems', which deals with the underlying theoretical background: advanced wind field modelling for fatigue and extreme event loading, modelling of wind farm flow and wake effects, rotor aerodynamics (e.g. stationary or dynamic effects, comparison of Blade Element Momentum theory and more advanced methods like free vortex methods or CFD), structural dynamics and dynamic modelling of wind turbine structures (modelling by ordinary or partial differential equations, stochastics, multi body system modelling), advanced control of wind turbines, design standards, design loads and design aspects of off-shore and onshore wind turbines. The students analyse in pairs a model of an entire wind turbine with the aid of a typical wind turbine design tool like GH Bladed, Flex5 or Aerodyn/FAST.</p>
<b>Reader's advisory</b>	<p>T. Burton et. al.: Wind Energy Handbook. John Wiley, New York, 2nd ed., 2011; R. Gasch, J. Twele: Wind Power Plants. Springer, Berlin, 2nd ed., 2011.;</p> <p>Garrad Hassan, Bladed, Wind Turbine Design Software, Theory Manual; Selected papers from e.g. Wind Energy Journal, Wiley Interscience</p>
<b>Links</b>	
<b>Language of instruction</b>	English
<b>Duration (semesters)</b>	1 Semester
<b>Module frequency</b>	Wintersemester
<b>Module capacity</b>	unlimited
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)
<b>Modulart / typ of module</b>	Wahlpflicht / Elective

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<b>Lehr-/Lernform / Teaching/Learning method</b>	Vorlesung: 2 SWS, Seminar: 2 SWS	
<b>Vorkenntnisse / Previous knowledge</b>	Basics in Wind Energy Utilisation	
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>	Exam or presentation or oral exam or homework or practical report	
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

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## phy687 - Advanced Engineering Topics in Renewable Energies

<b>Module label</b>	Advanced Engineering Topics in Renewable Energies	
<b>Module code</b>	phy687	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Overall workload of 180 h )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> </ul>	
<b>Responsible persons</b>	<p>Feudel, Ulrike (Authorized examiners)</p> <p>Holtorf, Hans-Gerhard (Authorized examiners)</p> <p>Kühn, Martin (Authorized examiners)</p> <p>Peinke, Joachim (Authorized examiners)</p> <p>Schmidt, Jonas (Authorized examiners)</p> <p>Stoevesandt, Bernhard (Authorized examiners)</p> <p>Kühn, Martin (Module responsibility)</p>	
<b>Prerequisites</b>	Related to selected course/s	
<b>Skills to be acquired in this module</b>	The aim of this module is, to give students further access to also small courses (3 CP) which address the specific interest of the student and deliver unique in-depth knowledge or the opportunity to train specific engineering skills in the field renewable energy technologies.	
<b>Module contents</b>	E.g. metrology, data logging, measurement methodology, construction, monitoring, control engineering, remote sensing.	
<b>Reader's advisory</b>	Related to selected course/s	
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	Sommer- oder Wintersemester	
<b>Module capacity</b>	unlimited	
<b>Reference text</b>	This module offers special as well as advanced courses in engineering science. The list of eligible courses will be updated each academic year. Please refer to the courses listed for this module in Stud.IP.	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Related to selected course/s	
<b>Vorkenntnisse / Previous knowledge</b>	Related to selected course/s	
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>	Related to selected course/s	
<b>Course type</b>	Lecture ( oder Seminar mit Praktikum ) ( <i>Hier ist ein Kommentar</i> )	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

## phy689 - Advanced Topics in Renewable Energies

<b>Module label</b>	Advanced Topics in Renewable Energies			
<b>Module code</b>	phy689			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Overall workload of 180 h )			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> </ul>			
<b>Responsible persons</b>	Feudel, Ulrike (Authorized examiners) Holtorf, Hans-Gerhard (Authorized examiners) Kühn, Martin (Authorized examiners) Peinke, Joachim (Authorized examiners) Stoevesandt, Bernhard (Authorized examiners) Wächter, Matthias (Authorized examiners) Wark, Michael (Authorized examiners) Kühn, Martin (Module responsibility)			
<b>Prerequisites</b>	Related to selected course/s			
<b>Skills to be acquired in this module</b>	The aim of this module is, to give students further access to also small courses (3 CP) which address the specific interest of the student and deliver unique in-depth knowledge or the opportunity to train specific engineering skills.			
<b>Module contents</b>	Photonics, Optics, Metrology			
<b>Reader's advisory</b>	Related to selected course/s			
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>	Sommer- oder Wintersemester			
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>	Related to selected course/s			
<b>Vorkenntnisse / Previous knowledge</b>	Related to selected course/s			
Examination	Time of examination		Type of examination	
<b>Final exam of module</b>	Related to selected course/s			
Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		4	SoSe oder WiSe	56
Seminar		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				84 h



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## phy984 - Semiconducting Materials for Solar Energy

<b>Module label</b>	Semiconducting Materials for Solar Energy	
<b>Module code</b>	phy984	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h	
<b>Applicability of the module</b>	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	EB (Ergänzungsbereich / Complementary)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Seminar	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	28 h	

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## phy987 - Control of Wind Turbines and Wind Farms

<b>Module label</b>	Control of Wind Turbines and Wind Farms
<b>Module code</b>	phy987
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( 180 h (Präsenzzeit 72h, Selbststudium: 108h) )
<b>Applicability of the module</b>	<ul style="list-style-type: none"><li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li><li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li></ul>
<b>Responsible persons</b>	Kühn, Martin (Authorized examiners)  Petrovic, Vlaho (Authorized examiners)  Kühn, Martin (Module responsibility)
<b>Prerequisites</b>	
<b>Skills to be acquired in this module</b>	

After successful completion of the course, students

- will have understood the structure and the main components of the control system in a wind farm
- will have understood the main objectives for a wind farm control system and will be able to develop appropriate control algorithms for the said objectives
- will have understood relevant physical phenomena in a wind farm
- will be able to develop a control-oriented model of a wind turbine, and will have understood how to use it for the design and analysis of control algorithms
- will be able to independently apply different techniques from control engineering
- will have trained how to use methods from linear algebra and mathematical analysis for the design and analysis of control algorithms

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### Module contents

The course covers the main techniques used in wind turbine and wind farm control. The course is structured in five sections:

Section I: Introduction to control in wind energy

- Introduction to the governing physics
- Control objectives in wind energy
- Overview of the control system

Section II: Control oriented modelling

- Modelling in time domain
- Modelling in frequency domain
- Time and frequency response

Section III: Standard wind turbine control

- Torque and pitch control
- Tuning of a PI controller
- Stability analysis

- Control of coupled systems

Section IV: Advanced wind turbine control

- Advanced control design approaches
- State space control
- Estimation techniques

Section V: Wind farm control

- Wake control strategies
- Active power control
- Power maximization

#### Reader's advisory

Burton et al: Wind Energy Handbook, John Wiley, New York, Second Edition, 2011.

Ogata: Modern Control Engineering, Prentice Hall, Upper Saddle River, New Jersey, Third Edition, 1997

#### Links

<b>Language of instruction</b>	English
<b>Duration (semesters)</b>	1 Semester
<b>Module frequency</b>	jährlich
<b>Module capacity</b>	unlimited
<b>Modullevel / module level</b>	EB (Ergänzungsbereich / Complementary)
<b>Modulart / typ of module</b>	Wahlpflicht / Elective
<b>Lehr-/Lernform / Teaching/Learning method</b>	Vorlesung: 4 SWS, Übung: 2 SWS
<b>Vorkenntnisse / Previous knowledge</b>	Basic knowledge in linear algebra and mathematical analysis is required. Furthermore, a basic understanding of wind turbines and wind farms is required (e.g. Design of Wind Energy Systems). A good grasp of the Matlab/Simulink environment is required for exercises.

Examination		Time of examination	Type of examination	
Final exam of module		KL		
Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>

## phy967 - Advanced Laboratories in Renewable Energies

<b>Module label</b>	Advanced Laboratories in Renewable Energies	
<b>Module code</b>	phy967	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> </ul>	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		Praktikumsbericht
<b>Course type</b>	Practical training	
<b>SWS</b>		
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	0 h	

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## pre022 - Solar Energy

<b>Module label</b>	Solar Energy
<b>Module code</b>	pre022
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h
<b>Applicability of the module</b>	<ul style="list-style-type: none"><li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li><li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li></ul>
<b>Responsible persons</b>	Torio, Herena (Authorized examiners) Knipper, Martin (Authorized examiners) Torio, Herena (Module responsibility) Agert, Carsten (Module responsibility)
<b>Prerequisites</b>	
<b>Skills to be acquired in this module</b>	

After successful completion of the module students should be able to:

- understand, describe and compare major technologies for solar energy use: solar thermal and photovoltaic systems
- analyse various system components and their interconnections within a solar energy system.
- critically appraise and assess various technologies for solar energy use and components involved in such solar systems.
- size and evaluate the performance of solar systems as a function of their operation conditions, components and system layout
- critically evaluate non-technical impact and side effects when implementing renewable energy supply systems

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### Module contents

This module gives an overview on solar thermal and photovoltaic technologies. Main focus hereby are the scientific principles of components and their technical description as well as first suitable system performance assessment methods.

Photovoltaics (Lecture: 90 h workload)

Physics of PV:

- Basic and most important properties of solar radiation related to photovoltaics
- PV cells basics: Fundamental physical processes in photovoltaic materials
- Characterization and basic modelling of solar cells
- Component Description: PV generator; Charge controller; Inverter; Balance of system components; System Description
- Grid Connected System
- Stand Alone System

Solar Thermal Energy (Seminar & Exercises: 90 h workload)

- Assessment of solar thermal ambient parameters: regional global, diffuse, reflected solar radiation on horizontal and on tilted plane, ambient temperature

- Solar thermal system components: collectors; heat exchangers; thermal storage; thermally driven compression chillers
- Solar cooling systems and components
- Characterization of solar thermal systems, their operation and performance
- F-Chart and Utilizability methods as main methods for assessing system performance

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#### Reader's advisory

##### Solar Energy PV

- Green, Martin A., 1981: Solar cells : operating principles, technology and system applications, Prentice Hall.
- Green, M.A., 2007: Third Generation Photovoltaics, Advanced Solar Energy Conversion, Springer Series in Photonics
- Markvart, Tom and Castaner, Luis, 2003: Practical Handbook of Photovoltaics, Fundamentals and Applications, Elsevier Science
- Nelson, Jenny, 2003: The Physics of Solar Cells (Properties of Semiconductor Materials), Imperial College Press.
- Stuart R. Wenham, Martin A. Green, Muriel E. Watt & Richard Corkish (Edit.), 2007: Applied Photovoltaics, Earthscan Publications Ltd.;
- Twidell, John & Weir, Toni, 2005: Renewable Energy Resources Taylor & Francis.

##### Solar Thermal

- DGS, (2010) Planning and installing solar thermal systems, a guide for installers, architects and engineers, 2nd ed.
- Duffie JA, Beckman WA (2013) Solar engineering of thermal processes: Wiley.
- Henning H-M. 2007. Solar assisted air conditioning of buildings - an overview. Applied Thermal Engineering 27(10):1734-1749; DOI: 10.1016/j.applthermaleng.2006.07.021

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#### Links

#### Languages of instruction

**Duration (semesters)** 1 Semester

#### Module frequency

**Module capacity** unlimited

**Modullevel / module level** MM (Mastermodul / Master module)

**Modulart / typ of module** Pflicht / Mandatory

#### Lehr-/Lernform / Teaching/Learning method

#### Vorkenntnisse / Previous knowledge

Examination	Time of examination	Type of examination
<b>Final exam of module</b>	At the end of the lecture period; submission of the report at the end of the semester	2 Examinations: Written Exam (1.5h, weight 50%) and Presentation of a Paper (15 min presentation, 5 pages report, weight 50%)

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>

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## pre042 - Water and Biomass Energy

<b>Module label</b>	Water and Biomass Energy
<b>Module code</b>	pre042
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( 180 Stunden )
<b>Applicability of the module</b>	<ul style="list-style-type: none"><li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li><li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li></ul>
<b>Responsible persons</b>	Wark, Michael (Authorized examiners)  Holtorf, Hans-Gerhard (Authorized examiners)  Pehlken, Alexandra (Authorized examiners)  Wark, Michael (Module responsibility)  Holtorf, Hans-Gerhard (Module responsibility)
<b>Prerequisites</b>	
<b>Skills to be acquired in this module</b>	

After the completion of the module students should be able to

- critically evaluate and compare two Renewable Energy conversion processes which allow continuous power supply on demand (hydropower and biomass energy)
- confront those systems to a Renewable Energy conversion process with intermittent output (marine power)
- discuss extreme situations in Renewable Energy systems' source and transfer such situations to other Renewable Energy systems
- analyse various system components and their interconnections within a complex Renewable Energy supply system,
- evaluate the Renewable Energy supply systems' operational size and efficiency,
- critically evaluate non-technical impact and side effects when implementing renewable energy supply systems
- understand the basic chemical background of bioenergy-related materials, systems and processes

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### Module contents

Biomass Energy (Lecture - 90 h workload)

- Energy mix overview; gas, heat, electricity, Pros and Cons, of biomass,
- Chemical composition of biomass: sugar, cellulose, starch, fats, oils, proteins, lignin,
- Natural photosynthesis in plants: chemical storage of solar energy; general mechanisms,
- Chemistry and Biology (microorganism) of Biogas Technology,
- Conversion processes of biomass: classification, main pathways,
- Introduction to catalysis used in biomass conversion,
- Chemical fuels (chemical energy storage) from biomass,
- Routes to platform chemicals and separation processes,

- Technology concepts for bioenergy usage,
- Introduction into economical and legal constraints.

#### Hydro and Marine Power (Lecture + Excursion - 90 h workload)

- Revision of hydraulic basics and their application to hydro and marine power.
- Hydropower and marine power resources and their representation
- Technological and economical state of the art.
- Description of such systems' components, their characteristics, their interaction in a system, their main features and their challenges

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### Reader's advisory

#### Biomass Energy

- IEA (2019), Renewables 2019, IEA, Paris <https://www.iea.org/reports/renewables-2019>
- Fagerström, A., Al Seadi, T., Rasi, S., Briseid, T, (2018).
- The role of Anaerobic Digestion and Biogas in the Circular Economy. Murphy, J.D. (Ed.) IEA Bioenergy Task 37, 2018: 8
- IEA (2020), Outlook for biogas and biomethane: Prospects for organic growth, IEA, Paris <https://www.iea.org/reports/outlook-for-biogas-and-biomethane-prospects-for-organic-growth>
- International Finance Corporation. 2017. Converting Biomass to Energy: A Guide for Developers and Investors. Washington, DC © <https://openknowledge.worldbank.org/handle/10986/28305> License: CC BY-NC-ND 3.0 IGO.
- Cushion, Elizabeth, Adrian Whiteman, and Gerhard Dieterle. Bioenergy development: issues and impacts for poverty and natural resource management
- Pehlken, A., Wulf, K., Grecksch, K., Klenke, T., Tsydenova, N.; More Sustainable Bioenergy by Making Use of Regional Alternative Biomass?, Sustainability 2020, 12(19), 7849; <https://doi.org/10.3390/su12197849>
- Schlögl, Robert (2013). Chemical energy storage (Elektronische Ressource ed.). Berlin [u.a.]: De Gruyter.
- Sackheim, G.I., Lehman, D.D.: Chemistry for the Health Sciences (8<sup>th</sup> edition), Prentice Hall, 1998
- Chemistry – General, Organic and Biological, Pearson International Edition (2<sup>nd</sup> edition), 2007
- Alonso, D.M., Bond, J.Q., Dumesic, J.A., Catalytic conversion of biomasses to biofuels, Green Chem. 12, 2010, 1493-1513

#### Hydro and Marine Power

- Charlier R.H., (2009) Ocean Energy: Tide and Tidal Power.
- Chtrakar P (2005) Micro-hydropower design aids manual: Small Hydropower Promotion Project, Mini Grid Support Programme. 107p.
- Croockewit J (2004) Handbook for developing micro hydro in British Columbia: BChydro. 69 p.
- Giesecke J, Heimerl S, Mosonyi E (2014) Wasserkraftanlagen: Springer Vieweg. XXVI, 940 p.
- Inversin AR (1986) Micro-hydropower sourcebook: NRECA International Foundation.
- Meder K (2011) Environment Assessment and Watershed Action Planning related to GIZ ECO MHP Projects: Field Manual. GIZ. 24 p.



- Pelikan B (2004) Guide on how to develop a small hydropower plant. European Small Hydropower Association ESHA. 151 p.
- Penche C (1988) Layman's handbook on how to develop a small hydro site; Commission E, editor.
- Rodriguez L, Sánchez T (2011) Designing and building mini and micro hydropower schemes - a practical guide; Action P, editor: Practical Action Publishing Ltd. xxii, 359 p.

<b>Links</b>				
<b>Language of instruction</b>		English		
<b>Duration (semesters)</b>		1 Semester		
<b>Module frequency</b>		Wintersemester		
<b>Module capacity</b>		unlimited		
<b>Reference text</b>				
<p>Within the lecture Hydro and Marine Power an excursion to a hydropower plant and the catchment area will be offered. The duration of this excursion will be in total 5 hours.</p> <p>It is recommended to know the basics of photosynthesis.</p>				
<b>Modullevel / module level</b>		MM (Mastermodul / Master module)		
<b>Modulart / typ of module</b>		Pflicht / Mandatory		
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>		Basics of - Hydrodynamics - Mechanical Engineering - Electrical Engineering - Recommended: Basic knowledge of General Chemistry		
<b>Examination</b>		<b>Time of examination</b>		<b>Type of examination</b>
<b>Final exam of module</b>		End of Winter Semester		Written Exam and active participation
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				56 h

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## pre113 - Photovoltaic Systems

<b>Module label</b>	Photovoltaic Systems
<b>Module code</b>	pre113
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( 180 Stunden )
<b>Applicability of the module</b>	<ul style="list-style-type: none"><li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li><li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li></ul>
<b>Responsible persons</b>	Holtorf, Hans-Gerhard (Authorized examiners)  Knipper, Martin (Authorized examiners)  Torio, Herena (Module responsibility)  Holtorf, Hans-Gerhard (Module responsibility)
<b>Prerequisites</b>	
<b>Skills to be acquired in this module</b>	

After successful completion of the module students should be able to:

- categorize and feature different PV systems
    - o PV on-grid,
    - o PV off-grid / stand alone,
    - o PV-pumping,
    - o PV-hybridby their setup and by standard quality indicators.
  - explain the operation principles of the listed PV systems
  - explain concepts behind PV system design
  - design a photovoltaic system by Fermi Estimate
  - design a photovoltaic system by a simulation software
  - be aware of the limitation of both design methods
  - discuss energy flow diagrams of PV systems
  - describe in depth involved balance of system components e.g.
    - o inverter,
    - o charge controllers
    - o cabling
    - o generator stand
- storage battery with a focus on housing (ventilation)

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### Module contents

This specialization module covers more in-depth topics concerning photovoltaics systems.

The module consists of:

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### Photovoltaic Systems Lecture (90h workload)

Description and operation of PV System's balance of system components

- o inverter,
- o charge controllers
- o cabling
- o generator stand
- o storage battery with a focus on housing (ventilation)

Quality indicators for PV Systems and their regional differences

- o PV on-grid,
- o PV off-grid / stand alone,
- o PV-pumping,
- o PV-hybrid

Sizing of PV systems – back of the envelope approach as well as by a simulation software

### Photovoltaic Systems Seminar (90h workload)

Within the seminar groups of up to five students select a PV system related research question, work on the solution and present their findings.

In addition, external PV experts are invited to present from their work experience.

An excursion to a PV power plant concludes the lessons learned in the field.

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#### **Reader's advisory**

- S. Hegedus, A. Luque, Handbook of Photovoltaic Science and Engineering, published John Wiley and Sons (2nd Edition 2011)
- C.B.Honsberg and S.G.Bowden, "Photovoltaics Education Website," [www.pveducation.org](http://www.pveducation.org), 2019, <https://www.pveducation.org/pvcdrom/welcome-to-pvcdrom/instructions>, Access date 21/07/2021
- Deutsche Gesellschaft fuer Solarenergie, Planning and installing photovoltaic systems: a guide for installers, architects and engineers. Earthscan, London, Third Edition, 2013 (ISBN-13: 978-1849713436)
- Heinrich Haeberlin, Photovoltaics: System Design and Practice, John Wiley and Sons, First Edition, Chichester, 2012.(ISBN-13: 978-1119992851)
- Konrad Mertens, Photovoltaik, Lehrbuch zu Grundlagen, Technologie und Praxis, 5. Aktualisierte Auflage
- GSES, Off-Grid PV Systems – Design and Installation, first edition international, April 2020
- Lecture notes for the respective courses

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#### **Links**

**Languages of instruction** German, English

**Duration (semesters)** 1 Semester

**Module frequency**

**Module capacity** unlimited

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<b>Modullevel / module level</b>	SPM (Schwerpunktmodul / Main emphasis)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Lecture, Exercise, Seminar & Excursion	
<b>Vorkenntnisse / Previous knowledge</b>	It is desirable to have passed the lecture Photovoltaics 5.06.M121	
Examination	Time of examination	Type of examination
<b>Final exam of module</b>	Throughout the Semester	

Active Participation and Seminar Presentation

Lecture, Exercise, Seminar & Excursion

Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>

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## pre114 - Solar Energy Meteorology

<b>Module label</b>	Solar Energy Meteorology
<b>Module code</b>	pre114
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( 180 Stunden )
<b>Applicability of the module</b>	<ul style="list-style-type: none"><li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li><li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li></ul>
<b>Responsible persons</b>	Torio, Herena (Module responsibility)  Holtorf, Hans-Gerhard (Module responsibility)  Schmidt, Thomas (Authorized examiners)
<b>Prerequisites</b>	Successful participation in "Energy Meteorology 5.06.M117"
<b>Skills to be acquired in this module</b>	

After successful completion of the module students should be able to

- explain the concepts of physical processes governing the surface solar irradiance available for solar energy applications
- model the solar radiation and show their expertise in application, adaptation and development of models
- discuss state-of-the-art-methods in satellite-based irradiance estimation and solar power forecasting
- discuss and present state of the art of the application of modern solar energy meteorology on a wide range (from residential systems to solar power plants, from solar thermal to photovoltaic systems)

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### Module contents

This specialization module covers more in-depth topics concerning solar energy meteorology.

Based on students' knowledge about the solar resource, solar thermal and photovoltaic technology, students deepen their knowledge on the resource for such systems.

#### I. Adv. Solar Energy Meteorology (Lecture - 90 h workload)

- Physics of radiative processes in the atmosphere
- Physical modelling of atmospheric radiative transfer (incl. computing tools)
- Solar irradiance modelling for solar energy applications
- Solar spectral irradiance: Theory and relevance for solar energy systems
- Satellite-based estimation of solar irradiance
- Solar irradiance (and solar power) forecasting
- Solar radiation measurements: Basics and setup of high quality measurement system

#### II. Solar Energy Meteorology Applications (Lecture and Seminar – 90h workload)

- sources of solar data and discussion of their quality
- solar resource assessment:
  - o basic models,
  - o measurements,
  - o satellite models
  - o data sets
- validation and application of solar resource data sets
- forecasting of solar radiation: sky-camera forecasts, satellite-based forecasts, numerical weather predictions, statistical methods
- forecast validation
- selected applications
- irradiance and PV power forecasting
- application of solar resource data for yield assessment

#### Reader's advisory

- S. Hegedus, A. Luque, Handbook of Photovoltaic Science and Engineering, published John Wiley and Sons (2nd Edition 2011)
- MSG Cloud Physical Properties (CPP) by KNMI [http://msgcpp.knmi.nl/mediawiki/index.php/MSG\\_Cloud\\_Physical\\_Properties\\_\(CPP\)](http://msgcpp.knmi.nl/mediawiki/index.php/MSG_Cloud_Physical_Properties_(CPP))
- CAMS Copernicus Atmospheric monitoring service <https://atmosphere.copernicus.eu/catalogue#/product/urn:xwmo:md:int.ecmwf::copernicus:cams:prod:an:surface-solar-irradiation:pid327>
- [https://wui.cmsaf.eu/safira/action/viewDoiDetails?acronym=SARAH\\_V001](https://wui.cmsaf.eu/safira/action/viewDoiDetails?acronym=SARAH_V001)
- <https://nsrdb.nrel.gov/>
- [re.jrc.ec.europa.eu/pvgis/](http://re.jrc.ec.europa.eu/pvgis/)

Links				
<b>Language of instruction</b>	English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>	Annual, summer semester			
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>	Presence (when possible)			
<b>Vorkenntnisse / Previous knowledge</b>	Physical principles of Black Body Radiation Basics of Solar Radiation			
Examination	Time of examination	Type of examination		
<b>Final exam of module</b>	During the semester	1 Referat		
Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				56 h

## phy964 - Advanced Computing

<b>Module label</b>	Advanced Computing			
<b>Module code</b>	phy964			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Biomedical Physics</li> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		4	SoSe oder WiSe	56
Exercises		4	SoSe oder WiSe	56
<b>Total time of attendance for the module</b>				112 h

# European Wind Energy Master

## phy616 - Computational Fluid Dynamics 1 / 2

<b>Module label</b>	Computational Fluid Dynamics 1 / 2	
<b>Module code</b>	phy616	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> <li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li> </ul>	
<b>Responsible persons</b>	Lukassen, Laura (Authorized examiners)  Stoevesandt, Bernhard (Authorized examiners)  Lukassen, Laura (Module responsibility)	
<b>Prerequisites</b>	Fluid Dynamics I	
<b>Skills to be acquired in this module</b>	Deeper understanding of the fundamental equations of fluid dynamics. Overview of numerical methods for the solution of the fundamental equations of fluid dynamics. Confrontation with complex problems in fluid dynamics. To become acquainted with different, widely used CFD models that are used to study complex problems in fluid dynamics. Ability to apply these CFD models to certain defined problems and to critically evaluate the results of numerical models.	
<b>Module contents</b>	CFD I: The Navier-Stokes equations, filtering / averaging of Navier- Stokes equations, introduction to numerical methods, finite- differences, finite-volume methods, linear equation systems, NS-solvers, RANS, URANS, LES, DNS, turbulent flows, incompressible flows, compressible flows, efficiency and accuracy. CFD II: Introduction to different CFD models, such as OpenFOAM and PALM. Application of these CFD models to defined problems from rotor aerodynamics and the atmospheric boundary layer.	
<b>Reader's advisory</b>	J.H. Ferziger, M. Peric, Computational Methods for Fluid Dynamics, Springer, 2002; C. Hirsch, Numerical Computation of Internal and External Flows: Introduction to the Fundamentals of CFD, Vol 1: Fundamentals of Computational Fluid Dynamics, 2nd edition, Butterworth-Heinemann, Amsterdam; P. Sagaut, Large Eddy Simulation for Incompressible Flows, Springer, Berlin, 1998; J. Fröhlich, Large Eddy Simulationen turbulenter Strömungen, Teubner, Wiesbaden, 2006 (in German)	
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	Sommersemester	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Pflicht / Mandatory	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Lecture: 2hrs/week, Excercise: 2hrs/week	
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>	<ul style="list-style-type: none"> <li>• 1 Klausur oder</li> <li>• 1 Referat oder</li> <li>• 1 mündliche Prüfung oder</li> <li>• 1 fachpraktische Übung</li> </ul>	
<b>Course type</b>	Course selection ( Vorlesungen oder Praktikum oder Seminar )	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	



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**Workload attendance**

56 h

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## phy659 - Introduction to Micro Meteorology

<b>Module label</b>	Introduction to Micro Meteorology	
<b>Module code</b>	phy659	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Language of instruction</b>	German	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Pflicht / Mandatory	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Course selection ( Das Modul wird an der Patnerhochschule angeboten. )	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

## phy670 - Fluidynamics II/Wind Energy Meterology

<b>Module label</b>	Fluidynamics II/Wind Energy Meterology			
<b>Module code</b>	phy670			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Language of instruction</b>	German			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Pflicht / Mandatory			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>

## phy673 - Diffusions and Stochastic Differential Equations

<b>Module label</b>	Diffusions and Stochastic Differential Equations	
<b>Module code</b>	phy673	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Language of instruction</b>	German	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Pflicht / Mandatory	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture and tutorial ( Das Modul wird an der Patnerhochschule angeboten. )	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

## phy674 - Turbulence Theory

<b>Module label</b>	Turbulence Theory	
<b>Module code</b>	phy674	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Language of instruction</b>	German	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Pflicht / Mandatory	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture and tutorial ( Das Modul wird an der Patnerhochschule angeboten. )	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

## phy684 - Wind Turbine Technology and Aerodynamics

<b>Module label</b>	Wind Turbine Technology and Aerodynamics			
<b>Module code</b>	phy684			
<b>Credit points</b>	10.0 KP			
<b>Workload</b>	300 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Language of instruction</b>	German			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Pflicht / Mandatory			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture (Das Modul wird an der Patnerhochschule angeboten.)		2	SoSe oder WiSe	28
Seminar (Das Modul wird an der Patnerhochschule angeboten.)		2	SoSe oder WiSe	28
Exercises (Das Modul wird an der Patnerhochschule angeboten.)		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>84 h</b>

## phy688 - Planning and Development of Wind Farms

<b>Module label</b>	Planning and Development of Wind Farms	
<b>Module code</b>	phy688	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Language of instruction</b>	German	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Pflicht / Mandatory	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Course selection ( Das Modul wird an der Patnerhochschule angeboten. )	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

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## phy692 - Research Project EWEM

<b>Module label</b>	Research Project EWEM	
<b>Module code</b>	phy692	
<b>Credit points</b>	9.0 KP	
<b>Workload</b>	270 h	
<b>Applicability of the module</b>	• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Languages of instruction</b>		
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		BE
<b>Course type</b>	Seminar	
<b>SWS</b>		
<b>Frequency</b>		
<b>Workload attendance</b>	0 h	



## phy991 - Stochastic Processes

<b>Module label</b>	Stochastic Processes			
<b>Module code</b>	phy991			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Language of instruction</b>	English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>84 h</b>

## phy992 - Time Series Analysis

<b>Module label</b>	Time Series Analysis			
<b>Module code</b>	phy992			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Language of instruction</b>	German			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>

## phy993 - Advanced Time Series Analysis

<b>Module label</b>	Advanced Time Series Analysis			
<b>Module code</b>	phy993			
<b>Credit points</b>	10.0 KP			
<b>Workload</b>	300 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Language of instruction</b>	German			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		4	SoSe oder WiSe	56
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>84 h</b>

## phy994 - Optimization and Data Fitting

<b>Module label</b>	Optimization and Data Fitting			
<b>Module code</b>	phy994			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Language of instruction</b>	English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Practical training		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>

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## phy995 - Physics of Sustainable Energy

<b>Module label</b>	Physics of Sustainable Energy	
<b>Module code</b>	phy995	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Applicability of the module</b>	• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Language of instruction</b>	German	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

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## phy996 - Offshore Wind Energy

<b>Module label</b>	Offshore Wind Energy	
<b>Module code</b>	phy996	
<b>Credit points</b>	10.0 KP	
<b>Workload</b>	300 h	
<b>Applicability of the module</b>	• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture	
<b>SWS</b>	6	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	84 h	

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## phy997 - Wind Turbine Measurement Techniques

<b>Module label</b>	Wind Turbine Measurement Techniques	
<b>Module code</b>	phy997	
<b>Credit points</b>	10.0 KP	
<b>Workload</b>	300 h	
<b>Applicability of the module</b>	• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Language of instruction</b>	German	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture	
<b>SWS</b>	6	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	84 h	

## phy998 - Probabilistic Methods in Wind Energy

<b>Module label</b>	Probabilistic Methods in Wind Energy			
<b>Module code</b>	phy998			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Language of instruction</b>	German			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>



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## phy621 - Advanced Engineering Topics in Wind Energy

<b>Module label</b>	Advanced Engineering Topics in Wind Energy	
<b>Module code</b>	phy621	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Applicability of the module</b>	• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	EB (Ergänzungsbereich / Complementary)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Course selection	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	28 h	

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## phy622 - Advanced Topics in Wind Energy

<b>Module label</b>	Advanced Topics in Wind Energy	
<b>Module code</b>	phy622	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Applicability of the module</b>	• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Language of instruction</b>	German	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	EB (Ergänzungsbereich / Complementary)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Course selection	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	28 h	

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## phy645 - Wind Physics Measurement Project

<b>Module label</b>	Wind Physics Measurement Project	
<b>Module code</b>	phy645	
<b>Credit points</b>	3.0 KP	
<b>Workload</b>	90 h	
<b>Applicability of the module</b>	• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	EB (Ergänzungsbereich / Complementary)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	28 h	

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## phy985 - Stochastic Processes in Experiments

<b>Module label</b>	Stochastic Processes in Experiments	
<b>Module code</b>	phy985	
<b>Credit points</b>	3.0 KP	
<b>Workload</b>	90 h	
<b>Applicability of the module</b>	• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	EB (Ergänzungsbereich / Complementary)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Seminar	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	28 h	

## phy624 - Composite Materials and Fibres

<b>Module label</b>	Composite Materials and Fibres			
<b>Module code</b>	phy624			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>

## phy627 - Emerging and disruptive Technologies of Electricity Grids

<b>Module label</b>	Emerging and disruptive Technologies of Electricity Grids			
<b>Module code</b>	phy627			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>

## phy628 - Modelling and Analysis of Sustainable Energy Systems using Operations Research

<b>Module label</b>	Modelling and Analysis of Sustainable Energy Systems using Operations Research			
<b>Module code</b>	phy628			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				56 h

## phy629 - Optimization in modern Power Systems

<b>Module label</b>	Optimization in modern Power Systems			
<b>Module code</b>	phy629			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>



## phy657 - Experimental Structural Mechanics

<b>Module label</b>	Experimental Structural Mechanics			
<b>Module code</b>	phy657			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>

## phy675 - Integration of Wind Power in the Power System

<b>Module label</b>	Integration of Wind Power in the Power System			
<b>Module code</b>	phy675			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Pflicht / Mandatory			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>

## phy981 - HardTech Entrepreneurship

<b>Module label</b>	HardTech Entrepreneurship			
<b>Module code</b>	phy981			
<b>Credit points</b>	10.0 KP			
<b>Workload</b>	300 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>

## phy983 - Life Cycle Assessment of Products and Systems

<b>Module label</b>	Life Cycle Assessment of Products and Systems			
<b>Module code</b>	phy983			
<b>Credit points</b>	10.0 KP			
<b>Workload</b>	300 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>

## phy986 - System Safety and Reliability Engineering

<b>Module label</b>	System Safety and Reliability Engineering			
<b>Module code</b>	phy986			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>

## phy623 - Advanced Wind Energy Meteorology

<b>Module label</b>	Advanced Wind Energy Meteorology			
<b>Module code</b>	phy623			
<b>Credit points</b>	3.0 KP			
<b>Workload</b>	90 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>	TEST			
<b>Module contents</b>	Test			
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Pflicht / Mandatory			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>

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## phy625 - Deep Learning

<b>Module label</b>	Deep Learning	
<b>Module code</b>	phy625	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Applicability of the module</b>	• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>	Kompetenzziele	
<b>Module contents</b>	Inhalt	
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	28 h	

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## phy626 - Dynamical Systems

<b>Module label</b>	Dynamical Systems	
<b>Module code</b>	phy626	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Applicability of the module</b>	• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Pflicht / Mandatory	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	28 h	



## phy631 - Advanced Metrology

<b>Module label</b>	Advanced Metrology			
<b>Module code</b>	phy631			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> <li>• Master's Programme Engineering Physics (Master) &gt; Pflichtmodule</li> </ul>			
<b>Responsible persons</b>	<p>Huke, Philipp (Module responsibility)</p> <p>Huke, Philipp (Authorized examiners)</p> <p>Huke, Philipp (Module counselling)</p>			
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>	<p>The course in Advanced Metrology sets up a high level route enabling the students to acquire skills to allow them to operate effectively in the majors of Engineering Physics. This is achieved by provision of state-of-the-art technical and physical approaches covering broad aspects of advanced metrology within the context of Laser&amp;optics, Biomedical physics &amp; acoustics, and renewable energies.</p> <p>Demonstrate systematic knowledge across appropriate advanced metrology technologies, management and environmental issues to provide solutions for international industries and/or research organisations</p>			
<b>Module contents</b>	<p>The module combines theory and practical applications of the fundamentals of metrology in all majors.</p> <ul style="list-style-type: none"> <li>• Fundamentals of Metrology</li> <li>• Dimensional Measurement Systems</li> <li>• Basic metrology operators including Association and Filtration.</li> <li>• Optical Metrology and Instrumentation</li> <li>• Surface and Nanometrology</li> <li>• Machine Tool and Large Volume Metrology</li> <li>• Process Measurement and Control</li> <li>• Individual Project</li> </ul>			
<b>Reader's advisory</b>	T. Yoshizawa (Ed.): Handbook of Optical Metrology: Principles and Applications, 2nd rev. ed., Crc Pr Inc., 2015 Recent publications on specific topics			
<b>Links</b>				
<b>Language of instruction</b>	English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>	halbjährlich			
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	je nach Studiengang Pflicht oder Wahlpflicht			
<b>Lehr-/Lernform / Teaching/Learning method</b>	Lecture: 4 hrs/week first, 2 hrs/week second half of semester Experimental /Seminar work: 0 hrs/week first, 2 hrs/week second half of semester			
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Time of examination		Type of examination	
<b>Final exam of module</b>			1 written exam or 1 presentation or 1 oral exam or 1 seminar paper	
Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Course selection (Specialization Biomedical Physics)		4	WiSe	56
Course selection (Specialization Acoustics)		2	WiSe	28
Course selection (Specialization Renewable Energies)		2	WiSe	28
Course selection (Specialization Laser & Optics)		2	WiSe	28
<b>Total time of attendance for the module</b>				140 h



## phy982 - Intelligent Systems

<b>Module label</b>	Intelligent Systems			
<b>Module code</b>	phy982			
<b>Credit points</b>	10.0 KP			
<b>Workload</b>	300 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>56 h</b>

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## phy988 - Introduction to Machine Learning and Data Mining

<b>Module label</b>	Introduction to Machine Learning and Data Mining	
<b>Module code</b>	phy988	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Applicability of the module</b>	• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
<b>Responsible persons</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Reader's advisory</b>		
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	28 h	

# Schwerpunkt: Acoustics

## phy605 - Digital Signal Processing

<b>Module label</b>	Digital Signal Processing	
<b>Module code</b>	phy605	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> </ul>	
<b>Responsible persons</b>	Doclo, Simon (Authorized examiners)  Doclo, Simon (Module responsibility)	
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>	The students acquire knowledge about theoretical concepts and methods of signal processing and system theory for discrete-time signals and systems. The students are able to apply these theoretical concepts and methods in analytical, numerical and programming exercises.	
<b>Module contents</b>	System properties (stability, linearity, time-invariance, causality); Discrete-time signal processing: sampling theorem, time-domain analysis (impulse response, convolution), z-transform, frequency-domain analysis (transfer function, discrete-time Fourier transform, discrete Fourier transform, FFT, STFT), digital filter design (FIR, IIR, linear phase filter, all-pass filter, signal flow graph), multi-rate signal processing (down/up-sampling, filter banks); Statistical signal processing: stationarity, ergodicity, correlation, Wiener-Khinchin theorem, spectral estimation; Adaptive filters: optimal filters, Wiener filter, time-domain algorithms (RLS, NLMS), frequency-domain algorithms (FDAF); Matlab exercises about discrete-time signal processing and adaptive filters.	
<b>Reader's advisory</b>	<p>A. V. Oppenheim, R. W. Schaffer, "Discrete-Time Signal Processing", Prentice Hall, 2013.</p> <p>J. G. Proakis, D. G. Manolakis, "Digital Signal Processing – Principles, Algorithms and Applications", Prentice Hall, 2013.</p> <p>S. Haykin, "Adaptive Filter Theory", Pearson, 2013.</p> <p>P. P. Vaidyanathan, "Multirate systems and filter banks", Prentice Hall, 1993.</p> <p>K.-D. Kammeyer, K. Kroschel, "Digitale Signalverarbeitung: Filterung und Spektralanalyse mit MATLAB Übungen", Broschert, 2018</p>	
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>		
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Vorlesung: 2 SWS, Übung: 2 SWS	
<b>Vorkenntnisse / Previous knowledge</b>	Basic knowledge about continuous-time signals and systems and statistics. In addition, Matlab programming skills are required.	
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		Max. 180 min. Klausur oder 30 min. mündliche Prüfung
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

## phy677 - Speech processing

<b>Module label</b>	Speech processing	
<b>Module code</b>	phy677	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( 180 h (Präsenzzeit 56h, Selbststudium: 124h) )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> </ul>	
<b>Responsible persons</b>	<p>Doclo, Simon (Authorized examiners)</p> <p>Kollmeier, Birger (Authorized examiners)</p> <p>Meyer, Bernd (Authorized examiners)</p> <p>Doclo, Simon (Module responsibility)</p>	
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>	The students will be able to (a) explain the foundations of speech production, perception and analysis, (b) understand the mathematical and information-theoretical principles of speech signal processing, and (c) apply the studied methods to explain the working principle of practical speech processing systems.	
<b>Module contents</b>	Speech production and perception, speech analysis, speech signal processing (STFT, LPC, cepstrum, speech enhancement), speech coding, speech synthesis, automatic speech recognition, speech quality and intelligibility measures, selected topics on speech processing research.	
<b>Reader's advisory</b>	<p>M. R. Schroeder, Computer Speech: Recognition, Compression, Synthesis, Springer, 2013.</p> <p>J. R. Deller, J. H. L. Hansen, J. G. Proakis: Discrete-Time Processing of Speech Signals, Wiley-IEEE Press, 1999.</p> <p>P. Vary, R. Martin: Digital Speech Transmission, Wiley, 2006.</p> <p>J. Benesty, M. M. Sondhi, Y. Huang: Handbook of Speech Processing, Springer, 2008.</p> <p>D. Yu, L. Deng: Automatic Speech Recognition: A Deep Learning Approach, Springer, 2015.</p>	
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	jährlich	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Vorlesung: 2 SWS, Übung: 2 SWS	
<b>Vorkenntnisse / Previous knowledge</b>	Introductory signals and systems lecture	
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

## phy679 - Acoustics

<b>Module label</b>	Acoustics	
<b>Module code</b>	phy679	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> </ul>	
<b>Responsible persons</b>	<p>Ewert, Stephan (Authorized examiners)</p> <p>Kollmeier, Birger (Authorized examiners)</p> <p>van de Par, Steven (Authorized examiners)</p> <p>van de Par, Steven (Module responsibility)</p>	
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>	The students acquire knowledge about advanced concepts in acoustics, electro-acoustics, room acoustics, acoustical measurement methods and virtual acoustics. The students acquire skills to critically and independently apply these concepts and methods to acoustical problems.	
<b>Module contents</b>	Acoustical measurement methods (sound pressure, spectrum, transfer function, intensity); Non-linear measurement methods (Hammerstein model); Inverse problems in acoustics and regularization; High-resolution methods, acoustic camera; Binaural virtual acoustics; Spherical harmonics, virtual acoustics (Ambisonics, Wave Field Synthesis); Transaural systems; Room acoustics simulation.	
<b>Reader's advisory</b>	<p>G. Müller, M. Möser: Akustische Messtechnik, Springer, 2017;</p> <p>H. Kuttruff: Room Acoustics, CRC Press, 2016;</p> <p>M. Vorländer: Auralization: Fundamentals of Acoustics, Modelling, Simulation, Algorithms and Acoustic Virtual Reality, Springer, 2020</p>	
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	jährlich	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Lecture: 3hrs/week; Excercise: 1hrs/week	
<b>Vorkenntnisse / Previous knowledge</b>	Introductory acoustics lecture	
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

## phy685 - Advanced Engineering Topics in Biomedical Physics & Acoustics

<b>Module label</b>	Advanced Engineering Topics in Biomedical Physics & Acoustics	
<b>Module code</b>	phy685	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Overall workload of 180 h )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Biomedical Physics</li> </ul>	
<b>Responsible persons</b>	<p>Doclo, Simon (Module responsibility)</p> <p>Poppe, Björn (Module responsibility)</p> <p>Anemüller, Jörn (Authorized examiners)</p> <p>Blau, Matthias (Authorized examiners)</p> <p>Brand, Thomas (Authorized examiners)</p> <p>Dietz, Mathias (Authorized examiners)</p> <p>Doclo, Simon (Authorized examiners)</p> <p>Ewert, Stephan (Authorized examiners)</p> <p>Hohmann, Volker (Authorized examiners)</p> <p>Kollmeier, Birger (Authorized examiners)</p> <p>Lücke, Jörg (Authorized examiners)</p> <p>Meyer, Bernd (Authorized examiners)</p> <p>Oetjen, Arne (Authorized examiners)</p> <p>Poppe, Björn (Authorized examiners)</p> <p>Siedenburg, Kai (Authorized examiners)</p> <p>Uppenkamp, Stefan (Authorized examiners)</p> <p>van de Par, Steven (Authorized examiners)</p>	
<b>Prerequisites</b>	Related to selected course/s	
<b>Skills to be acquired in this module</b>	The aim of this module is, to give students further access to also small courses (3 CP) which address the specific interest of the student and deliver unique in-depth knowledge or the opportunity to train specific engineering skills.	
<b>Module contents</b>	Photonics, Optics, Metrology,	
<b>Reader's advisory</b>	Related to selected course/s	
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	Sommer- oder Wintersemester	
<b>Module capacity</b>	unlimited	
<b>Reference text</b>	This module offers special as well as advanced engineering courses in Biomedical Physics and Acoustics. The list of eligible courses will be updated each academic year. Please refer to the courses listed for this module in Stud.IP.	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Related to selected course/s	
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Time of examination	Type of examination



Examination		Time of examination	Type of examination	
<b>Final exam of module</b>			Related to selected course/s	
Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		4	SoSe oder WiSe	56
Seminar		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
Practical training		1	SoSe oder WiSe	14
<b>Total time of attendance for the module</b>				126 h

## phy686 - Advanced Topics in Biomedical Physics & Acoustics

<b>Module label</b>	Advanced Topics in Biomedical Physics & Acoustics			
<b>Module code</b>	phy686			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Overall workload of 180 h )			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Biomedical Physics</li> </ul>			
<b>Responsible persons</b>	<p>Anemüller, Jörn (Authorized examiners)</p> <p>Blau, Matthias (Authorized examiners)</p> <p>Brand, Thomas (Authorized examiners)</p> <p>Dietz, Mathias (Authorized examiners)</p> <p>Doclo, Simon (Authorized examiners)</p> <p>Ewert, Stephan (Authorized examiners)</p> <p>Hohmann, Volker (Authorized examiners)</p> <p>Kollmeier, Birger (Authorized examiners)</p> <p>Lücke, Jörg (Authorized examiners)</p> <p>Meyer, Bernd (Authorized examiners)</p> <p>Oetjen, Arne (Authorized examiners)</p> <p>Poppe, Björn (Authorized examiners)</p> <p>Siedenburg, Kai (Authorized examiners)</p> <p>Uppenkamp, Stefan (Authorized examiners)</p> <p>van de Par, Steven (Authorized examiners)</p> <p>Doclo, Simon (Module responsibility)</p> <p>Poppe, Björn (Module responsibility)</p>			
<b>Prerequisites</b>	Related to selected course/s			
<b>Skills to be acquired in this module</b>	The aim of this module is, to give students further access to also small courses (3 CP) which address the specific interest of the student and deliver unique in-depth knowledge or the opportunity to train specific engineering skills.			
<b>Module contents</b>	Photonics, Optics, Metrology,			
<b>Reader's advisory</b>	Related to selected course/s			
<b>Links</b>				
<b>Language of instruction</b>	English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>	Sommer- oder Wintersemester			
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>	Related to selected course/s			
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Time of examination	Type of examination		
<b>Final exam of module</b>	Related to selected course/s			
Course type	Comment	SWS	Frequency	Workload of compulsory attendance

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Course type	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		4	SoSe oder WiSe	56
Seminar			SoSe oder WiSe	0
<b>Total time of attendance for the module</b>				<b>56 h</b>

## phy694 - Machine Learning II

<b>Module label</b>	Machine Learning II	
<b>Module code</b>	phy694	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> </ul>	
<b>Responsible persons</b>	<p>Lücke, Jörg (Authorized examiners)</p> <p>Lücke, Jörg (Module responsibility)</p>	
<b>Prerequisites</b>	<p>The course requires the introductory course "Machine Learning - Probabilistic Unsupervised Learning" or equivalent courses. Furthermore, basic knowledge in higher Mathematics as taught as part of first degrees in Physics, Mathematics, Statistics, Engineering or Computer Science (basic linear algebra and analysis) is required. Additionally, programming skills are required (the course supports matlab and python). Many relations to statistical physics, statistics, probability theory, stochastic exist but the course's content will be developed independently of detailed prior knowledge in these fields.</p>	
<b>Skills to be acquired in this module</b>	<p>The students will deepen their knowledge on mathematical models of data and sensory signals. Building up on the previously acquired Machine Learning models and methods, the students will be lead closer to current research topics and will learn about models that currently represent the state-of-the-art. Based on these models, the students will be exposed to the typical theoretical and practical challenges in the development of current Machine Learning algorithms. Typical such challenges are analytical and computational intractabilities, or local optima problems. Based on concrete examples, the students will learn how to address such problems. Applications to different data will teach skills to use the appropriate model for a desired task and the ability to interpret an algorithm's result as well as ways for further improvements. Furthermore, the students will learn interpretations of biological and artificial intelligence based on state-of-the-art Machine Learning models.</p>	
<b>Module contents</b>	<p>This course builds up on the basic models and methods introduced in introductory Machine Learning lectures. Advanced Machine Learning models will be introduced alongside methods for efficient parameter optimization. Analytical approximations for computationally intractable models will be defined and discussed as well as stochastic (Monte Carlo) approximations. Advantages of different approximations will be contrasted with their potential disadvantages. Advanced models in the lecture will include models for clustering, classification, recognition, denoising, compression, dimensionality reduction, deep learning, tracking etc. Typical application domains will be general pattern recognition, computational neuroscience and sensory data models including computer hearing and computer vision.</p>	
<b>Reader's advisory</b>	<p>Pattern Recognition and Machine Learning, C. M. Bishop, Springer 2006. (best suited for lecture).; Information Theory, Inference, and Learning Algorithms, D. MacKay, Cambridge University Press, 2003. (free online)</p>	
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	Sommersemester	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modular / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Lecture: 2hrs/week, Exercise: 2hrs/week (incl. prog. laboratory)	
<b>Vorkenntnisse / Previous knowledge</b>	<p>Basic knowledge in higher Mathematics taught as part of first degrees in Physics, Mathematics, Statistics, Engineering or Computer Science (basic linear algebra and analysis) is required. Additionally, programming skills are required (Matlab or python).</p>	
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>		KL
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

## phy696 - Advanced Topics Speech and Audio Processing

<b>Module label</b>	Advanced Topics Speech and Audio Processing	
<b>Module code</b>	phy696	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> </ul>	
<b>Responsible persons</b>	Doclo, Simon (Module responsibility)	
<b>Prerequisites</b>	Basic principles of signal processing (preferably successfully completed the course Signal- und Systemtheorie and/or Blockpraktikum Digitale Signalverarbeitung)	
<b>Skills to be acquired in this module</b>	The students will gain in-depth knowledge on the subjects' speech and audio processing. The practical part of the course mediates insight about important properties of the methods treated in a self-study approach, while the application and transfer of theoretical concepts to practical applications is gained by implementing algorithms on a computer.	
<b>Module contents</b>	After reviewing the basic principles of speech processing and statistical signal processing (adaptive filtering, estimation theory), this course covers techniques and underlying algorithms that are essential in many modern-day speech communication and audio processing systems (e.g. mobile phones, hearing aids, headphones): acoustic echo and feedback cancellation, noise reduction, dereverberation, microphone and loudspeaker array processing, active noise control. During the exercises a typical hands-free speech communication or audio processing system is implemented (in Matlab).	
<b>Reader's advisory</b>	J. Benesty, M. M. Sondhi, Y. Huang: Handbook of Speech Processing, Springer, 2008.; P. Vary, R. Martin: Digital Speech Transmission, Wiley, 2006.; P. Loizou: Speech Enhancement: Theory and Practice, CRC Press, 2007.; S. Vaseghi: Advanced Digital Signal Processing and Noise Reduction, Wiley, 2006.; S. Haykin: Adaptive Filter Theory, Prentice Hall, 2013.	
<b>Links</b>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	jährlich	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	Wahlpflicht / Elective	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Vorlesung: 2 SWS, Übung: 2 SWS	
<b>Vorkenntnisse / Previous knowledge</b>	Basic principles of discrete-time signal processing (preferably completed the course Digital Signal Processing). In addition, Matlab programming skills are required	
<b>Examination</b>	Time of examination	Type of examination
<b>Final exam of module</b>	Exam or presentation or oral exam or homework or practical report	
<b>Course type</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload attendance</b>	56 h	

## phy960 - Psychoacoustics

<b>Module label</b>	Psychoacoustics			
<b>Module code</b>	phy960			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( 180 h (Präsenzzeit 56h, Selbststudium: 124h) )			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> </ul>			
<b>Responsible persons</b>	van de Par, Steven (Module responsibility)			
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>	The students acquire knowledge about concepts and methods in auditory perception, psychoacoustics, subjective test design, and auditory scene analysis. The students acquire skills to apply these concepts and methods in practice (e.g. sound quality measurement, signal processing algorithms).			
<b>Module contents</b>	<p><i>Applied psychophysics</i></p> <p>Subjective listening experiment design and models of human auditory perception will be treated with a focus on application in sound quality measurement (e.g. for vehicle noise and sound reproduction) and in digital signal processing algorithm development (e.g. for low bit-rate audio coding and headphone virtualizers).</p> <p><i>Auditory Scene Analysis in Speech and Music</i></p> <p>Basic principles of auditory scene analysis: sequential and simultaneous segregation, schema-based segregation; scene analysis in music perception: the cocktail party problem, speech intelligibility in complex acoustic environments, hearing loss, and experimental methods; speech and music perception with hearing aids and cochlear implants</p>			
<b>Reader's advisory</b>	<p>H. Fastl, E. Zwicker: Psychoacoustics: Facts and Models, Springer, 2007.</p> <p>A.S. Bregman: Auditory Scene Analysis, MIT press, 1990.</p> <p>P. Damaske: Acoustics and Hearing, Springer, 2008.</p>			
<b>Links</b>				
<b>Language of instruction</b>	English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>	jährlich			
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>	Vorlesung: 3 SWS, Übung: 1 SWS			
<b>Vorkenntnisse / Previous knowledge</b>	Introductory acoustics lecture			
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			Max. 180 min. Klausur oder 30 min. mündliche Prüfung (1 oder 2 Prüfungen)	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Total time of attendance for the module</b>				<b>84 h</b>

## phy964 - Advanced Computing

<b>Module label</b>	Advanced Computing			
<b>Module code</b>	phy964			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h			
<b>Applicability of the module</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Biomedical Physics</li> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> </ul>			
<b>Responsible persons</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Reader's advisory</b>				
<b>Links</b>				
<b>Languages of instruction</b>	German, English			
<b>Duration (semesters)</b>	1 Semester			
<b>Module frequency</b>				
<b>Module capacity</b>	unlimited			
<b>Modullevel / module level</b>	MM (Mastermodul / Master module)			
<b>Modulart / typ of module</b>	Wahlpflicht / Elective			
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Time of examination		Type of examination	
<b>Final exam of module</b>			KL	
<b>Course type</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		4	SoSe oder WiSe	56
Exercises		4	SoSe oder WiSe	56
<b>Total time of attendance for the module</b>				112 h

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# Abschlussmodul

## mam - Master's Thesis Module

<b>Module label</b>	Master's Thesis Module
<b>Module code</b>	mam
<b>Credit points</b>	30.0 KP
<b>Workload</b>	900 h
<b>Applicability of the module</b>	<ul style="list-style-type: none"><li>• Master's Programme Engineering Physics (Master) &gt; Abschlussmodul</li></ul>
<b>Responsible persons</b>	<p>der Masterarbeit, BetreuerIn (Module responsibility)</p> <p>Agert, Carsten (Authorized examiners)</p> <p>Brückner, Hans Josef (Authorized examiners)</p> <p>Biehs, Svend-Age (Authorized examiners)</p> <p>Brand, Thomas (Authorized examiners)</p> <p>Dietz, Mathias (Authorized examiners)</p> <p>Doclo, Simon (Authorized examiners)</p> <p>Ewert, Stephan (Authorized examiners)</p> <p>Hohmann, Volker (Authorized examiners)</p> <p>Feudel, Ulrike (Authorized examiners)</p> <p>Hartmann, Alexander (Authorized examiners)</p> <p>Schüning, Thomas (Authorized examiners)</p> <p>Kollmeier, Birger (Authorized examiners)</p> <p>Kühn, Martin (Authorized examiners)</p> <p>Kunz-Drolshagen, Jutta (Authorized examiners)</p> <p>Lienau, Christoph (Authorized examiners)</p> <p>Lücke, Jörg (Authorized examiners)</p> <p>Lukassen, Laura (Authorized examiners)</p> <p>Poppe, Björn (Authorized examiners)</p> <p>Neu, Walter (Authorized examiners)</p> <p>Meyer, Bernd (Authorized examiners)</p> <p>Nilius, Niklas (Authorized examiners)</p> <p>Peinke, Joachim (Authorized examiners)</p> <p>Schäfer, Sascha (Authorized examiners)</p> <p>Schmidt, Thorsten (Authorized examiners)</p> <p>Strybny, Jann (Authorized examiners)</p> <p>Struve, Bert (Authorized examiners)</p> <p>Teubner, Ulrich (Authorized examiners)</p> <p>Uppenkamp, Stefan (Authorized examiners)</p> <p>van de Par, Steven (Authorized examiners)</p> <p>Wark, Michael (Authorized examiners)</p>



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Wollenhaupt, Matthias (Authorized examiners)

<b>Prerequisites</b>	Master Curriculum Engineering Physics	
<b>Skills to be acquired in this module</b>	<p>As a general objective for the Master Thesis, the student shall demonstrate the ability to constructively, critically and independently formulate, discuss and communicate issues at stake, integrating theory and methodology. As specific competency objectives within the Master Thesis, after completion the student shall be able to:</p> <ul style="list-style-type: none"><li>- demonstrate knowledge of relevant and latest publications concerning the selected topic</li><li>- elaborate the Master Thesis on the basis of clearly formulated, general objectives and specific characteristics of the topic</li><li>- identify and put to use in an operational manner empirical or other scientific material and methods that are appropriate in relation to the subject</li><li>- develop a balanced discussion of material, methods, results and possible consequences of these in relation to the field of Renewable Energy</li><li>- present the Master Thesis orally and defend the results and conclusions in a critical discussion</li></ul> <p>The module is designed to apply and deepen the methodologies acquainted throughout the program to a specific scientific problem given by the supervisor. In order to achieve a result the student needs to apply scientific as well as keycompetencies described in the next section. Students have understood the scientific problem, they have learned the ropes of the problem, they have selected, acquainted or deepened a set of scientific and methodologies and key-competencies necessary to solve the problem and they have applied those methods.</p>	
<b>Module contents</b>	<p>The master thesis module finalizes and concludes the master programme. The student presents the achieved results as a written thesis and defends the results / conclusions to a board of examiners. Within this framework, the students work independently on a current topic from the research areas of the working groups. The work is accompanied by a seminar to present and review results and the progress of the work intermittently. The results will be presented and defended in a final colloquium. The publication of thesis results is appreciated.</p>	
<b>Reader's advisory</b>	as required	
<b>Links</b>		
<b>Languages of instruction</b>	German, English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	jährlich	
<b>Module capacity</b>	unlimited	
<b>Modullevel / module level</b>	---	
<b>Modulart / typ of module</b>	je nach Studiengang Pflicht oder Wahlpflicht	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Seminar, Labor und Selbststudium	
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Time of examination	Type of examination
<b>Final exam of module</b>		Master thesis and colloquium
<b>Course type</b>	Seminar	
<b>SWS</b>		
<b>Frequency</b>		
<b>Workload attendance</b>	0 h	

