

---

**Modulhandbuch**  
**Engineering Physics - Master's Programme**  
im Wintersemester 2023/2024  
erstellt am 20/10/23

---

<b>phy611 - Theoretical Methods</b>	7
<b>phy631 - Advanced Metrology</b>	10
<b>phy640 - Seminar Advanced Topics in EP</b>	11
<b>phy681 - Tools and Skills for Scientific Engineering</b>	12
<b>phy691 - Advanced Research Project (Preparation Master Thesis)</b>	13
<b>phy602 - Advanced Nuclear &amp; Particle Physics</b>	15
<b>phy603 - Fluid Dynamics</b>	17
<b>phy607 - Selected Topics in Advanced Physics</b>	18
<b>phy633 - Optics</b>	19
<b>phy617 - Fourier Methods</b>	20
<b>phy950 - Audiologie und Akustik</b>	22
<b>bio279 - Basic Concepts in Animal Physiology</b>	24
<b>phy614 - Personalized Medicine</b>	25
<b>phy678 - Processing and analysis of biomedical data</b>	26
<b>phy685 - Advanced Engineering Topics in Biomedical Physics &amp; Acoustics</b>	27
<b>phy686 - Advanced Topics in Biomedical Physics &amp; Acoustics</b>	29
<b>phy698 - Selected Topics on Medical Radiation Physics</b>	30
<b>phy959 - Medizinische Strahlenphysik II</b>	32
<b>phy955 - Medizinische Strahlenphysik I</b>	33
<b>phy964 - Advanced Computing</b>	34
<b>phy954 - Imaging and Data Analysis</b>	35

---

<b>phy608 - Medical Optics</b>	36
<b>phy632 - Spectrophysics</b>	38
<b>phy634 - Biophotonics and Spectroscopy</b>	39
<b>phy637 - Laser Design and Beam Guiding</b>	41
<b>phy638 - Laser material processing</b>	42
<b>phy682 - Advanced Engineering Topics in Laser and Optics</b>	43
<b>phy683 - Advanced Topics in Laser and Optics</b>	44
<b>phy965 - Engineering Scientific Instrumentation</b>	45
<b>phy966 - Intense Light Physics</b>	46
<b>phy600 - Photonics</b>	47
<b>phy624 - Optoelectronics</b>	48
<b>inf511 - Smart Grid Management</b>	49
<b>phy609 - Photovoltaic Physics</b>	51
<b>phy616 - Computational Fluid Dynamics 1 / 2</b>	52
<b>phy641 - Energy Resources &amp; Systems</b>	54
<b>phy644 - Wind Energy Physics, Data &amp; Analysis</b>	56
<b>phy646 - Wind Physics Student's Lab</b>	58
<b>phy647 - Future Power Supply Systems</b>	60
<b>phy648 - Wind Resources and their Applications</b>	62
<b>phy649 - Design of Wind Energy Systems</b>	64
<b>phy687 - Advanced Engineering Topics in Renewable Energies</b>	66
<b>phy689 - Advanced Topics in Renewable Energies</b>	67
<b>phy984 - Semiconducting Materials for Solar Energy</b>	68

---

<b>phy987 - Control of Wind Turbines and Wind Farms</b>	69
<b>phy967 - Advanced Laboratories in Renewable Energies</b>	71
<b>pre022 - Solar Energy</b>	72
<b>pre113 - Photovoltaic Systems</b>	75
<b>pre114 - Solar Energy Meteorology</b>	78
<b>phy964 - Advanced Computing</b>	80
<b>pre200 - Selected Renewable Energy Technologies</b>	81
<b>phy616 - Computational Fluid Dynamics 1 / 2</b>	83
<b>phy659 - Introduction to Micro Meteorology for Wind Energy</b>	85
<b>phy670 - Fluidynamics II/Wind Energy Meterology</b>	86
<b>phy673 - Diffusions and Stochastic Differential Equations</b>	87
<b>phy674 - Turbulent Flows</b>	88
<b>phy684 - Wind Turbine Technology and Aerodynamics</b>	89
<b>phy688 - Planning and Development of Wind Farms</b>	90
<b>phy692 - Research Project EWEM</b>	91
<b>phy991 - Stochastic Processes</b>	92
<b>phy992 - Time Series Analysis</b>	93
<b>phy993 - Advanced Time Series Analysis</b>	94
<b>phy994 - Optimization and Data Fitting</b>	95
<b>phy995 - Physics of Sustainable Energy</b>	96
<b>phy996 - Offshore Wind Energy</b>	97
<b>phy997 - Wind Turbine Measurement Techniques</b>	98
<b>phy998 - Probabilistic Methods in Wind Energy</b>	99

---

<b>phy621 - Advanced Engineering Topics in Wind Energy</b>	100
<b>phy622 - Advanced Topics in Wind Energy</b>	101
<b>phy645 - Wind Physics Measurement Project</b>	102
<b>phy985 - Stochastic Processes in Experiments</b>	103
<b>phy629 - Optimization in modern Power Systems</b>	104
<b>phy675 - Integration of Wind Power in the Power System</b>	105
<b>phy981 - HardTech Entrepreneurship</b>	106
<b>phy986 - System Safety and Reliability Engineering</b>	107
<b>phy623 - Advanced Wind Energy Meteorology</b>	108
<b>phy625 - Deep Learning</b>	109
<b>phy626 - Introduction to Dynamical Systems</b>	110
<b>phy988 - Introduction to Machine Learning and Data Mining</b>	111
<b>phy627 - Hydrodynamics II</b>	112
<b>phy628 - Computational Tool for Data Science</b>	113
<b>phy629 - Advanced CFD</b>	114
<b>phy657 - Energy Economics</b>	115
<b>phy605 - Digital Signal Processing</b>	116
<b>phy677 - Speech processing</b>	118
<b>phy679 - Acoustics</b>	119
<b>phy685 - Advanced Engineering Topics in Biomedical Physics &amp; Acoustics</b>	120
<b>phy686 - Advanced Topics in Biomedical Physics &amp; Acoustics</b>	122
<b>phy694 - Machine Learning II</b>	123

---

<b>phy696 - Advanced Topics Speech and Audio Processing</b>	
.....	125
<b>phy960 - Psychoacoustics</b>	
.....	126
<b>phy964 - Advanced Computing</b>	
.....	128
<b>mam - Master's Thesis Module</b>	
.....	129

## Pflichtmodule

### phy611 - Theoretical Methods

<b>Module label</b>	Theoretical Methods
<b>Modulkürzel</b>	phy611
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( attendance: 56 hrs, self study: 124 hrs )
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Pflichtmodule</li> </ul>
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Cocchi, Caterina (module responsibility)</li> <li>• Anemüller, Jörn (Prüfungsberechtigt)</li> <li>• Avila Canellas, Kerstin (Prüfungsberechtigt)</li> <li>• Cocchi, Caterina (Prüfungsberechtigt)</li> <li>• Doclo, Simon (Prüfungsberechtigt)</li> <li>• Hartmann, Alexander (Prüfungsberechtigt)</li> <li>• Kühn, Martin (Prüfungsberechtigt)</li> <li>• Kunz-Drolshagen, Jutta (Prüfungsberechtigt)</li> <li>• Neu, Walter (Prüfungsberechtigt)</li> <li>• Peinke, Joachim (Prüfungsberechtigt)</li> <li>• Poppe, Björn (Prüfungsberechtigt)</li> <li>• Schmidt, Thorsten (Prüfungsberechtigt)</li> <li>• Stoesesandt, Bernhard (Prüfungsberechtigt)</li> <li>• Strybny, Jann (Prüfungsberechtigt)</li> </ul>
<b>Prerequisites</b>	basic programming skills (matlab, python, C/C++)
<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>Computerorientierte Physik 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>Modelling and Simulation 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>
<b>Module contents</b>	<p>Computational Fluid Dynamics (CFD I &amp; II)</p> <ul style="list-style-type: none"> <li>• CFD I: The Navier-Stokes equations, filtering / averaging of Navier-Stokes equations, introduction to numerical methods, finite-differences,</li> </ul>

---

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

---

#### Literatureempfehlungen

- 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.

---

#### Links



<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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>	<b>According selected course</b>			
<b>Form of instruction</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>Präsenzzeit Modul insgesamt</b>				<b>56 h</b>

## phy631 - Advanced Metrology

<b>Module label</b>	Advanced Metrology			
<b>Modulkürzel</b>	phy631			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Pflichtmodule</li> </ul>			
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Huke, Philipp (module responsibility)</li> <li>• Huke, Philipp (Prüfungsberechtigt)</li> <li>• Huke, Philipp (Module counselling)</li> </ul>			
<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>Literatureempfehlungen</b>	<p>T. Yoshizawa (Ed.): Handbook of Optical Metrology: Principles and Applications, 2nd rev. ed., Crc Pr Inc., 2015</p> <p>Recent publications on specific topics</p>			
<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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>		1 written exam or 1 presentation or 1 oral exam or 1 seminar paper		
<b>Form of instruction</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
VA-Auswahl (Specialization Biomedical Physics)		4	WiSe	56
VA-Auswahl (Specialization Acoustics)		2	WiSe	28
VA-Auswahl (Specialization Renewable Energies)		2	WiSe	28
VA-Auswahl (Specialization Laser & Optics)		2	WiSe	28
<b>Präsenzzeit Modul insgesamt</b>				140 h

## phy640 - Seminar Advanced Topics in EP

<b>Module label</b>	Seminar Advanced Topics in EP	
<b>Modulkürzel</b>	phy640	
<b>Credit points</b>	3.0 KP	
<b>Workload</b>	90 h ( Attendance: 28 hrs, Self study: 62 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Pflichtmodule</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Neu, Walter (module responsibility)</li> <li>• Herráez, Iván (Prüfungsberechtigt)</li> <li>• Neu, Walter (Prüfungsberechtigt)</li> <li>• Koch, Sandra (Prüfungsberechtigt)</li> </ul>	
<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>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Prüfungszeiten	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>Form of instruction</b>	Seminar	
<b>SWS</b>	2	
<b>Frequency</b>	--	
<b>Workload Präsenzzeit</b>	28 h	

## phy681 - Tools and Skills for Scientific Engineering

<b>Module label</b>	Tools and Skills for Scientific Engineering			
<b>Modulkürzel</b>	phy681			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Attendance: 28 hrs, Self study: 152 hrs )			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Pflichtmodule</li> </ul>			
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Huke, Philipp (module responsibility)</li> <li>• Doclo, Simon (Prüfungsberechtigt)</li> <li>• Huke, Philipp (Prüfungsberechtigt)</li> <li>• Koch, Sandra (Prüfungsberechtigt)</li> <li>• Neu, Walter (Prüfungsberechtigt)</li> <li>• Petrovic, Vlaho (Prüfungsberechtigt)</li> <li>• Poppe, Björn (Prüfungsberechtigt)</li> <li>• Reck, Martin (Prüfungsberechtigt)</li> <li>• Schüning, Thomas (Prüfungsberechtigt)</li> <li>• Schellenberg, Markus (Prüfungsberechtigt)</li> <li>• Schmidt, Jonas (Prüfungsberechtigt)</li> <li>• Teubner, Ulrich (Prüfungsberechtigt)</li> <li>• Silies, Martin (Prüfungsberechtigt)</li> </ul>			
<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>Literatureempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	Prüfungszeiten		Type of examination	
<b>Final exam of module</b>	Acc. selected course			
<b>Form of instruction</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
Practical training		1	SoSe oder WiSe	14
<b>Präsenzzeit Modul insgesamt</b>				<b>98 h</b>

## phy691 - Advanced Research Project (Preparation Master Thesis)

<b>Module label</b>	Advanced Research Project (Preparation Master Thesis)
<b>Modulkürzel</b>	phy691
<b>Credit points</b>	15.0 KP
<b>Workload</b>	450 h ( Attendance: 320 hrs, Self study: 130 hrs )
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Pflichtmodule</li> </ul>
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Neu, Walter (module responsibility)</li> <li>• Agert, Carsten (Prüfungsberechtigt)</li> <li>• Avila Canellas, Kerstin (Prüfungsberechtigt)</li> <li>• Anemüller, Jörn (Prüfungsberechtigt)</li> <li>• Knecht, Robin (Prüfungsberechtigt)</li> <li>• Gülker, Gerd (Prüfungsberechtigt)</li> <li>• Biehs, Svend-Age (Prüfungsberechtigt)</li> <li>• Brand, Thomas (Prüfungsberechtigt)</li> <li>• Holtorf, Hans-Gerhard (Prüfungsberechtigt)</li> <li>• Torio, Herena (Prüfungsberechtigt)</li> <li>• Cocchi, Caterina (Prüfungsberechtigt)</li> <li>• Dietz, Mathias (Prüfungsberechtigt)</li> <li>• Doclo, Simon (Prüfungsberechtigt)</li> <li>• Doerner, Karl-Joachim (Prüfungsberechtigt)</li> <li>• Drolshagen, Gerhard (Prüfungsberechtigt)</li> <li>• Englert, Lars (Prüfungsberechtigt)</li> <li>• Enzner, Gerald (Prüfungsberechtigt)</li> <li>• Lücke, Jörg (Prüfungsberechtigt)</li> <li>• Ewert, Stephan (Prüfungsberechtigt)</li> <li>• Feudel, Ulrike (Prüfungsberechtigt)</li> <li>• Fatikow, Sergej (Prüfungsberechtigt)</li> <li>• Gütay, Levent (Prüfungsberechtigt)</li> <li>• Hartmann, Alexander (Prüfungsberechtigt)</li> <li>• Herráez, Iván (Prüfungsberechtigt)</li> <li>• Hohmann, Volker (Prüfungsberechtigt)</li> <li>• Neu, Walter (Prüfungsberechtigt)</li> <li>• Huke, Philipp (Prüfungsberechtigt)</li> <li>• Knipper, Martin (Prüfungsberechtigt)</li> <li>• Koch, Sandra (Prüfungsberechtigt)</li> <li>• Kollmeier, Birger (Prüfungsberechtigt)</li> <li>• Kühn, Martin (Prüfungsberechtigt)</li> <li>• Lehnhoff, Sebastian (Prüfungsberechtigt)</li> <li>• Lukassen, Laura (Prüfungsberechtigt)</li> <li>• Kunz-Drolshagen, Jutta (Prüfungsberechtigt)</li> <li>• Lienau, Christoph (Prüfungsberechtigt)</li> <li>• Looe, Hui Khee (Prüfungsberechtigt)</li> <li>• Nilius, Niklas (Prüfungsberechtigt)</li> <li>• Meyer, Bernd (Prüfungsberechtigt)</li> <li>• Poppe, Björn (Prüfungsberechtigt)</li> <li>• Oetjen, Arne (Prüfungsberechtigt)</li> <li>• Steinfeld, Gerald (Prüfungsberechtigt)</li> <li>• Peinke, Joachim (Prüfungsberechtigt)</li> <li>• Pehlken, Alexandra (Prüfungsberechtigt)</li> <li>• Reck, Martin (Prüfungsberechtigt)</li> <li>• Ruehmann, Antje (Prüfungsberechtigt)</li> <li>• Schellenberg, Markus (Prüfungsberechtigt)</li> <li>• Schneider, Christian (Prüfungsberechtigt)</li> <li>• Schmidt, Andreas Hermann (Prüfungsberechtigt)</li> <li>• Schmidt, Thorsten (Prüfungsberechtigt)</li> <li>• Silies, Martin (Prüfungsberechtigt)</li> <li>• Siedenburg, Kai (Prüfungsberechtigt)</li> <li>• Stoevesandt, Bernhard (Prüfungsberechtigt)</li> <li>• Teubner, Ulrich (Prüfungsberechtigt)</li> <li>• van de Par, Steven (Prüfungsberechtigt)</li> <li>• Uppenkamp, Stefan (Prüfungsberechtigt)</li> <li>• Wark, Michael (Prüfungsberechtigt)</li> <li>• Wollenhaupt, Matthias (Prüfungsberechtigt)</li> </ul>
<b>Prerequisites</b>	Sound knowledge in the specialisation field of Master thesis
<b>Skills to be acquired in this module</b>	Students are able to search for and to state an adequate research problem in the field of the working group or industry (problem should be related to the topics covered in the masters programme). They are capable to derive research questions based on the statement of the problem and prepare an elaborated research proposal yielding lab work that serves as the preliminary

study for the Master's Thesis.

Students are in a position to develop the specialised bases (detailed theoretical background of the topic, ample and critically annotated literature review, research objectives and research question(s), fully developed methods section, sketched workplan) of the Master's Thesis Project in terms of content and style in such a way that they form a sound basis for a successful Master's Thesis.

Students gain expertise

in workflow optimization, data collection and data analysis. Independent management and transformation of a complex and unpredictable problem from the general field of study contexts of the Master degree program "Engineering Physics" (including related subject areas) utilizing scientific state-of-the-art research methods.

<b>Module contents</b>	Independent research for the definition of a physics and engineering solution to a problem in the chosen field. Specialized knowledge of a subject area as foundation for the student's research. The assignment of specific tasks will be given after consulting the responsible lecturers and is depending upon the current research profile. The Advanced research project (preliminary study to the Master's thesis) forms the basis of the Master's Thesis Project and must contain the following aspects: - Detailed theoretical background of the topic - Ample and critically annotated literature review - Research objectives and research question(s) - Fully developed methods section - Draft of a fully formed table of contents	
<b>Literatureempfehlungen</b>	Acc. Research eld, Recent publications on specific topics	
<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>		
Examination	Prüfungszeiten	Type of examination
<b>Final exam of module</b>		S
<b>Form of instruction</b>	Seminar	
<b>SWS</b>		
<b>Frequency</b>		
<b>Workload Präsenzzeit</b>	0 h	

# Advanced Physics

## phy602 - Advanced Nuclear & Particle Physics

<b>Module label</b>	Advanced Nuclear & Particle Physics	
<b>Modulkürzel</b>	phy602	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Advanced Physics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Poppe, Björn (module responsibility)</li> <li>• Poppe, Björn (Prüfungsberechtigt)</li> <li>• Drolshagen, Gerhard (Prüfungsberechtigt)</li> <li>• Looe, Hui Khee (Prüfungsberechtigt)</li> </ul>	
<b>Prerequisites</b>	Basic lectures in physics / engineering	
<b>Skills to be acquired in this module</b>	<p>High-Energy Radiation Physics: 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>Space Environment: 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>High-Energy Radiation Physics: 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>Space Environment: 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>Literatureempfehlungen</b>	H. Krieger: Strahlungsmessung und Dosimetrie, Springer Verlag, Wiesbaden, 2013; Grun: Astroparticle Physics, Springer Verlag, Heidelberg, 2005; Falkenburg, Rhode (Eds.): From Ultra Rays to Astroparticles, Springer Verlag, Heidelberg, 2012	
<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>	je nach Studiengang Pflicht oder Wahlpflicht	
<b>Lehr-/Lernform / Teaching/Learning method</b>	each lecture: 2hrs/week	
<b>Vorkenntnisse / Previous knowledge</b>	Basic lectures in physics / engineering	
<b>Examination</b>	Prüfungszeiten	Type of examination
<b>Final exam of module</b>		written exam Max. 180 min. or oral exam 30 min.
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	

---

**Frequency** SoSe oder WiSe

---

**Workload Präsenzzeit** 56 h

---



## phy603 - Fluid Dynamics

<b>Module label</b>	Fluid Dynamics	
<b>Modulkürzel</b>	phy603	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 84 hrs, Self study: 96 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Advanced Physics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Peinke, Joachim (module responsibility)</li> <li>• Avila Canellas, Kerstin (Prüfungsberechtigt)</li> <li>• Lukassen, Laura (Prüfungsberechtigt)</li> <li>• Peinke, Joachim (Prüfungsberechtigt)</li> </ul>	
<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>	<p>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</p> <p>Fluid Dynamics II: Reynolds-equation, "closing problem" of turbulence: Turbulence models: Cascade models, Stochastic models</p>	
<b>Literatureempfehlungen</b>	<p>J. Spurk, N. Aksamit: 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</p>	
<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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy607 - Selected Topics in Advanced Physics

<b>Module label</b>	Selected Topics in Advanced Physics	
<b>Modulkürzel</b>	phy607	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Overall workload of 180 h )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Advanced Physics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Neu, Walter (module responsibility)</li> <li>• Avila Canellas, Kerstin (Prüfungsberechtigt)</li> <li>• Gülker, Gerd (Prüfungsberechtigt)</li> <li>• Lienau, Christoph (Prüfungsberechtigt)</li> <li>• Nilius, Niklas (Prüfungsberechtigt)</li> </ul>	
<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>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Prüfungszeiten	Type of examination
<b>Final exam of module</b>		Related to selected course/s
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy633 - Optics

<b>Module label</b>	Optics	
<b>Modulkürzel</b>	phy633	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Advanced Physics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Teubner, Ulrich (module responsibility)</li> <li>• Teubner, Ulrich (Prüfungsberechtigt)</li> </ul>	
<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>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<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>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

---

## phy617 - Fourier Methods

<b>Module label</b>	Fourier Methods
<b>Modulkürzel</b>	phy617
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( Attendance: 56hrs, Self Study: 124 hrs )
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"><li>• Master's Programme Engineering Physics (Master) &gt; Advanced Physics</li></ul>
<b>Zuständige Personen</b>	<ul style="list-style-type: none"><li>• Teubner, Ulrich (module responsibility)</li><li>• Teubner, Ulrich (Prüfungsberechtigt)</li><li>• Silies, Martin (Prüfungsberechtigt)</li></ul>
<b>Prerequisites</b>	
<b>Skills to be acquired in this module</b>	

### 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

---

### Literatureempfehlungen

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)

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.

---

<b>Links</b>		
<hr/>		
<b>Language of instruction</b>	English	
<b>Duration (semesters)</b>	1 Semester	
<b>Module frequency</b>	jährlich	
<b>Module capacity</b>	unlimited	
<hr/>		
<b>Modullevel / module level</b>		
<hr/>		
<b>Modulart / typ of module</b>		
<hr/>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<hr/>		
<b>Vorkenntnisse / Previous knowledge</b>		
<hr/>		
Examination	Prüfungszeiten	Type of examination
<b>Final exam of module</b>	2 * 3 hours written or 2 * 30 minutes oral exams	
<b>Form of instruction</b>	Lecture	
<hr/>		
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	28 h	
<hr/>		

---

## phy950 - Audiologie und Akustik

<b>Module label</b>	Audiologie und Akustik
<b>Modulkürzel</b>	phy950
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"><li>• Master's Programme Engineering Physics (Master) &gt; Advanced Physics</li></ul>
<b>Zuständige Personen</b>	<ul style="list-style-type: none"><li>• van de Par, Steven (module responsibility)</li><li>• Kollmeier, Birger (module responsibility)</li><li>• van de Par, Steven (Prüfungsberechtigt)</li><li>• Kollmeier, Birger (Prüfungsberechtigt)</li><li>• Ewert, Stephan (Prüfungsberechtigt)</li></ul>
<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, Schallleitungs- und Schallempfindungsstörungen, Tinnitus, Otoakustische Emissionen (Diagnostisch), Stapediusreflexaudiometrie, 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>Literaturempfehlungen</b>	<p>B. Kollmeier: Skriptum Physikalische, technische und medizinische Akustik, Universität Oldenburg;</p> <p>H. Kuttruff, Akustik: Eine Einführung, 2004;</p> <p>P. Damaske, Acoustics and Hearing, Springer, 2008;</p> <p>M. Heckl, G. Müller: Taschenbuch der technischen Akustik, Springer-Verlag, 2012</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>	MM (Mastermodul / Master module)	
<b>Modulart / typ of module</b>	je nach Studiengang Pflicht oder Wahlpflicht	
<b>Lehr-/Lernform / Teaching/Learning method</b>	Lecture: 3hrs/week; Excercise: 1hrs/week	
<b>Vorkenntnisse / Previous knowledge</b>	Einführendes Akustik Modul	
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>	one or two examination, totaling to 180 min. written exam or 30 min. oral exam	
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

# Schwerpunkt: Biomedical Physics

## bio279 - Basic Concepts in Animal Physiology

<b>Module label</b>	Basic Concepts in Animal Physiology	
<b>Modulkürzel</b>	bio279	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h	
<b>Verwendbarkeit des Moduls</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>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Heyers, Dominik (module responsibility)</li> <li>• Köppl, Christine (Module counselling)</li> <li>• Dedek, Karin (Module counselling)</li> <li>• Heyers, Dominik (Prüfungsberechtigt)</li> <li>• Köppl, Christine (Prüfungsberechtigt)</li> <li>• Dedek, Karin (Prüfungsberechtigt)</li> </ul>	
<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>Literatureempfehlungen</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>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>	within a few weeks after the winter term lecture period	written exam (100%)
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>		
<b>Workload Präsenzzeit</b>	56 h	



## phy614 - Personalized Medicine

<b>Module label</b>	Personalized Medicine	
<b>Modulkürzel</b>	phy614	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( attendance: 56 hrs, self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Biomedical Physics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Schmidt, Thorsten (module responsibility)</li> <li>• Schmidt, Thorsten (Prüfungsberechtigt)</li> </ul>	
<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>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	28 h	

## phy678 - Processing and analysis of biomedical data

<b>Module label</b>	Processing and analysis of biomedical data	
<b>Modulkürzel</b>	phy678	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Biomedical Physics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Poppe, Björn (module responsibility)</li> <li>• Brand, Thomas (Prüfungsberechtigt)</li> <li>• Ewert, Stephan (Prüfungsberechtigt)</li> <li>• Hohmann, Volker (Prüfungsberechtigt)</li> <li>• Uppenkamp, Stefan (Prüfungsberechtigt)</li> </ul>	
<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>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		Exam or presentation or oral exam or homework or practical report
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

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

<b>Module label</b>	Advanced Engineering Topics in Biomedical Physics & Acoustics			
<b>Modulkürzel</b>	phy685			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Overall workload of 180 h )			
<b>Verwendbarkeit des Moduls</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>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Doclo, Simon (module responsibility)</li> <li>• Poppe, Björn (module responsibility)</li> <li>• Anemüller, Jörn (Prüfungsberechtigt)</li> <li>• Biehs, Svend-Age (Prüfungsberechtigt)</li> <li>• Blau, Matthias (Prüfungsberechtigt)</li> <li>• Brand, Thomas (Prüfungsberechtigt)</li> <li>• Dietz, Mathias (Prüfungsberechtigt)</li> <li>• Doclo, Simon (Prüfungsberechtigt)</li> <li>• Enzner, Gerald (Prüfungsberechtigt)</li> <li>• Ewert, Stephan (Prüfungsberechtigt)</li> <li>• Hohmann, Volker (Prüfungsberechtigt)</li> <li>• Kollmeier, Birger (Prüfungsberechtigt)</li> <li>• Lücke, Jörg (Prüfungsberechtigt)</li> <li>• Meyer, Bernd (Prüfungsberechtigt)</li> <li>• Oetjen, Arne (Prüfungsberechtigt)</li> <li>• Poppe, Björn (Prüfungsberechtigt)</li> <li>• Siedenburg, Kai (Prüfungsberechtigt)</li> <li>• Töpken, Stephan (Prüfungsberechtigt)</li> <li>• Uppenkamp, Stefan (Prüfungsberechtigt)</li> <li>• van de Par, Steven (Prüfungsberechtigt)</li> </ul>			
<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>Literatureempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Prüfungszeiten		Type of examination	
<b>Final exam of module</b>	Related to selected course/s			
Form of instruction	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>Präsenzzeit Modul insgesamt</b>				126 h



## phy686 - Advanced Topics in Biomedical Physics & Acoustics

<b>Module label</b>	Advanced Topics in Biomedical Physics & Acoustics		
<b>Modulkürzel</b>	phy686		
<b>Credit points</b>	6.0 KP		
<b>Workload</b>	180 h ( Overall workload of 180 h )		
<b>Verwendbarkeit des Moduls</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>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Doclo, Simon (module responsibility)</li> <li>• Poppe, Björn (module responsibility)</li> <li>• Anemüller, Jörn (Prüfungsberechtigt)</li> <li>• Bitzer, Jörg (Prüfungsberechtigt)</li> <li>• Blau, Matthias (Prüfungsberechtigt)</li> <li>• Brand, Thomas (Prüfungsberechtigt)</li> <li>• Dietz, Mathias (Prüfungsberechtigt)</li> <li>• Doclo, Simon (Prüfungsberechtigt)</li> <li>• Enzner, Gerald (Prüfungsberechtigt)</li> <li>• Ewert, Stephan (Prüfungsberechtigt)</li> <li>• Hohmann, Volker (Prüfungsberechtigt)</li> <li>• Lücke, Jörg (Prüfungsberechtigt)</li> <li>• Kollmeier, Birger (Prüfungsberechtigt)</li> <li>• Meyer, Bernd (Prüfungsberechtigt)</li> <li>• Poppe, Björn (Prüfungsberechtigt)</li> <li>• Oetjen, Arne (Prüfungsberechtigt)</li> <li>• Siedenburg, Kai (Prüfungsberechtigt)</li> <li>• Töpken, Stephan (Prüfungsberechtigt)</li> <li>• van de Par, Steven (Prüfungsberechtigt)</li> <li>• Uppenkamp, Stefan (Prüfungsberechtigt)</li> </ul>		
<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>Literatureempfehlungen</b>	Related to selected course/s		
<b>Links</b>	Depending on selected courses		
<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>			
<b>Modulart / typ of module</b>			
<b>Lehr-/Lernform / Teaching/Learning method</b>			
<b>Vorkenntnisse / Previous knowledge</b>			
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>	
<b>Final exam of module</b>	Related to selected course/s		
<b>Form of instruction</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>
			<b>Workload of compulsory attendance</b>
Lecture		4	SoSe oder WiSe
Seminar			SoSe oder WiSe
<b>Präsenzzeit Modul insgesamt</b>			56 h

---

## phy698 - Selected Topics on Medical Radiation Physics

<b>Module label</b>	Selected Topics on Medical Radiation Physics
<b>Modulkürzel</b>	phy698
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"><li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Biomedical Physics</li></ul>
<b>Zuständige Personen</b>	<ul style="list-style-type: none"><li>• Poppe, Björn (module responsibility)</li><li>• Looe, Hui Khee (Prüfungsberechtigt)</li><li>• Poppe, Björn (Prüfungsberechtigt)</li><li>• Ruehmann, Antje (Prüfungsberechtigt)</li><li>• Chofoor, Ndimofor (Prüfungsberechtigt)</li></ul>
<b>Prerequisites</b>	
<b>Skills to be acquired in this module</b>	

5.04.4242:

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.

5.04.4642:

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.

---

### Module contents

5.04.4242:

Aktuelle Themen aus der Medizinischen Strahlenphysik

wie: IMRT, NMR, PET, SPECT usw.;

5.04.4642:

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.

---

### Literaturempfehlungen

5.04.4242:

Aktuelle Themen aus der Medizinischen Strahlenphysik

wie: IMRT, NMR, PET, SPECT usw.;

5.04.4642:

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.

<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>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Prüfungszeiten	Type of examination
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy959 - Medizinische Strahlenphysik II

<b>Module label</b>	Medizinische Strahlenphysik II	
<b>Modulkürzel</b>	phy959	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 58 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Biomedical Physics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Poppe, Björn (module responsibility)</li> <li>• Poppe, Björn (Prüfungsberechtigt)</li> </ul>	
<b>Prerequisites</b>	Medizinische Strahlenphysik I	
<b>Skills to be acquired in this module</b>	Die Studierenden werden die grundlegenden Kompetenzen eines Strahlenschutzbeauftragten kennen lernen. Dazu gehören neben den fachlichen Grundlagen im Strahlenschutz insbesondere die Kompetenz sich im deutschen Gesetz und Verwaltungssystem im Bereich des Strahlenschutzes zurecht zu finden.	
<b>Module contents</b>	Strahlenschutz in der Tele- und Brachytherapie, Aufbau von Beschleunigern, Dosimetrie, Baulicher und Organisatorischer Strahlenschutz, StrSchG und StrSchV sowie zugehörige DIN Normen.	
<b>Literatureempfehlungen</b>	StrSchG, StrSchV verschiedene DIN Normen	
<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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Prüfungszeiten	Type of examination
<b>Final exam of module</b>		Written examination: Between 90 and 180 minutes or Oral examination: Between 20 and 45 minutes
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	28 h	



## phy955 - Medizinische Strahlenphysik I

<b>Module label</b>	Medizinische Strahlenphysik I	
<b>Modulkürzel</b>	phy955	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Biomedical Physics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Poppe, Björn (module responsibility)</li> <li>• Poppe, Björn (Prüfungsberechtigt)</li> </ul>	
<b>Prerequisites</b>	Medizinische Strahlenphysik I	
<b>Skills to be acquired in this module</b>	Die Studierenden erlernen die Grundlegenden Inhalte der Bildgebenden Verfahren und des Strahlenschutzes. Sie werden im Rahmen des Grundkurses Strahlenschutz zudem erstmals mit dem beruflichen Fort- und Weiterbildungssystem in Deutschland vertraut gemacht.	
<b>Module contents</b>	<p>5.04.4022 Spezialkurs Strahlenschutzseminar Strahlenschutz in der Tele- und Brachytherapie, Aufbau von Beschleunigern, Dosimetrie, Baulicher und Organisatorischer Strahlenschutz, StrSchG und StrSchV sowie zugehörige DIN Normen</p> <p>5.04.4021 Bildgebende Verfahren Bildgebende Verfahren: Grundlagen der Bildgebenden Verfahren in der Medizin: CT, MRT, Ultraschall, Nuklearmedizin SPECT, PET sowie grundlegende Rekonstruktionstechniken</p>	
<b>Literaturempfehlungen</b>	<p>Grundkurs Strahlenschutz: Unterlagen werden zur Verfügung gestellt (Skript)</p> <p>Bildgebende Verfahren: werden in der VL bekannt gegeben.</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>	2 Written examinations: Between 45 and 90 minutes or Oral examinations: Between 10 and 20 minutes	2 Written examinations: Between 45 and 90 minutes or Oral examinations: Between 10 and 20 minutes
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy964 - Advanced Computing

<b>Module label</b>	Advanced Computing			
<b>Modulkürzel</b>	phy964			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )			
<b>Verwendbarkeit des Moduls</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>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Kühn, Martin (module responsibility)</li> <li>• Doclo, Simon (module responsibility)</li> </ul>			
<b>Prerequisites</b>	Basic knowledge in computing, knowledge in undergraduate mathematics and physics			
<b>Skills to be acquired in this module</b>	Learning of advanced programming concepts and their application in biomedical physics, acoustics, laser and optics, and renewable energies.			
<b>Module contents</b>	Advanced programming concepts for C, python and Matlab; Artificial Intelligence and Data Science; Visual Computing; Software Engineering			
<b>Literatureempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Prüfungszeiten	Type of examination		
<b>Final exam of module</b>		written exam: max 180 minutes or oral exam: max 30 minutes		
Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		4	SoSe oder WiSe	56
Exercises		4	SoSe oder WiSe	56
<b>Präsenzzeit Modul insgesamt</b>				112 h

## phy954 - Imaging and Data Analysis

<b>Module label</b>	Imaging and Data Analysis	
<b>Modulkürzel</b>	phy954	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Biomedical Physics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Poppe, Björn (module responsibility)</li> <li>• Poppe, Björn (Prüfungsberechtigt)</li> </ul>	
<b>Prerequisites</b>	Knowledge from the courses Astrophysics I and II	
<b>Skills to be acquired in this module</b>	The students learn to use modern astronomical instruments for observation (photographic) and spectroscopy, as well as to evaluate the obtained measurement data. They will gain insights into different areas of astrophysics and data processing and will be introduced to cutting-edge research areas. In addition, students learn how a consistent description of astrophysical processes emerges from observational data, theory and modeling.	
<b>Module contents</b>	Preparation of observations in a seminar including selection of relevant objects, determination of observation techniques (e.g. high resolution photography or spectroscopy), execution of observations at C2PU ("Centre Pédagogique Planète et Univers, South of France") and evaluation of observations.	
<b>Literatureempfehlungen</b>	<p>B.W. Carroll, Introduction to Modern Astrophysics, Addison-Wesley, 2013</p> <p>M. Camenzind, Compact Objects in Astrophysics, Springer, 2007</p> <p>P. Lena, D. Ruoan Observational Astrophysics, Springer 2012</p> <p>J.L. Starck, F. Murtagh, Astronomical Image and Data Analysis, Springer 2006</p> <p>D.S. Birney, G. Gonzalez. Observational Astronomy, Cambridge University Press, 2006</p> <p>BDWarner, Photometry and Lightcurve Analysis, Springer 2006</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		Written examination: Between 90 and 180 minutes or Oral examination: Between 20 and 45 minutes
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	28 h	

# Schwerpunkt: Laser and Optics

## phy608 - Medical Optics

<b>Module label</b>	Medical Optics			
<b>Modulkürzel</b>	phy608			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Attendance:56 hours, Self study: 124 hours )			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>			
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>Neu, Walter (module responsibility)</li> <li>Neu, Walter (Prüfungsberechtigt)</li> </ul>			
<b>Prerequisites</b>	Medizin for Scientist , Optics, Laser Physics			
<b>Skills to be acquired in this module</b>	To provide advanced knowledge in the field of medical optics and optical technologies in medicine as well as their theoretical background and experimental methods. Students will be scientifically competent positioned to critically follow current developments and initiate the design (development and design) of innovative optical applications in medicine.			
<b>Module contents</b>	Physiology and psychophysics of vision, theory of imaging systems, ophthalmic optics, lighting technology, photometry, vision in the workplace and in traffic, optical measurements on patients, diagnostic and therapeutic laser applications, radiation protection (infrared, UV, laser), microscopy, diagnosis and subdiagnosis limited methods, optical spectroscopy, fluorescence methods.			
<b>Literaturempfehlungen</b>	<p>Media: Lecture script, transparencies, blackboard, electronic media, presentation, lecture practical demonstrations</p> <p>Literature: 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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Prüfungszeiten	Type of examination		
<b>Final exam of module</b>			KL	
Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28

---

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
<b>Präsenzzeit Modul insgesamt</b>				<b>56 h</b>

---

## phy632 - Spectrophysics

<b>Module label</b>	Spectrophysics	
<b>Modulkürzel</b>	phy632	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 28 hrs, Self study: 62 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Neu, Walter (module responsibility)</li> <li>• Koch, Sandra (Prüfungsberechtigt)</li> <li>• Neu, Walter (Prüfungsberechtigt)</li> <li>• Schellenberg, Markus (Prüfungsberechtigt)</li> </ul>	
<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>Literatureempfehlungen</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. 1and2, Springer, 5nd 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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Prüfungszeiten	Type of examination
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy634 - Biophotonics and Spectroscopy

<b>Module label</b>	Biophotonics and Spectroscopy	
<b>Modulkürzel</b>	phy634	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Neu, Walter (module responsibility)</li> <li>• Koch, Sandra (Prüfungsberechtigt)</li> <li>• Neu, Walter (Prüfungsberechtigt)</li> <li>• Schellenberg, Markus (Prüfungsberechtigt)</li> </ul>	
<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>Literatureempfehlungen</b>	<p>R. Noll: Laser-Induced Breakdown Spectroscopy. Fundamentals and Applications. Springer, Berlin, 2012. ISBN: 978-3-642-20667-2;</p> <p>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;</p> <p>Braun, M., Gilch, P., Zinth, W.: Ultrashort Laser Pulses in Biology and Medicine. Springer Berlin; 2007. ISBN-13: 978-3540735656;</p> <p>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;</p> <p>B. Di Bartolo, John Collins (Eds.): Biophotonics: Spectroscopy, Imaging, Sensing, and Manipulation. Springer Netherlands, 2011. ISBN: 978-90-481-9976-1;</p> <p>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;</p> <p>Recent publications on specific topics</p>	
<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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Prüfungszeiten	Type of examination
<b>Final exam of module</b>		KL

---

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
<b>Präsenzzeit Modul insgesamt</b>				<b>56 h</b>



## phy637 - Laser Design and Beam Guiding

<b>Module label</b>	Laser Design and Beam Guiding	
<b>Modulkürzel</b>	phy637	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Neu, Walter (module responsibility)</li> <li>• Neu, Walter (Prüfungsberechtigt)</li> <li>• Huke, Philipp (Prüfungsberechtigt)</li> </ul>	
<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>Literaturempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Prüfungszeiten	Type of examination
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy638 - Laser material processing

<b>Module label</b>	Laser material processing	
<b>Modulkürzel</b>	phy638	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Neu, Walter (module responsibility)</li> <li>• Schüning, Thomas (module responsibility)</li> <li>• Neu, Walter (Prüfungsberechtigt)</li> <li>• Schüning, Thomas (Prüfungsberechtigt)</li> </ul>	
<b>Prerequisites</b>	Knowledge in physics, optics, production engineering	
<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>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Prüfungszeiten	Type of examination
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy682 - Advanced Engineering Topics in Laser and Optics

<b>Module label</b>	Advanced Engineering Topics in Laser and Optics			
<b>Modulkürzel</b>	phy682			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Overall workload of 180 h )			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>			
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Neu, Walter (module responsibility)</li> <li>• Neu, Walter (Prüfungsberechtigt)</li> <li>• Teubner, Ulrich (Prüfungsberechtigt)</li> <li>• Huke, Philipp (Prüfungsberechtigt)</li> </ul>			
<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>Literaturempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>		KL		
<b>Form of instruction</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
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>Präsenzzeit Modul insgesamt</b>				126 h

## phy683 - Advanced Topics in Laser and Optics

<b>Module label</b>	Advanced Topics in Laser and Optics	
<b>Modulkürzel</b>	phy683	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( 180 h )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Neu, Walter (module responsibility)</li> <li>• Englert, Lars (Prüfungsberechtigt)</li> <li>• Huke, Philipp (Prüfungsberechtigt)</li> <li>• Lienau, Christoph (Prüfungsberechtigt)</li> <li>• Neu, Walter (Prüfungsberechtigt)</li> </ul>	
<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>Literaturempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Prüfungszeiten	Type of examination
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy965 - Engineering Scientific Instrumentation

<b>Module label</b>	Engineering Scientific Instrumentation			
<b>Modulkürzel</b>	phy965			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>			
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Huke, Philipp (module responsibility)</li> <li>• Huke, Philipp (Prüfungsberechtigt)</li> </ul>			
<b>Prerequisites</b>	<ul style="list-style-type: none"> <li>• Basic tools in physics and engineering</li> <li>• Knowledge about current research areas</li> <li>• Basics in optics and spectroscopy</li> <li>• Advanced Metrology</li> </ul>			
<b>Skills to be acquired in this module</b>	Understanding the evolution of a scientific experiment from scratch to conduction. Understanding the physics / capabilities of an instrument. Learning tools for the development of a scientific instrument with an engineering and science team.			
<b>Module contents</b>	<p>Relevant scientific questions often require large scientific facilities like CERN or the ELT to conduct their experiment.</p> <p>The evolution of a scientific project from a question to a real experiment is a complex process between large teams of engineers and scientists.</p> <p>In this course students will learn:</p> <ol style="list-style-type: none"> <li>How to derive specification from a scientific question</li> <li>Translate these specifications to engineering</li> <li>Develop first simulations of the experiment</li> <li>Develop the physical design of an instrument including               <ol style="list-style-type: none"> <li>Trade-off studies</li> <li>Management tools for the communication</li> <li>Engineering tools for the instrument</li> </ol> </li> <li>Create a model of the instrument</li> <li>Conduct the experiment in the virtual environment</li> </ol> <p>Example project(s) from astrophysics</p>			
<b>Literatureempfehlungen</b>	White/Blue books of Instruments			
<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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Prüfungszeiten	Type of examination		
<b>Final exam of module</b>		Internship report: Between 15 and 30 pages or Written examination: 120 minutes		
Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
<b>Präsenzzeit Modul insgesamt</b>				56 h

## phy966 - Intense Light Physics

<b>Module label</b>	Intense Light Physics	
<b>Modulkürzel</b>	phy966	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Teubner, Ulrich (module responsibility)</li> <li>• Teubner, Ulrich (Prüfungsberechtigt)</li> </ul>	
<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 $\alpha$ -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>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		experimental work and laboratory reports or max. 2hr written examination or max 1h oral
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	28 h	

## phy600 - Photonics

<b>Module label</b>	Photonics	
<b>Modulkürzel</b>	phy600	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Teubner, Ulrich (module responsibility)</li> <li>• Teubner, Ulrich (Prüfungsberechtigt)</li> <li>• Silies, Martin (Prüfungsberechtigt)</li> </ul>	
<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>Literatureempfehlungen</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>		
<b>Modular / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Prüfungszeiten	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>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy624 - Optoelectronics

<b>Module label</b>	Optoelectronics			
<b>Modulkürzel</b>	phy624			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Laser and Optics</li> </ul>			
<b>Zuständige Personen</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Literatureempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>		<b>Klausur</b>		
<b>Form of instruction</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture			SoSe oder WiSe	0
Exercises			SoSe oder WiSe	0
<b>Präsenzzeit Modul insgesamt</b>				<b>0 h</b>



---

# Schwerpunkt: Renewable Energies

## inf511 - Smart Grid Management

<b>Module label</b>	Smart Grid Management
<b>Modulkürzel</b>	inf511
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h
<b>Verwendbarkeit des Moduls</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>Zuständige Personen</b>	<ul style="list-style-type: none"><li>• Lehnhoff, Sebastian (module responsibility)</li><li>• Lehrenden, Die im Modul (Prüfungsberechtigt)</li></ul>
<b>Prerequisites</b>	No participant requirements
<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>
<b>Module contents</b>	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. 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).

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)

#### Literatureempfehlungen

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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>	1VL + 1Ü			
<b>Vorkenntnisse / Previous knowledge</b>	none			
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>	At the end of the semester	written or oral exam		
<b>Form of instruction</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture		3	SoSe	42
Exercises		1	SoSe	14
<b>Präsenzzeit Modul insgesamt</b>				<b>56 h</b>

## phy609 - Photovoltaic Physics

<b>Module label</b>	Photovoltaic Physics			
<b>Modulkürzel</b>	phy609			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )			
<b>Verwendbarkeit des Moduls</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>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Kühn, Martin (module responsibility)</li> <li>• Gütay, Levent (Prüfungsberechtigt)</li> <li>• Knipper, Martin (Prüfungsberechtigt)</li> </ul>			
<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>Literatureempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Prüfungszeiten		Type of examination	
<b>Final exam of module</b>			1 Exam	
Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Präsenzzeit Modul insgesamt</b>				56 h

## phy616 - Computational Fluid Dynamics 1 / 2

<b>Module label</b>	Computational Fluid Dynamics 1 / 2	
<b>Modulkürzel</b>	phy616	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</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>• Master's Programme Environmental Modelling (Master) &gt; Mastermodule</li> <li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Lukassen, Laura (module responsibility)</li> <li>• Avila Canellas, Kerstin (Prüfungsberechtigt)</li> <li>• Lukassen, Laura (Prüfungsberechtigt)</li> <li>• Peinke, Joachim (Prüfungsberechtigt)</li> <li>• Stoevesandt, Bernhard (Prüfungsberechtigt)</li> </ul>	
<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>	<p>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.</p> <p>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.</p>	
<b>Literaturempfehlungen</b>	<p>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)</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Prüfungszeiten	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>Form of instruction</b>	VA-Auswahl ( Vorlesungen oder Praktikum oder Seminar )
----------------------------	--

---

<b>SWS</b>	4
------------	---

---

<b>Frequency</b>	SoSe oder WiSe
------------------	----------------

---

<b>Workload Präsenzzeit</b>	56 h
-----------------------------	------

---

---

## phy641 - Energy Resources & Systems

<b>Module label</b>	Energy Resources & Systems
<b>Modulkürzel</b>	phy641
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self-study: 124 hrs )
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"><li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li><li>• Master's Programme Environmental Modelling (Master) &gt; Mastermodule</li><li>• Master's Programme European Master in Renewable Energy (EUREC) (Master) &gt; Mastermodule</li><li>• Master's Programme Sustainability Economics and Management (Master) &gt; Additional Modules</li><li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li></ul>
<b>Zuständige Personen</b>	<ul style="list-style-type: none"><li>• Agert, Carsten (module responsibility)</li><li>• Knipper, Martin (module responsibility)</li><li>• Knipper, Martin (Prüfungsberechtigt)</li><li>• Torio, Herena (Prüfungsberechtigt)</li><li>• Schmidt, Thomas (Prüfungsberechtigt)</li></ul>
<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></ul>

- Advanced (power plant) technologies for conventional fuels,
- Electric power systems with large shares of renewables

## Literatureempfehlungen

### Energy Meteorology:

- IEA Word Energy Outlook (<http://wordenergyoutlook.org/>)
- Iqbal, M. 1984: An Introduction to Solar Radiation, Academic Press, Toronto
- 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 (Techne Press, Amsterdam, 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	Lectures, Exercises	
Vorkenntnisse / Previous knowledge		
Examination	Prüfungszeiten	Type of examination
Final exam of module	At the end of the lecture period	2 Written Exams (max 90 min each)
Form of instruction	Lecture	
SWS	4	
Frequency	SoSe oder WiSe	
Workload Präsenzzeit	56 h	

## phy644 - Wind Energy Physics, Data & Analysis

<b>Module label</b>	Wind Energy Physics, Data & Analysis
<b>Modulkürzel</b>	phy644
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( attendance: 2*28 hrs, self-study: 124 hrs )
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> </ul>
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>Kühn, Martin (module responsibility)</li> <li>Avila Canellas, Kerstin (Prüfungsberechtigt)</li> <li>Kühn, Martin (Prüfungsberechtigt)</li> <li>Peinke, Joachim (Prüfungsberechtigt)</li> <li>Steinfeld, Gerald (Prüfungsberechtigt)</li> <li>Schmidt, Andreas Hermann (Prüfungsberechtigt)</li> <li>Torio, Herena (Prüfungsberechtigt)</li> </ul>
<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>Literatureempfehlungen</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



---

**Reference text**

The module starts in the winter term: Wind Energy Physics has to be taken before participating in Wind Physics Measurement Project

---

**Modullevel / module level**

---

**Modulart / typ of module**

---

**Lehr-/Lernform / Teaching/Learning method**

---

**Vorkenntnisse / Previous knowledge**

---

Examination	Prüfungszeiten	Type of examination
<b>Final exam of module</b>		1 Exam
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

---

## phy646 - Wind Physics Student's Lab

<b>Module label</b>	Wind Physics Student's Lab
<b>Modulkürzel</b>	phy646
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> </ul>
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Schmidt, Andreas Hermann (Prüfungsberechtigt)</li> <li>• Kühn, Martin (module responsibility)</li> </ul>
<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>	<p>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.</p> <p>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.</p>
<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>

- set-up, execution, data acquisition and decommissioning of the experiment

3rd phase: Evaluation and documentation

- evaluating the experiment
- documentation with a short report (paper)
- presentation

<b>Literaturempfehlungen</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</p> <p>German Language: Robert Gasch, Windkraftanlagen - Grundlagen und Entwurf, 9th Ed., 2016, Springer + Vieweg; ISBN: 978-3-658-12360-4</p> <p>German Language: CEwind eG / Alois Schaffarczyk, Einführung in die Windenergietechnik; 1st Ed. 2012, Carl Hanser Verlag, Munich</p> <p>English Language: Erich Hau, Wind Turbines: Fundamentals, Technologies, Application, Economics, 3rd Ed., 2013, Springer-Verlag; ISBN 978-3-642-27151-9</p> <p>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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Prüfungszeiten	Type of examination
<b>Final exam of module</b>		Portfolio
<b>Form of instruction</b>	Seminar	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy647 - Future Power Supply Systems

<b>Module label</b>	Future Power Supply Systems
<b>Modulkürzel</b>	phy647
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <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>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Agert, Carsten (Prüfungsberechtigt)</li> <li>• Torio, Herena (module responsibility)</li> <li>• Agert, Carsten (module responsibility)</li> </ul>
<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,</li> <li>• "Smart City", "Smart Grid", "Smart Home",</li> <li>• 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>Literatureempfehlungen</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

---

**Modullevel / module level**

**Modulart / typ of module**

**Lehr-/Lernform / Teaching/Learning method**

**Vorkenntnisse / Previous knowledge**

Examination	Prüfungszeiten	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 announced at the beginning of the term.
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy648 - Wind Resources and their Applications

<b>Module label</b>	Wind Resources and their Applications
<b>Modulkürzel</b>	phy648
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( Attendance: 72 hrs, Self study: 108 hrs )
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <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>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Kühn, Martin (module responsibility)</li> <li>• Steinfeld, Gerald (Prüfungsberechtigt)</li> <li>• Waldl, Hans-Peter (Prüfungsberechtigt)</li> </ul>
<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 influences of meteorological/ climatological aspects on the performance of wind power systems,</p> <p>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>Literatureempfehlungen</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.</p> <p>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.</p> <p>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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Prüfungszeiten	Type of examination
<b>Final exam of module</b>		1 Exam
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy649 - Design of Wind Energy Systems

<b>Module label</b>	Design of Wind Energy Systems
<b>Modulkürzel</b>	phy649
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( Attendance: 72 hrs, Self study: 108 hrs )
<b>Verwendbarkeit des Moduls</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>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Kühn, Martin (module responsibility)</li> <li>• Kühn, Martin (Prüfungsberechtigt)</li> <li>• Schmidt, Andreas Hermann (Prüfungsberechtigt)</li> </ul>
<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. At the end of the lecture, they should be able to:</p> <ul style="list-style-type: none"> <li>estimate the site specific energy yield,</li> <li>calculate the aerodynamics of wind turbines using the blade element momentum theory,</li> <li>model wind fields to obtain specific design situations for wind turbines,</li> <li>estimate the influence of dynamics of a wind turbine, especially in the context of fatigue loads,</li> <li>transfer their knowledge to more complex topics such as simulation and measurements of dynamic loads,</li> <li>calculate the economic aspects of wind turbine</li> </ul> <p>Aeroelastic Simulation of Wind turbines: student who has met the objectives of the course will be able to:</p> <ul style="list-style-type: none"> <li>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</li> <li>(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,</li> <li>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.</li> </ul>
<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</p>



---

Aerodyn/FAST.

<b>Literaturempfehlungen</b>	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.; Garrad Hassan, Bladed, Wind Turbine Design Software, Theory Manual; Selected papers from e.g. Wind Energy Journal, Wiley Interscience	
<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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Prüfungszeiten	Type of examination
<b>Final exam of module</b>	Exam or presentation or oral exam or homework or practical report	
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy687 - Advanced Engineering Topics in Renewable Energies

<b>Module label</b>	Advanced Engineering Topics in Renewable Energies	
<b>Modulkürzel</b>	phy687	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Overall workload of 180 h )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Kühn, Martin (module responsibility)</li> <li>• Avila Canellas, Kerstin (Prüfungsberechtigt)</li> <li>• Holtorf, Hans-Gerhard (Prüfungsberechtigt)</li> <li>• Feudel, Ulrike (Prüfungsberechtigt)</li> <li>• Kühn, Martin (Prüfungsberechtigt)</li> <li>• Steinfeld, Gerald (Prüfungsberechtigt)</li> <li>• Peinke, Joachim (Prüfungsberechtigt)</li> <li>• Schmidt, Jonas (Prüfungsberechtigt)</li> <li>• Stoevesandt, Bernhard (Prüfungsberechtigt)</li> </ul>	
<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>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>	Related to selected course/s	
<b>Form of instruction</b>	Lecture ( oder Seminar mit Praktikum ) ( <i>Hier ist ein Kommentar</i> )	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy689 - Advanced Topics in Renewable Energies

<b>Module label</b>	Advanced Topics in Renewable Energies		
<b>Modulkürzel</b>	phy689		
<b>Credit points</b>	6.0 KP		
<b>Workload</b>	180 h ( Overall workload of 180 h )		
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> </ul>		
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Kühn, Martin (module responsibility)</li> <li>• Avila Canellas, Kerstin (Prüfungsberechtigt)</li> <li>• Feudel, Ulrike (Prüfungsberechtigt)</li> <li>• Holtorf, Hans-Gerhard (Prüfungsberechtigt)</li> <li>• Kühn, Martin (Prüfungsberechtigt)</li> <li>• Peinke, Joachim (Prüfungsberechtigt)</li> <li>• Wächter, Matthias (Prüfungsberechtigt)</li> <li>• Stoevesandt, Bernhard (Prüfungsberechtigt)</li> <li>• Steinfeld, Gerald (Prüfungsberechtigt)</li> <li>• Wark, Michael (Prüfungsberechtigt)</li> <li>• Steinberger-Wilckens, Robert (Prüfungsberechtigt)</li> </ul>		
<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>Literatureempfehlungen</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>			
<b>Modulart / typ of module</b>			
<b>Lehr-/Lernform / Teaching/Learning method</b>			
<b>Vorkenntnisse / Previous knowledge</b>			
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>	
<b>Final exam of module</b>	Related to selected course/s		
<b>Form of instruction</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>
			<b>Workload of compulsory attendance</b>
Lecture		4	SoSe oder WiSe
Seminar		2	SoSe oder WiSe
<b>Präsenzzeit Modul insgesamt</b>			<b>84 h</b>

## phy984 - Semiconducting Materials for Solar Energy

<b>Module label</b>	Semiconducting Materials for Solar Energy	
<b>Modulkürzel</b>	phy984	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> </ul>	
<b>Zuständige Personen</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Seminar	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	28 h	

---

## phy987 - Control of Wind Turbines and Wind Farms

<b>Module label</b>	Control of Wind Turbines and Wind Farms
<b>Modulkürzel</b>	phy987
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( Attendance: 72 hrs, Self study: 108 hrs )
<b>Verwendbarkeit des Moduls</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>Zuständige Personen</b>	<ul style="list-style-type: none"><li>• Kühn, Martin (module responsibility)</li><li>• Kühn, Martin (Prüfungsberechtigt)</li><li>• Petrovic, Vlaho (Prüfungsberechtigt)</li></ul>
<b>Prerequisites</b>	Wind Energy Utilization (Bachelor) or Wind Energy Physics (Master) or Basics of Wind Energy (Master SURE) and Design of Wind Energy Systems (can be attended in parallel)
<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

---

### 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

---

#### Literaturempfehlungen

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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>		KL		
<b>Form of instruction</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>Präsenzzeit Modul insgesamt</b>				56 h

## phy967 - Advanced Laboratories in Renewable Energies

<b>Module label</b>	Advanced Laboratories in Renewable Energies	
<b>Modulkürzel</b>	phy967	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Kühn, Martin (module responsibility)</li> <li>• Avila Canellas, Kerstin (Prüfungsberechtigt)</li> <li>• Hölling, Michael (Prüfungsberechtigt)</li> <li>• Kühn, Martin (Prüfungsberechtigt)</li> </ul>	
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>	Students acquire the competence to plan, execute, analyze, document and present complex and advanced physical experiments. They deepen their experience in working with state-of-the-art measurement and analyzing equipment within the field of Experimental Physics applied in the field of renewable Energy. The Adv. Labs are research oriented.	
<b>Module contents</b>	Each student performs 3 labs selected from a pool of labs addressing advanced measurement techniques and equipment represented in the Renewable Energy research work of various research groups at the Institute of Physics. The pool includes topics on material analysis, optical measurement techniques and state-of-the-art technologies.	
<b>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	Prüfungszeiten	Type of examination
<b>Final exam of module</b>		labs with 3 protocols plus Homework tasks
<b>Form of instruction</b>	Practical training	
<b>SWS</b>		
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	0 h	

---

## pre022 - Solar Energy

<b>Module label</b>	Solar Energy
<b>Modulkürzel</b>	pre022
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"><li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li><li>• Master's Programme Environmental Modelling (Master) &gt; Mastermodule</li><li>• Master's Programme Sustainability Economics and Management (Master) &gt; Additional Modules</li><li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li></ul>
<b>Zuständige Personen</b>	<ul style="list-style-type: none"><li>• Agert, Carsten (module responsibility)</li><li>• Torio, Herena (module responsibility)</li><li>• Torio, Herena (Prüfungsberechtigt)</li><li>• Knipper, Martin (Prüfungsberechtigt)</li><li>• Gütay, Levent (Prüfungsberechtigt)</li></ul>
<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

---

### Module contents

This module gives an overview on renewable energy heat 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)

- 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

#### Renewable Energy Heat (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; thermal 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

## Literatureempfehlungen

### 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.

### Renewable Energy Heat

- 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

## Links

## Languages of instruction

**Duration (semesters)** 1 Semester

## Module frequency

**Module capacity** unlimited

## Modullevel / module level

## Modulart / typ of module

## Lehr-/Lernform / Teaching/Learning method

## Vorkenntnisse / Previous knowledge

Examination	Prüfungszeiten	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%)

---

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
<b>Präsenzzeit Modul insgesamt</b>				<b>56 h</b>

---

## pre113 - Photovoltaic Systems

<b>Module label</b>	Photovoltaic Systems
<b>Modulkürzel</b>	pre113
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( 180 Stunden )
<b>Verwendbarkeit des Moduls</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>Zuständige Personen</b>	<ul style="list-style-type: none"><li>• Agert, Carsten (Prüfungsberechtigt)</li><li>• Knipper, Martin (Prüfungsberechtigt)</li><li>• Knipper, Martin (module responsibility)</li><li>• Agert, Carsten (module responsibility)</li></ul>
<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)

---

### Module contents

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

The module consists of:

---

#### 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.

---

#### **Literaturempfehlungen**

- 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

<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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>	Throughout the Semester	

Presentation: Between 20 and 45 minutes and regular active participation

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
<b>Präsenzzeit Modul insgesamt</b>				<b>56 h</b>

---

## pre114 - Solar Energy Meteorology

<b>Module label</b>	Solar Energy Meteorology
<b>Modulkürzel</b>	pre114
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )
<b>Verwendbarkeit des Moduls</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>Zuständige Personen</b>	<ul style="list-style-type: none"><li>• Torio, Herena (module responsibility)</li><li>• Agert, Carsten (module responsibility)</li><li>• Schmidt, Thomas (Prüfungsberechtigt)</li><li>• Lezaca Galeano, Jorge Enrique (Prüfungsberechtigt)</li></ul>
<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)

---

### 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.

#### Lecture

- 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

#### Seminar

- sources of solar data and discussion of their quality
- solar resource assessment:
- basic models,
- measurements,
- satellite models
- 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

### Literaturempfehlungen

- S. Hegedus, A. Luque, Handbook of Photovoltaic Science and Engineering, published by 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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Prüfungszeiten	Type of examination		
<b>Final exam of module</b>	During the semester	1 Written examination: 90 to 180 minutes and regular active participation		
Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
<b>Präsenzzeit Modul insgesamt</b>				<b>56 h</b>

## phy964 - Advanced Computing

<b>Module label</b>	Advanced Computing			
<b>Modulkürzel</b>	phy964			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )			
<b>Verwendbarkeit des Moduls</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>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Kühn, Martin (module responsibility)</li> <li>• Doclo, Simon (module responsibility)</li> </ul>			
<b>Prerequisites</b>	Basic knowledge in computing, knowledge in undergraduate mathematics and physics			
<b>Skills to be acquired in this module</b>	Learning of advanced programming concepts and their application in biomedical physics, acoustics, laser and optics, and renewable energies.			
<b>Module contents</b>	Advanced programming concepts for C, python and Matlab; Artificial Intelligence and Data Science; Visual Computing; Software Engineering			
<b>Literatureempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Prüfungszeiten	Type of examination		
<b>Final exam of module</b>	written exam: max 180 minutes or oral exam: max 30 minutes			
Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		4	SoSe oder WiSe	56
Exercises		4	SoSe oder WiSe	56
<b>Präsenzzeit Modul insgesamt</b>				112 h



---

## pre200 - Selected Renewable Energy Technologies

<b>Module label</b>	Selected Renewable Energy Technologies
<b>Modulkürzel</b>	pre200
<b>Credit points</b>	6.0 KP
<b>Workload</b>	180 h
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"><li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Renewable Energies</li><li>• Master's Programme Environmental Modelling (Master) &gt; Mastermodule</li><li>• Master's Programme Sustainability Economics and Management (Master) &gt; Additional Modules</li><li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li></ul>
<b>Zuständige Personen</b>	<ul style="list-style-type: none"><li>• Wark, Michael (module responsibility)</li><li>• Torio, Herena (module responsibility)</li><li>• Torio, Herena (Prüfungsberechtigt)</li><li>• Pehlken, Alexandra (Prüfungsberechtigt)</li><li>• Wark, Michael (Prüfungsberechtigt)</li><li>• Steinberger-Wilckens, Robert (Prüfungsberechtigt)</li></ul>
<b>Prerequisites</b>	
<b>Skills to be acquired in this module</b>	

The module intends to give an overview and deeper understanding of front-edge topics and technologies relevant for the energy transition.

Current main such topics are the rolling out of the hydrogen economy as well as circular economy and critical material use and ocean energy converters. In the context of the energy transition in the global south, small hydro turbines may play a relevant role and are also part of the module content. Main skills to be achieved in the module are:

- Understand and describe front-edge topics in the energy transition.
- Cross-sectoral topics, technologies and new research topics relevant for the energy transition.
- Understand the principles, chemical and energy conversion processes involved in hydrogen and fuel cell systems.
- Understand the role of hydrogen in the energy transformation and the main energy conversion processes in which it is involved.
- Critically evaluate and describe hydrogen storage systems (electrolyser, gas storage and fuel cells) as well as their uses, advantages, characteristics and pitfalls.
- Understand and describe principles governing ocean energy converters
- Understand and describe principles governing micro-hydro energy converters
- Understand and describe concepts for circular economy and recycling in the energy sector
- Understand methods for assessing critical materials, their definitions and importance for the energy transition

---

### Module contents

#### Hydrogen and fuel cells (3 CP)

- Basics of hydrogen production (materials, processes, efficiencies, environmental impacts)
- Basics of fuel cells (function, materials, construction, systems applications)
- Basics of hydrogen storage systems (their setup, control, safety aspects)

#### Hidden Champions of RE (3 CP)

- Basic concepts for circular economy and recycling of materials in the energy sector
- Basic definitions and methods for appraising critical materials for the energy transition
- Ocean energy converters: principles and examples
- Micro hydro energy converters: their principles, characteristics and

---

uses

<b>Literaturempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Prüfungszeiten	Type of examination
<b>Final exam of module</b>	At the end of the semester	Written exam (2x)
<b>Form of instruction</b>	VA-Auswahl	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

# European Wind Energy Master

## phy616 - Computational Fluid Dynamics 1 / 2

<b>Module label</b>	Computational Fluid Dynamics 1 / 2	
<b>Modulkürzel</b>	phy616	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</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>• Master's Programme Environmental Modelling (Master) &gt; Mastermodule</li> <li>• Sustainable Renewable Energy Technologies (Master) &gt; Mastermodule</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Lukassen, Laura (module responsibility)</li> <li>• Avila Canellas, Kerstin (Prüfungsberechtigt)</li> <li>• Lukassen, Laura (Prüfungsberechtigt)</li> <li>• Peinke, Joachim (Prüfungsberechtigt)</li> <li>• Stoevesandt, Bernhard (Prüfungsberechtigt)</li> </ul>	
<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>	<p>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.</p> <p>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.</p>	
<b>Literaturempfehlungen</b>	<p>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)</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>	<ul style="list-style-type: none"> <li>• 1 Klausur oder</li> <li>• 1 Referat oder</li> </ul>	

---

Examination	Prüfungszeiten	Type of examination
		<ul style="list-style-type: none"><li>• 1 mündliche Prüfung oder</li><li>• 1 fachpraktische Übung</li></ul>
<b>Form of instruction</b>	VA-Auswahl ( Vorlesungen oder Praktikum oder Seminar )	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

---

## phy659 - Introduction to Micro Meteorology for Wind Energy

<b>Module label</b>	Introduction to Micro Meteorology for Wind Energy	
<b>Modulkürzel</b>	phy659	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Zuständige Personen</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	VA-Auswahl ( Das Modul wird an der Patnerhochschule angeboten. )	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy670 - Fluidynamics II/Wind Energy Meterology

<b>Module label</b>	Fluidynamics II/Wind Energy Meterology			
<b>Modulkürzel</b>	phy670			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Zuständige Personen</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Literatureempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>		<b>KL</b>		
<b>Form of instruction</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>Präsenzzeit Modul insgesamt</b>				<b>56 h</b>

## phy673 - Diffusions and Stochastic Differential Equations

<b>Module label</b>	Diffusions and Stochastic Differential Equations	
<b>Modulkürzel</b>	phy673	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Zuständige Personen</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Literaturempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Vorlesung und Übung ( Das Modul wird an der Patnerhochschule angeboten. )	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy674 - Turbulent Flows

<b>Module label</b>	Turbulent Flows	
<b>Modulkürzel</b>	phy674	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Zuständige Personen</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Vorlesung und Übung ( Das Modul wird an der Patnerhochschule angeboten. )	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	



## phy684 - Wind Turbine Technology and Aerodynamics

<b>Module label</b>	Wind Turbine Technology and Aerodynamics			
<b>Modulkürzel</b>	phy684			
<b>Credit points</b>	10.0 KP			
<b>Workload</b>	300 h			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Zuständige Personen</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Literatureempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Prüfungszeiten		Type of examination	
<b>Final exam of module</b>			KL	
Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
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>Präsenzzeit Modul insgesamt</b>				84 h

## phy688 - Planning and Development of Wind Farms

<b>Module label</b>	Planning and Development of Wind Farms	
<b>Modulkürzel</b>	phy688	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Zuständige Personen</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Literaturempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	VA-Auswahl ( Das Modul wird an der Patnerhochschule angeboten. )	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

---

## phy692 - Research Project EWEM

<b>Module label</b>	Research Project EWEM	
<b>Modulkürzel</b>	phy692	
<b>Credit points</b>	9.0 KP	
<b>Workload</b>	270 h	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"><li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li></ul>	
<b>Zuständige Personen</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Literatureempfehlungen</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>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		BE
<b>Form of instruction</b>	Seminar	
<b>SWS</b>		
<b>Frequency</b>		
<b>Workload Präsenzzeit</b>	0 h	

## phy991 - Stochastic Processes

<b>Module label</b>	Stochastic Processes			
<b>Modulkürzel</b>	phy991			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Zuständige Personen</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Literatureempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>			KL	
<b>Form of instruction</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>Präsenzzeit Modul insgesamt</b>				<b>84 h</b>

## phy992 - Time Series Analysis

<b>Module label</b>	Time Series Analysis			
<b>Modulkürzel</b>	phy992			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Zuständige Personen</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Literaturempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>			KL	
<b>Form of instruction</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>Präsenzzeit Modul insgesamt</b>				<b>56 h</b>

## phy993 - Advanced Time Series Analysis

<b>Module label</b>	Advanced Time Series Analysis			
<b>Modulkürzel</b>	phy993			
<b>Credit points</b>	10.0 KP			
<b>Workload</b>	300 h			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Zuständige Personen</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Literaturempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>			KL	
<b>Form of instruction</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>Präsenzzeit Modul insgesamt</b>				<b>84 h</b>

## phy994 - Optimization and Data Fitting

<b>Module label</b>	Optimization and Data Fitting			
<b>Modulkürzel</b>	phy994			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Zuständige Personen</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Literaturempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>			KL	
<b>Form of instruction</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>Präsenzzeit Modul insgesamt</b>				<b>56 h</b>

## phy995 - Physics of Sustainable Energy

<b>Module label</b>	Physics of Sustainable Energy	
<b>Modulkürzel</b>	phy995	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Zuständige Personen</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Literaturempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	



## phy996 - Offshore Wind Energy

<b>Module label</b>	Offshore Wind Energy	
<b>Modulkürzel</b>	phy996	
<b>Credit points</b>	10.0 KP	
<b>Workload</b>	300 h	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Zuständige Personen</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	6	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	84 h	

## phy997 - Wind Turbine Measurement Techniques

<b>Module label</b>	Wind Turbine Measurement Techniques	
<b>Modulkürzel</b>	phy997	
<b>Credit points</b>	10.0 KP	
<b>Workload</b>	300 h	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Zuständige Personen</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	6	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	84 h	

## phy998 - Probabilistic Methods in Wind Energy

<b>Module label</b>	Probabilistic Methods in Wind Energy			
<b>Modulkürzel</b>	phy998			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Zuständige Personen</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Literaturempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>			KL	
<b>Form of instruction</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>Präsenzzeit Modul insgesamt</b>				<b>56 h</b>

## phy621 - Advanced Engineering Topics in Wind Energy

<b>Module label</b>	Advanced Engineering Topics in Wind Energy	
<b>Modulkürzel</b>	phy621	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Zuständige Personen</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	VA-Auswahl	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	28 h	

## phy622 - Advanced Topics in Wind Energy

<b>Module label</b>	Advanced Topics in Wind Energy	
<b>Modulkürzel</b>	phy622	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Zuständige Personen</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	VA-Auswahl	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	28 h	

## phy645 - Wind Physics Measurement Project

<b>Module label</b>	Wind Physics Measurement Project	
<b>Modulkürzel</b>	phy645	
<b>Credit points</b>	3.0 KP	
<b>Workload</b>	90 h	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Zuständige Personen</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Literaturempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	28 h	

## phy985 - Stochastic Processes in Experiments

<b>Module label</b>	Stochastic Processes in Experiments	
<b>Modulkürzel</b>	phy985	
<b>Credit points</b>	3.0 KP	
<b>Workload</b>	90 h	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Zuständige Personen</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Literaturempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Seminar	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	28 h	

## phy629 - Optimization in modern Power Systems

<b>Module label</b>	Optimization in modern Power Systems			
<b>Modulkürzel</b>	phy629			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Zuständige Personen</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Literaturempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>				KL
<b>Form of instruction</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>Präsenzzeit Modul insgesamt</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>Modulkürzel</b>	phy675			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Zuständige Personen</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Literaturempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>		<b>KL</b>		
<b>Form of instruction</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>Präsenzzeit Modul insgesamt</b>				<b>56 h</b>

## phy981 - HardTech Entrepreneurship

<b>Module label</b>	HardTech Entrepreneurship			
<b>Modulkürzel</b>	phy981			
<b>Credit points</b>	10.0 KP			
<b>Workload</b>	300 h			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Zuständige Personen</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Literaturempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>			KL	
<b>Form of instruction</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>Präsenzzeit Modul insgesamt</b>				<b>56 h</b>

## phy986 - System Safety and Reliability Engineering

<b>Module label</b>	System Safety and Reliability Engineering			
<b>Modulkürzel</b>	phy986			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Zuständige Personen</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Literaturempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>				<b>KL</b>
<b>Form of instruction</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>Präsenzzeit Modul insgesamt</b>				<b>56 h</b>

## phy623 - Advanced Wind Energy Meteorology

<b>Module label</b>	Advanced Wind Energy Meteorology			
<b>Modulkürzel</b>	phy623			
<b>Credit points</b>	3.0 KP			
<b>Workload</b>	90 h			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Zuständige Personen</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>	TEST			
<b>Module contents</b>	Test			
<b>Literatureempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>			KL	
<b>Form of instruction</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>Präsenzzeit Modul insgesamt</b>				<b>56 h</b>

## phy625 - Deep Learning

<b>Module label</b>	Deep Learning	
<b>Modulkürzel</b>	phy625	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Zuständige Personen</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>	Kompetenzziele	
<b>Module contents</b>	Inhalt	
<b>Literaturempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	28 h	

## phy626 - Introduction to Dynamical Systems

<b>Module label</b>	Introduction to Dynamical Systems	
<b>Modulkürzel</b>	phy626	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Zuständige Personen</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Literaturempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	28 h	

## phy988 - Introduction to Machine Learning and Data Mining

<b>Module label</b>	Introduction to Machine Learning and Data Mining	
<b>Modulkürzel</b>	phy988	
<b>Credit points</b>	5.0 KP	
<b>Workload</b>	150 h	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>	
<b>Zuständige Personen</b>		
<b>Prerequisites</b>		
<b>Skills to be acquired in this module</b>		
<b>Module contents</b>		
<b>Literaturempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	2	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	28 h	

## phy627 - Hydrodynamics II

<b>Module label</b>	Hydrodynamics II			
<b>Modulkürzel</b>	phy627			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Zuständige Personen</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Literaturempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>		<b>KL</b>		
<b>Form of instruction</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture			SoSe oder WiSe	0
Exercises			SoSe oder WiSe	0
<b>Präsenzzeit Modul insgesamt</b>				<b>0 h</b>



## phy628 - Computational Tool for Data Science

<b>Module label</b>	Computational Tool for Data Science			
<b>Modulkürzel</b>	phy628			
<b>Credit points</b>	3.0 KP			
<b>Workload</b>	90 h			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Zuständige Personen</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Literaturempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>		<b>KL</b>		
<b>Form of instruction</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture			SoSe oder WiSe	0
Exercises			SoSe oder WiSe	0
<b>Präsenzzeit Modul insgesamt</b>				<b>0 h</b>

## phy629 - Advanced CFD

<b>Module label</b>	Advanced CFD			
<b>Modulkürzel</b>	phy629			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Zuständige Personen</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Literaturempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>		KL		
<b>Form of instruction</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture			SoSe oder WiSe	0
Exercises			SoSe oder WiSe	0
<b>Präsenzzeit Modul insgesamt</b>				<b>0 h</b>

## phy657 - Energy Economics

<b>Module label</b>	Energy Economics			
<b>Modulkürzel</b>	phy657			
<b>Credit points</b>	5.0 KP			
<b>Workload</b>	150 h			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; European Wind Energy Master</li> </ul>			
<b>Zuständige Personen</b>				
<b>Prerequisites</b>				
<b>Skills to be acquired in this module</b>				
<b>Module contents</b>				
<b>Literaturempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>		
<b>Final exam of module</b>		KL		
<b>Form of instruction</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>	<b>Workload of compulsory attendance</b>
Lecture			SoSe oder WiSe	0
Exercises			SoSe oder WiSe	0
<b>Präsenzzeit Modul insgesamt</b>				<b>0 h</b>

# Schwerpunkt: Acoustics

## phy605 - Digital Signal Processing

<b>Module label</b>	Digital Signal Processing	
<b>Modulkürzel</b>	phy605	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>Doclo, Simon (module responsibility)</li> <li>Doclo, Simon (Prüfungsberechtigt)</li> </ul>	
<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>Literaturempfehlungen</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", Broschiert, 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>		
<b>Modulart / typ of module</b>		
<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>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		Max. 180 min. Klausur oder 30 min. mündliche Prüfung
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	

---

**Workload Präsenzzeit**

56 h

---

## phy677 - Speech processing

<b>Module label</b>	Speech processing	
<b>Modulkürzel</b>	phy677	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( 180 h (Präsenzzeit 56h, Selbststudium: 124h) )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Doclo, Simon (module responsibility)</li> <li>• Doclo, Simon (Prüfungsberechtigt)</li> <li>• Enzner, Gerald (Prüfungsberechtigt)</li> <li>• Kollmeier, Birger (Prüfungsberechtigt)</li> <li>• Meyer, Bernd (Prüfungsberechtigt)</li> </ul>	
<b>Prerequisites</b>	Introductory signals and systems lecture	
<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>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy679 - Acoustics

<b>Module label</b>	Acoustics	
<b>Modulkürzel</b>	phy679	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• van de Par, Steven (module responsibility)</li> <li>• Ewert, Stephan (Prüfungsberechtigt)</li> <li>• Kollmeier, Birger (Prüfungsberechtigt)</li> <li>• van de Par, Steven (Prüfungsberechtigt)</li> </ul>	
<b>Prerequisites</b>	Introductory acoustics lecture	
<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>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Prüfungszeiten	Type of examination
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

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

<b>Module label</b>	Advanced Engineering Topics in Biomedical Physics & Acoustics			
<b>Modulkürzel</b>	phy685			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Overall workload of 180 h )			
<b>Verwendbarkeit des Moduls</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>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Doclo, Simon (module responsibility)</li> <li>• Poppe, Björn (module responsibility)</li> <li>• Anemüller, Jörn (Prüfungsberechtigt)</li> <li>• Biehs, Svend-Age (Prüfungsberechtigt)</li> <li>• Blau, Matthias (Prüfungsberechtigt)</li> <li>• Brand, Thomas (Prüfungsberechtigt)</li> <li>• Dietz, Mathias (Prüfungsberechtigt)</li> <li>• Doclo, Simon (Prüfungsberechtigt)</li> <li>• Enzner, Gerald (Prüfungsberechtigt)</li> <li>• Ewert, Stephan (Prüfungsberechtigt)</li> <li>• Hohmann, Volker (Prüfungsberechtigt)</li> <li>• Kollmeier, Birger (Prüfungsberechtigt)</li> <li>• Lücke, Jörg (Prüfungsberechtigt)</li> <li>• Meyer, Bernd (Prüfungsberechtigt)</li> <li>• Oetjen, Arne (Prüfungsberechtigt)</li> <li>• Poppe, Björn (Prüfungsberechtigt)</li> <li>• Siedenburg, Kai (Prüfungsberechtigt)</li> <li>• Töpken, Stephan (Prüfungsberechtigt)</li> <li>• Uppenkamp, Stefan (Prüfungsberechtigt)</li> <li>• van de Par, Steven (Prüfungsberechtigt)</li> </ul>			
<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>Literatureempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Prüfungszeiten		Type of examination	
<b>Final exam of module</b>	Related to selected course/s			
Form of instruction	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>Präsenzzeit Modul insgesamt</b>				126 h





## phy686 - Advanced Topics in Biomedical Physics & Acoustics

<b>Module label</b>	Advanced Topics in Biomedical Physics & Acoustics		
<b>Modulkürzel</b>	phy686		
<b>Credit points</b>	6.0 KP		
<b>Workload</b>	180 h ( Overall workload of 180 h )		
<b>Verwendbarkeit des Moduls</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>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Doclo, Simon (module responsibility)</li> <li>• Poppe, Björn (module responsibility)</li> <li>• Anemüller, Jörn (Prüfungsberechtigt)</li> <li>• Bitzer, Jörg (Prüfungsberechtigt)</li> <li>• Blau, Matthias (Prüfungsberechtigt)</li> <li>• Brand, Thomas (Prüfungsberechtigt)</li> <li>• Dietz, Mathias (Prüfungsberechtigt)</li> <li>• Doclo, Simon (Prüfungsberechtigt)</li> <li>• Enzner, Gerald (Prüfungsberechtigt)</li> <li>• Ewert, Stephan (Prüfungsberechtigt)</li> <li>• Hohmann, Volker (Prüfungsberechtigt)</li> <li>• Lücke, Jörg (Prüfungsberechtigt)</li> <li>• Kollmeier, Birger (Prüfungsberechtigt)</li> <li>• Meyer, Bernd (Prüfungsberechtigt)</li> <li>• Poppe, Björn (Prüfungsberechtigt)</li> <li>• Oetjen, Arne (Prüfungsberechtigt)</li> <li>• Siedenburg, Kai (Prüfungsberechtigt)</li> <li>• Töpken, Stephan (Prüfungsberechtigt)</li> <li>• van de Par, Steven (Prüfungsberechtigt)</li> <li>• Uppenkamp, Stefan (Prüfungsberechtigt)</li> </ul>		
<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>Literatureempfehlungen</b>	Related to selected course/s		
<b>Links</b>	Depending on selected courses		
<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>			
<b>Modulart / typ of module</b>			
<b>Lehr-/Lernform / Teaching/Learning method</b>			
<b>Vorkenntnisse / Previous knowledge</b>			
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>	
<b>Final exam of module</b>	Related to selected course/s		
<b>Form of instruction</b>	<b>Comment</b>	<b>SWS</b>	<b>Frequency</b>
			<b>Workload of compulsory attendance</b>
Lecture		4	SoSe oder WiSe
Seminar			SoSe oder WiSe
<b>Präsenzzeit Modul insgesamt</b>			56 h

## phy694 - Machine Learning II

<b>Module label</b>	Machine Learning II	
<b>Modulkürzel</b>	phy694	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Lücke, Jörg (module responsibility)</li> <li>• Lücke, Jörg (Prüfungsberechtigt)</li> </ul>	
<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>Literatureempfehlungen</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Prüfungszeiten	Type of examination
<b>Final exam of module</b>		KL
<b>Form of instruction</b>	Lecture	

---

<b>SWS</b>	4
<b>Frequency</b>	SoSe oder WiSe
<b>Workload Präsenzzeit</b>	56 h

---

## phy696 - Advanced Topics Speech and Audio Processing

<b>Module label</b>	Advanced Topics Speech and Audio Processing	
<b>Modulkürzel</b>	phy696	
<b>Credit points</b>	6.0 KP	
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )	
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> </ul>	
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Doclo, Simon (module responsibility)</li> <li>• Doclo, Simon (Prüfungsberechtigt)</li> <li>• Gerkmann, Timo (Prüfungsberechtigt)</li> </ul>	
<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>Literaturempfehlungen</b>	<p>J. Benesty, M. M. Sondhi, Y. Huang: Handbook of Speech Processing, Springer, 2008.;</p> <p>P. Vary, R. Martin: Digital Speech Transmission, Wiley, 2006.;</p> <p>P. Loizou: Speech Enhancement: Theory and Practice, CRC Press, 2007.;</p> <p>S. Vaseghi: Advanced Digital Signal Processing and Noise Reduction, Wiley, 2006.;</p> <p>S. Haykin: Adaptive Filter Theory, Prentice Hall, 2013.</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>		
<b>Modulart / typ of module</b>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
<b>Examination</b>	<b>Prüfungszeiten</b>	<b>Type of examination</b>
<b>Final exam of module</b>		Exam or presentation or oral exam or homework or practical report
<b>Form of instruction</b>	Lecture	
<b>SWS</b>	4	
<b>Frequency</b>	SoSe oder WiSe	
<b>Workload Präsenzzeit</b>	56 h	

## phy960 - Psychoacoustics

<b>Module label</b>	Psychoacoustics			
<b>Modulkürzel</b>	phy960			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )			
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"> <li>• Master's Programme Engineering Physics (Master) &gt; Schwerpunkt: Acoustics</li> </ul>			
<b>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• van de Par, Steven (module responsibility)</li> <li>• van de Par, Steven (Prüfungsberechtigt)</li> </ul>			
<b>Prerequisites</b>	Introductory acoustics lecture			
<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>Literatureempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Prüfungszeiten	Type of examination		
<b>Final exam of module</b>	one or two examination, totaling to 180 min. written exam or 30 min. oral exam			
Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28

---

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Exercises		2	SoSe oder WiSe	28
<b>Präsenzzeit Modul insgesamt</b>				<b>84 h</b>

---

## phy964 - Advanced Computing

<b>Module label</b>	Advanced Computing			
<b>Modulkürzel</b>	phy964			
<b>Credit points</b>	6.0 KP			
<b>Workload</b>	180 h ( Attendance: 56 hrs, Self study: 124 hrs )			
<b>Verwendbarkeit des Moduls</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>Zuständige Personen</b>	<ul style="list-style-type: none"> <li>• Kühn, Martin (module responsibility)</li> <li>• Doclo, Simon (module responsibility)</li> </ul>			
<b>Prerequisites</b>	Basic knowledge in computing, knowledge in undergraduate mathematics and physics			
<b>Skills to be acquired in this module</b>	Learning of advanced programming concepts and their application in biomedical physics, acoustics, laser and optics, and renewable energies.			
<b>Module contents</b>	Advanced programming concepts for C, python and Matlab; Artificial Intelligence and Data Science; Visual Computing; Software Engineering			
<b>Literatureempfehlungen</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>				
<b>Modulart / typ of module</b>				
<b>Lehr-/Lernform / Teaching/Learning method</b>				
<b>Vorkenntnisse / Previous knowledge</b>				
Examination	Prüfungszeiten	Type of examination		
<b>Final exam of module</b>		written exam: max 180 minutes or oral exam: max 30 minutes		
Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		4	SoSe oder WiSe	56
Exercises		4	SoSe oder WiSe	56
<b>Präsenzzeit Modul insgesamt</b>				112 h



---

# Abschlussmodul

## mam - Master's Thesis Module

<b>Module label</b>	Master's Thesis Module
<b>Modulkürzel</b>	mam
<b>Credit points</b>	30.0 KP
<b>Workload</b>	900 h
<b>Verwendbarkeit des Moduls</b>	<ul style="list-style-type: none"><li>• Master's Programme Engineering Physics (Master) &gt; Abschlussmodul</li></ul>
<b>Zuständige Personen</b>	<ul style="list-style-type: none"><li>• Brückner, Hans Josef (Prüfungsberechtigt)</li><li>• Agert, Carsten (Prüfungsberechtigt)</li><li>• Avila Canellas, Kerstin (Prüfungsberechtigt)</li><li>• Biehs, Svend-Age (Prüfungsberechtigt)</li><li>• Brand, Thomas (Prüfungsberechtigt)</li><li>• Struve, Bert (Prüfungsberechtigt)</li><li>• Dietz, Mathias (Prüfungsberechtigt)</li><li>• Doclo, Simon (Prüfungsberechtigt)</li><li>• Ewert, Stephan (Prüfungsberechtigt)</li><li>• Hohmann, Volker (Prüfungsberechtigt)</li><li>• Feudel, Ulrike (Prüfungsberechtigt)</li><li>• Hartmann, Alexander (Prüfungsberechtigt)</li><li>• Schüning, Thomas (Prüfungsberechtigt)</li><li>• Lücke, Jörg (Prüfungsberechtigt)</li><li>• Kollmeier, Birger (Prüfungsberechtigt)</li><li>• Kühn, Martin (Prüfungsberechtigt)</li><li>• Neu, Walter (Prüfungsberechtigt)</li><li>• Lukassen, Laura (Prüfungsberechtigt)</li><li>• Kunz-Drolshagen, Jutta (Prüfungsberechtigt)</li><li>• Lienau, Christoph (Prüfungsberechtigt)</li><li>• Poppe, Björn (Prüfungsberechtigt)</li><li>• Meyer, Bernd (Prüfungsberechtigt)</li><li>• Nilius, Niklas (Prüfungsberechtigt)</li><li>• Peinke, Joachim (Prüfungsberechtigt)</li><li>• van de Par, Steven (Prüfungsberechtigt)</li><li>• Schmidt, Thorsten (Prüfungsberechtigt)</li><li>• Strybny, Jann (Prüfungsberechtigt)</li><li>• Teubner, Ulrich (Prüfungsberechtigt)</li><li>• Uppenkamp, Stefan (Prüfungsberechtigt)</li><li>• Wark, Michael (Prüfungsberechtigt)</li><li>• Wollenhaupt, Matthias (Prüfungsberechtigt)</li><li>• der Masterarbeit, BetreuerIn (module responsibility)</li></ul>
<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.</p> <p>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.</p> <p>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.</p> <p>Within this framework, the students work independently on a current topic from</p>

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.

<b>Literaturempfehlungen</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>		
<b>Lehr-/Lernform / Teaching/Learning method</b>		
<b>Vorkenntnisse / Previous knowledge</b>		
Examination	Prüfungszeiten	Type of examination
<b>Final exam of module</b>		Master thesis and colloquium
<b>Form of instruction</b>	Seminar	
<b>SWS</b>		
<b>Frequency</b>		
<b>Workload Präsenzzeit</b>	0 h	

