Pflichtmodule

phy611 - Theoretical Methods

Module label	Theoretical Methods
Modulkürzel	phy611
Credit points	6.0 KP
Workload	180 h (attendance: 56 hrs, self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Pflichtmodule
Zuständige Personen	• Cocchi, Caterina (module responsibility) • Anemüller, Jörn (Prüfungsberechtigt) • Avila Canellas, Kerstin (Prüfungsberechtigt) • Cocchi, Caterina (Prüfungsberechtigt) • Doclo, Simon (Prüfungsberechtigt) • Hartmann, Alexander (Prüfungsberechtigt) • Kühn, Martin (Prüfungsberechtigt) • Kunz-Drolshagen, Jutta (Prüfungsberechtigt) • Neu, Walter (Prüfungsberechtigt) • Peinke, Joachim (Prüfungsberechtigt) • Poppe, Björn (Prüfungsberechtigt) • Schmidt, Thorsten (Prüfungsberechtigt) • Stoevesandt, Bernhard (Prüfungsberechtigt) • Strybny, Jann (Prüfungsberechtigt)
Prerequisites	basic programming skills (matlab, python, C/C++)
Skills to be acquired in this module	Computational Fluid Dynamics (CFD I & II) • 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 fluiddynamics. • 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. 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. 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.
Module contents	Computational Fluid Dynamics (CFD I & II) • CFD I: The Navier-Stokes equations, filtering / averaging of Navier-Stokes equations, introduction to numerical methods, finite- differences,

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

Computerorientierte Physik

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

Modelling and Simulation

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

Literaturempfehlungen

- 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

Languages of instruction			German, English		
Duration (semesters)			1 Semester		
Module frequency			halbjährlich		
Module capacity			unlimited		
Examination		Prüfungszeiten		Type of examination	
Final exam of module				According selected course	
Form of instruction	Comment		SWS	Frequency	Workload of compulsory attendance
Lecture			2	SoSe oder WiSe	28
Exercises			2	SoSe oder WiSe	28
Präsenzzeit Modul insgesamt					56 h

phy631 - Advanced Metrology

Module label	Advanced Metrology
Modulkürzel	phy631
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Pflichtmodule
Zuständige Personen	• Huke, Philipp (module responsibility) • Huke, Philipp (Prüfungsberechtigt) • Huke, Philipp (Module counselling)
Prerequisites	
Skills to be acquired in this module	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&optics, Biomedical physics & acoustics, and renewable energies. Demonstrate systematic knowledge across appropriate advanced metrology technologies, management and environmental issues to provide solutions for international industries and/or research organisations
Module contents	The module combines theory and practical applications of the fundaments of metrology in all majors. • Fundamentals of Metrology • Dimensional Measurement Systems • Basic metrology operators including Association and Filtration. • Optical Metrology and Instrumentation • Surface and Nanometrology • Machine Tool and Large Volume Metrology • Process Measurement and Control • Individual Project
Literaturempfehlungen	T. Yoshizawa (Ed.): Handbook of Optical Metrology: Principles and Applications, 2nd rev. ed., Crc Pr Inc., 2015 Recent publications on specific topics
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	halbjährlich
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		1 written exam or 1 presentation or 1 oral exam or 1 seminar paper

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
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
Präsenzzeit Modul insgesamt				140 h

phy640 - Seminar Advanced Topics in EP

Module label	Seminar Advanced Topics in EP
Modulkürzel	phy640
Credit points	3.0 KP
Workload	90 h (Attendance: 28 hrs, Self study: 62 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Pflichtmodule
Zuständige Personen	• Neu, Walter (module responsibility) • Herráez, Iván (Prüfungsberechtigt) • Neu, Walter (Prüfungsberechtigt) • Koch, Sandra (Prüfungsberechtigt)
Prerequisites	Participation: 1st -3rd semester. Presentation: Master thesis work in progress or finished; at least one successfully completed specialization module.
Skills to be acquired in this module	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.
Module contents	Current seminar topics
Literaturempfehlungen	M. Alley: The Craft of Scientific Presentations, Springer, 2nd ed., 2013 Publications according to seminar topics
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	halbjährlich
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		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.

Form of instruction	Seminar
SWS	2
Frequency	--
Workload Präsenzzeit	28 h

phy681 - Tools and Skills for Scientific Engineering

Module label	Tools and Skills for Scientific Engineering
Modulkürzel	phy681
Credit points	6.0 KP
Workload	180 h (Attendance: 28 hrs, Self study: 152 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Pflichtmodule
Zuständige Personen	• Huke, Philipp (module responsibility) • Doclo, Simon (Prüfungsberechtigt) • Huke, Philipp (Prüfungsberechtigt) • Koch, Sandra (Prüfungsberechtigt) • Neu, Walter (Prüfungsberechtigt) • Petrovic, Vlaho (Prüfungsberechtigt) • Poppe, Björn (Prüfungsberechtigt) • Reck, Martin (Prüfungsberechtigt) • Schellenberg, Markus (Prüfungsberechtigt) • Schüning, Thomas (Prüfungsberechtigt) • Teubner, Ulrich (Prüfungsberechtigt) • Silies, Martin (Prüfungsberechtigt)
Prerequisites	Acc. selected course
Skills to be acquired in this module	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. 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.
Module contents	Acc. selected course
Literaturempfehlungen	Acc. selected course
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	halbjährlich
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		Acc. selected course

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
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
Präsenzzeit Modul insgesamt				98 h

phy691 - Advanced Research Project (Preparation Master Thesis)

Module label	Advanced Research Project (Preparation Master Thesis)
Modulkürzel	phy691
Credit points	15.0 KP
Workload	450 h (Attendance: 320 hrs, Self study: 130 hrs Project work: 40 hours/week or part time)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Pflichtmodule
Zuständige Personen	• Neu, Walter (module responsibility) • Agert, Carsten (Prüfungsberechtigt) • Drolshagen, Gerhard (Prüfungsberechtigt) • Avila Canellas, Kerstin (Prüfungsberechtigt) • Gülker, Gerd (Prüfungsberechtigt) • Anemüller, Jörn (Prüfungsberechtigt) • Knecht, Robin (Prüfungsberechtigt) • Biehs, Svend-Age (Prüfungsberechtigt) • Brand, Thomas (Prüfungsberechtigt) • Torio, Herena (Prüfungsberechtigt) • Holtorf, Hans-Gerhard (Prüfungsberechtigt) • Cocchi, Caterina (Prüfungsberechtigt) • Dietz, Mathias (Prüfungsberechtigt) • Doclo, Simon (Prüfungsberechtigt) • Doerner, Karl-Joachim (Prüfungsberechtigt) • Englert, Lars (Prüfungsberechtigt) • Enzner, Gerald (Prüfungsberechtigt) • Lücke, Jörg (Prüfungsberechtigt) • Lukassen, Laura (Prüfungsberechtigt) • Ewert, Stephan (Prüfungsberechtigt) • Feudel, Ulrike (Prüfungsberechtigt) • Gütay, Levent (Prüfungsberechtigt) • Fatikow, Sergej (Prüfungsberechtigt) • Hartmann, Alexander (Prüfungsberechtigt) • Herráez, Iván (Prüfungsberechtigt) • Hohmann, Volker (Prüfungsberechtigt) • Neu, Walter (Prüfungsberechtigt) • Huke, Philipp (Prüfungsberechtigt) • Knipper, Martin (Prüfungsberechtigt) • Koch, Sandra (Prüfungsberechtigt) • Kollmeier, Birger (Prüfungsberechtigt) • Kühn, Martin (Prüfungsberechtigt) • Lehnhoff, Sebastian (Prüfungsberechtigt) • Kunz-Drolshagen, Jutta (Prüfungsberechtigt) • Lienau, Christoph (Prüfungsberechtigt) • Looe, Hui Khee (Prüfungsberechtigt) • Nilius, Niklas (Prüfungsberechtigt) • Meyer, Bernd (Prüfungsberechtigt) • Poppe, Björn (Prüfungsberechtigt) • Peinke, Joachim (Prüfungsberechtigt) • Oetjen, Arne (Prüfungsberechtigt) • Steinfeld, Gerald (Prüfungsberechtigt) • Pehlken, Alexandra (Prüfungsberechtigt) • Schneider, Christian (Prüfungsberechtigt) • Reck, Martin (Prüfungsberechtigt) • Ruehmann, Antje (Prüfungsberechtigt) • Schellenberg, Markus (Prüfungsberechtigt) • Schmidt, Andreas Hermann (Prüfungsberechtigt) • Schmidt, Thorsten (Prüfungsberechtigt) • Silies, Martin (Prüfungsberechtigt) • Siedenburg, Kai (Prüfungsberechtigt) • Stoevesandt, Bernhard (Prüfungsberechtigt) • Teubner, Ulrich (Prüfungsberechtigt) • van de Par, Steven (Prüfungsberechtigt) • Uppenkamp, Stefan (Prüfungsberechtigt) • Wark, Michael (Prüfungsberechtigt) • Wollenhaupt, Matthias (Prüfungsberechtigt)
Prerequisites	Sound knowledge in the specialisation field of Master thesis
Skills to be acquired in this module	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-pf-the-art research methods.	
Module contents		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	
Literaturempfehlungen		Acc. Research eld, Recent publications on specific topics	
Links			
Languages of instruction			
Duration (semesters)		1 Semester	
Module frequency			
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			S
Form of instruction	Seminar		
Frequency			

Advanced Physics

phy602 - Advanced Nuclear & Particle Physics

Module label	Advanced Nuclear & Particle Physics
Modulkürzel	phy602
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Advanced Physics
Zuständige Personen	• Poppe, Björn (module responsibility) • Drolshagen, Gerhard (Prüfungsberechtigt) • Poppe, Björn (Prüfungsberechtigt) • Looe, Hui Khee (Prüfungsberechtigt)
Prerequisites	Basic lectures in physics / engineering
Skills to be acquired in this module	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. 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.
Module contents	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. 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.
Literaturempfehlungen	H. Krieger: Strahlungsmessung und Dosimetrie, Springer Verlag, Wiesbaden, 2013; Grupen: Astroparticle Physics, Springer Verlag, Heidelberg, 2005; Falkenburg, Rhode (Eds.): From Ultra Rays to Astroparticles, Springer Verlag, Heidelberg, 2012
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	jährlich
Module capacity	unlimited
Type of module	je nach Studiengang Pflicht oder Wahlpflicht
Module level	MM (Mastermodul / Master module)
Teaching/Learning method	each lecture: 2hrs/week
Previous knowledge	Basic lectures in physics / engineering

Examination	Prüfungszeiten	Type of examination
Final exam of module		written exam Max. 180 min. or oral exam 30 min.

Form of instruction	Lecture
SWS	4

Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy603 - Fluid Dynamics

Module label	Fluid Dynamics
Modulkürzel	phy603
Credit points	6.0 KP
Workload	180 h (Attendance: 84 hrs, Self study: 96 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Advanced Physics
Zuständige Personen	• Peinke, Joachim (module responsibility) • Avila Canellas, Kerstin (Prüfungsberechtigt) • Lukassen, Laura (Prüfungsberechtigt) • Peinke, Joachim (Prüfungsberechtigt)
Prerequisites	
Skills to be acquired in this module	Fundamental knowledge and comprehension on the movement of fluids
Module contents	Fluid Dynamics I: Basic equations: Navier-Stokes-equation, Continuity- equation, Bernoulli-equation; Vortex- equation { and Energy balance equations; laminar ows and stability analysis; exact solutions, application of basic equations Fluid Dynamics II: Reynolds-equation, "closing problem" of turbulence: Turbulence models: Cascade models, Stsochastic models
Literaturempfehlungen	J. Spurk, N. Aksel: Fluid Mechanics, Springer D. J. Tritton: Physical Fluid dynamics. Clarendon Press, Oxford, 2003 G. K. Batchelor: An introduction to fluid dynamics. Cambridge University Press, Cambridge, 2002 U. Frisch: Turbulence: the legacy of A. N. Kolmogorov. Cambridge University Press, Cambridge, 2001 J. Mathieu, J. Scott: An introduction to turbulent ow. Cambridge University Press, Cambridge, 2000 P.A. Davidson: turbulence Oxford 2004
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited
Reference text	Unterrichtssprache: English. German on demand, if no international students participate

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

Form of instruction	Lecture
SWS	4
Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy607 - Selected Topics in Advanced Physics

Module label	Selected Topics in Advanced Physics
Modulkürzel	phy607
Credit points	6.0 KP
Workload	180 h (Overall workload of 180 h)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Advanced Physics
Zuständige Personen	• Neu, Walter (module responsibility) • Avila Canellas, Kerstin (Prüfungsberechtigt) • Gülker, Gerd (Prüfungsberechtigt) • Lienau, Christoph (Prüfungsberechtigt) • Nilius, Niklas (Prüfungsberechtigt)
Prerequisites	Related to selected course/s
Skills to be acquired in this module	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.
Module contents	Photonics, Optics, Metrology,
Literaturempfehlungen	Related to selected course/s
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	Sommer- oder Wintersemester
Module capacity	unlimited
Reference text	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.

Examination	Prüfungszeiten	Type of examination
Final exam of module		Related to selected course/s

Form of instruction	Lecture
SWS	4
Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy633 - Optics

Module label	Optics
Modulkürzel	phy633
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Advanced Physics
Zuständige Personen	• Teubner, Ulrich (module responsibility) • Teubner, Ulrich (Prüfungsberechtigt)
Prerequisites	Electrodynamics
Skills to be acquired in this module	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.
Module contents	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 abberations, 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)
Literaturempfehlungen	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
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	Wintersemester
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module	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

Form of instruction	Lecture
SWS	4
Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy617 - Fourier Methods

Module label	Fourier Methods
Modulkürzel	phy617
Credit points	6.0 KP
Workload	180 h (Attendance: 56hrs, Self Study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Advanced Physics
Zuständige Personen	• Teubner, Ulrich (module responsibility) • Teubner, Ulrich (Prüfungsberechtigt) • Silies, Martin (Prüfungsberechtigt)
Prerequisites	
Skills to be acquired in this module	Physics with ultrashort pulses: Students will get competences on the special aspects on ultrashort laser pulses which do not play a role in standard optics or laser physics. Starting from basics, the module yields advanced knowledge of the physics of femtosecond light pulses and their interaction with matter, as well as the physics of femtosecond lasers. The students will obtain skills to work with such lasers, in particular, on generation, handling, measurement, application of femtosecond pulses. Fourier methods: The students acquire deeper knowledge on Fourier mathematics and ist 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
Literaturempfehlungen	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.	
Links			
Language of instruction		English	
Duration (semesters)		1 Semester	
Module frequency		jährlich	
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			2 * 3 hours written or 2 * 30 minutes oral exams
Form of instruction	Lecture		
SWS	2		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	28 h		

phy950 - Audiologie und Akustik

Module label	Audiologie und Akustik
Modulkürzel	phy950
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Advanced Physics
Zuständige Personen	• van de Par, Steven (module responsibility) • Kollmeier, Birger (module responsibility) • van de Par, Steven (Prüfungsberechtigt) • Kollmeier, Birger (Prüfungsberechtigt) • Ewert, Stephan (Prüfungsberechtigt)
Prerequisites	Einfuhrendes Akustik Modul
Skills to be acquired in this module	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.
Module contents	*Psychophysik und Audiologie* - 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). - Audiologie: Audiogramm, BERA, Schallleitungs- und Schallempfindungs-störungen, Tinnitus, Otoakustische Emissionen (Diagnostisch), Stapediusreflex-audiometrie, Impedanzaudiometrie - Psychophysik: Wahrnehmungsgrößen, JNDs, Weber-Fechnersches Gesetz, Schwellen, Signaldetektion, dprime/ROC, Lautheit, Tonhöhe, Stevenssches Gesetz, Zeitliche und spektrale Maskierung, Modulationswahrnehmung, auditorische Szenenanalyse, effektive Signalverarbeitungs-Modelle *Akustik* 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.
Literaturempfehlungen	B. Kollmeier: Skriptum Physikalische, technische und medizinische Akustik, Universität Oldenburg; H. Kuttruff, Akustik: Eine Einführung, 2004; P. Damaske, Acoustics and Hearing, Springer, 2008; M. Heckl, G. Müller: Taschenbuch der technischen Akustik, Springer-Verlag, 2012
Links	
Language of instruction	German
Duration (semesters)	1 Semester

Module frequency		jährlich	
Module capacity		unlimited	
Type of module		je nach Studiengang Pflicht oder Wahlpflicht	
Module level		MM (Mastermodul / Master module)	
Teaching/Learning method		Lecture: 3hrs/week; Excersise: 1hrs/week	
Previous knowledge		Einf•uhrendes Akustik Modul	
Examination	Prüfungszeiten		Type of examination
Final exam of module			one or two examination, totaling to 180 min. written exam or 30 min. oral exam
Form of instruction	Lecture		
SWS	4		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	56 h		

Schwerpunkt: Biomedical Physics

bio279 - Basic Concepts in Animal Physiology

Module label	Basic Concepts in Animal Physiology	
Modulkürzel	bio279	
Credit points	6.0 KP	
Workload	180 h	
Verwendbarkeit des Moduls	• Master of Education Programme (Special Needs Education) Biology (Master of Education) > Mastermodule • Master's Programme Engineering Physics (Master) > Schwerpunkt: Biomedical Physics	
Zuständige Personen	• Heyers, Dominik (module responsibility) • Köppl, Christine (Module counselling) • Dedek, Karin (Module counselling) • Heyers, Dominik (Prüfungsberechtigt) • Köppl, Christine (Prüfungsberechtigt) • Dedek, Karin (Prüfungsberechtigt)	
Prerequisites		
Skills to be acquired in this module	++ biological knowledge ++ knowledge of biological working methods + biologically relevant knowledge in the natural sciences and mathematics + statistics & scientific programming ++ abstract, logical, analytical thinking + deepened expertise in biological specialist field ++ independent learning and (research-based) working + teamwork Basic knowledge on physiological processes and their underlying mechanisms with a focus on human physiology. Performing, analysing and documenting physiological experiments.	
Module contents	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.	
Literaturempfehlungen	Klinke, Pape, Kurtz, Silbernagl: Physiologie, Aufl. 6, 2010 Schmidt, Lang, Heckmann: Physiologie des Menschen mit Pathophysiologie, Aufl. 31, 2011 (if available: Wehner, Gehring: Zoologie)	
Links		
Language of instruction	German	
Duration (semesters)	1 Semester	
Module frequency	jährlich	
Module capacity	unlimited	
Examination	Prüfungszeiten	Type of examination
Final exam of module	within a few weeks after the winter term lecture period	written exam (100%)
Form of instruction	Lecture	
SWS	4	
Frequency		
Workload Präsenzzeit	56 h	

phy614 - Personalized Medicine

Module label	Personalized Medicine
Modulkürzel	phy614
Credit points	6.0 KP
Workload	180 h (attendance: 56 hrs, self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Biomedical Physics
Zuständige Personen	• Schmidt, Thorsten (module responsibility) • Schmidt, Thorsten (Prüfungsberechtigt)
Prerequisites	Statistics, Computing
Skills to be acquired in this module	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.
Module contents	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 gives an introduction to a data-driven view of disease biology
Literaturempfehlungen	Genomic and Personalized Medicine: V1-2 Huntington F. Willard, Geoffrey S. Ginsburg; Academic Press; 2. Edition. (30. Oktober 2012); Cancer Genomics: From Bench to Personalized Medicine; Graham Dellaire, Jason Berman; Academic Press; 1. Edition (17. January 2014); Systems Biology: A Textbook; Eda Klipp et al (2009); Wiley-VCH Verlag GmbH, Co. KGaA; Auflage: 1. Edition;
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	jährlich
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

Form of instruction	Lecture
SWS	2
Frequency	SoSe oder WiSe
Workload Präsenzzeit	28 h

phy678 - Processing and analysis of biomedical data

Module label	Processing and analysis of biomedical data
Modulkürzel	phy678
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Biomedical Physics
Zuständige Personen	• Poppe, Björn (module responsibility) • Brand, Thomas (Prüfungsberechtigt) • Ewert, Stephan (Prüfungsberechtigt) • Hohmann, Volker (Prüfungsberechtigt) • Uppenkamp, Stefan (Prüfungsberechtigt)
Prerequisites	Basic signal processing, algebra knowledge
Skills to be acquired in this module	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.
Module contents	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.
Literaturempfehlungen	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
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Wintersemester
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		Exam or presentation or oral exam or homework or practical report

Form of instruction	Lecture
SWS	4
Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy685 - Advanced Engineering Topics in Biomedical Physics & Acoustics

Module label	Advanced Engineering Topics in Biomedical Physics & Acoustics
Modulkürzel	phy685
Credit points	6.0 KP
Workload	180 h (Overall workload of 180 h)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Acoustics • Master's Programme Engineering Physics (Master) > Schwerpunkt: Biomedical Physics
Zuständige Personen	• Doclo, Simon (module responsibility) • Poppe, Björn (module responsibility) • Anemüller, Jörn (Prüfungsberechtigt) • Biehs, Svend-Age (Prüfungsberechtigt) • Blau, Matthias (Prüfungsberechtigt) • Brand, Thomas (Prüfungsberechtigt) • Dietz, Mathias (Prüfungsberechtigt) • Doclo, Simon (Prüfungsberechtigt) • Enzner, Gerald (Prüfungsberechtigt) • Ewert, Stephan (Prüfungsberechtigt) • Hohmann, Volker (Prüfungsberechtigt) • Kollmeier, Birger (Prüfungsberechtigt) • Lücke, Jörg (Prüfungsberechtigt) • Meyer, Bernd (Prüfungsberechtigt) • Oetjen, Arne (Prüfungsberechtigt) • Poppe, Björn (Prüfungsberechtigt) • Siedenburg, Kai (Prüfungsberechtigt) • Töpken, Stephan (Prüfungsberechtigt) • Uppenkamp, Stefan (Prüfungsberechtigt) • van de Par, Steven (Prüfungsberechtigt)
Prerequisites	Related to selected course/s
Skills to be acquired in this module	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.
Module contents	Photonics, Optics, Metrology,
Literaturempfehlungen	Related to selected course/s
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Sommer- oder Wintersemester
Module capacity	unlimited
Reference text	This module o ers 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.

Examination	Prüfungszeiten	Type of examination
Final exam of module		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
Präsenzzeit Modul insgesamt				126 h

phy686 - Advanced Topics in Biomedical Physics & Acoustics

Module label	Advanced Topics in Biomedical Physics & Acoustics
Modulkürzel	phy686
Credit points	6.0 KP
Workload	180 h (Overall workload of 180 h)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Acoustics • Master's Programme Engineering Physics (Master) > Schwerpunkt: Biomedical Physics
Zuständige Personen	• Doclo, Simon (module responsibility) • Poppe, Björn (module responsibility) • Anemüller, Jörn (Prüfungsberechtigt) • Bitzer, Jörg (Prüfungsberechtigt) • Blau, Matthias (Prüfungsberechtigt) • Brand, Thomas (Prüfungsberechtigt) • Dietz, Mathias (Prüfungsberechtigt) • Doclo, Simon (Prüfungsberechtigt) • Enzner, Gerald (Prüfungsberechtigt) • Ewert, Stephan (Prüfungsberechtigt) • Hohmann, Volker (Prüfungsberechtigt) • Lücke, Jörg (Prüfungsberechtigt) • Kollmeier, Birger (Prüfungsberechtigt) • Meyer, Bernd (Prüfungsberechtigt) • Poppe, Björn (Prüfungsberechtigt) • Oetjen, Arne (Prüfungsberechtigt) • Siedenburg, Kai (Prüfungsberechtigt) • Töpken, Stephan (Prüfungsberechtigt) • van de Par, Steven (Prüfungsberechtigt) • Uppenkamp, Stefan (Prüfungsberechtigt)
Prerequisites	Related to selected course/s
Skills to be acquired in this module	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.
Module contents	Photonics, Optics, Metrology,
Literaturempfehlungen	Related to selected course/s
Links	Depending on selected courses
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Sommer- oder Wintersemester
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		Related to selected course/s

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		4	SoSe oder WiSe	56
Seminar			SoSe oder WiSe	0
Präsenzzeit Modul insgesamt				56 h

phy698 - Selected Topics on Medical Radiation Physics

Module label	Selected Topics on Medical Radiation Physics
Modulkürzel	phy698
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Biomedical Physics
Zuständige Personen	• Poppe, Björn (module responsibility) • Looe, Hui Khee (Prüfungsberechtigt) • Poppe, Björn (Prüfungsberechtigt) • Ruehmann, Antje (Prüfungsberechtigt) • Chofor, Ndimofor (Prüfungsberechtigt)
Prerequisites	
Skills to be acquired in this module	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 d er 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, Einfu¨uhrung 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.

Links			
Languages of instruction		German, English	
Duration (semesters)		1 Semester	
Module frequency		jährlich	
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			KL
Form of instruction	Lecture		
SWS	4		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	56 h		

phy959 - Medizinische Strahlenphysik II

Module label	Medizinische Strahlenphysik II
Modulkürzel	phy959
Credit points	6.0 KP
Workload	180 h (Attendance: 58 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Biomedical Physics
Zuständige Personen	• Poppe, Björn (module responsibility) • Poppe, Björn (Prüfungsberechtigt)
Prerequisites	Medizinische Strahlenphysik I
Skills to be acquired in this module	Die Studierenden werden die grundlegenden Kompetenzen eines Strahlenschutzbeauftragten kennen lernen. Dazu gehoren neben den fachlichen Grundlagen im Strahlenschutz insbesondere die Kompetenz sich im deutschen Gesetz und Verwaltungssystem im Bereich des Strahlenschutzes zurecht zu finden.
Module contents	Strahlenschutz in der Tele- und Brachytherapie, Aufbau von Beschleunigern, Dosimetrie, Baulicher und Organisatorischer Strahlenschutz, StrSchG und StrSchV sowie zugehörgie DIN Normen.
Literaturempfehlungen	StrSchG, StrSchV verschiedene DIN Normen
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		Written examination: Between 90 and 180 minutes or Oral examination: Between 20 and 45 minutes

Form of instruction	Lecture
SWS	2
Frequency	SoSe oder WiSe
Workload Präsenzzeit	28 h

phy955 - Medizinische Strahlenphysik I

Module label	Medizinische Strahlenphysik I
Modulkürzel	phy955
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Biomedical Physics
Zuständige Personen	• Poppe, Björn (module responsibility) • Poppe, Björn (Prüfungsberechtigt)
Prerequisites	Medizinische Strahlenphysik I
Skills to be acquired in this module	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.
Module contents	5.04.4022 Spezialkurs Strahlenschutzseminar Strahlenschutz in der Tele- und Brachytherapie, Aufbau von Beschleunigern, Dosimetrie, Baulicher und Organisatorischer Strahlenschutz, StrSchG und StrSchV sowie zugehorige DIN Normen 5.04.4021 Bildgebende Verfahren Bildgebende Verfahren: Grundlagen der Bildgebenden Verfahren in der Medizin: CT, MRT, Ultraschall, Nuklearmedizin SPECT, PET sowie grundlegende Rekonstrukltionstechniken
Literaturempfehlungen	Grundkurs Strahlenschutz: Unterlagen werden zur Verfugung gestellt (Skript) Bildgebende Verfahren: werden in der VL bekannt gegeben.
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module	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

Form of instruction	Lecture
SWS	4
Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy964 - Advanced Computing

Module label	Advanced Computing
Modulkürzel	phy964
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Acoustics • Master's Programme Engineering Physics (Master) > Schwerpunkt: Biomedical Physics • Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies
Zuständige Personen	• Kühn, Martin (module responsibility) • Doclo, Simon (module responsibility)
Prerequisites	Basic knowledge in computing, knowledge in undergraduate mathematics and physics
Skills to be acquired in this module	Learning of advanced programming concepts and their application in biomedical physics, acoustics, laser and optics, and renewable energies.
Module contents	Advanced programming concepts for C, python and Matlab; Arti cial Intelligence and Data Science; Visual Computing; Software Engineering
Literaturempfehlungen	
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		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
Präsenzzeit Modul insgesamt				112 h

phy954 - Imaging and Data Analysis

Module label	Imaging and Data Analysis
Modulkürzel	phy954
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Biomedical Physics
Zuständige Personen	• Poppe, Björn (module responsibility) • Poppe, Björn (Prüfungsberechtigt)
Prerequisites	Knowledge from the courses Astrophysics I and II
Skills to be acquired in this module	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 di erent 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.
Module contents	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 Pedagogique Planete et Univers, South of France") and evaluation of observations.
Literaturempfehlungen	B.W. Caroll, Introduction to Modern Astrophysics, Addison-Wesley, 2013 M. Camenzind, Compact Objects in Astrophysics, Springer, 2007 P. Lena, D. Ruoan Observational Astrophysics, Springer 2012 J.L. Starck, F. Murtagh, Astronomical Image and Data Analysis, Springer 2006 D.S. Birney, G. Gonzalez. Observational Astronomy, Cambridge University Press, 2006 BDWarner, Photometry and Lightcurve Analysis, Springer 2006
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		Written examination: Between 90 and 180 minutes or Oral examination: Between 20 and 45 minutes

Form of instruction	Lecture
SWS	2
Frequency	SoSe oder WiSe
Workload Präsenzzeit	28 h

Schwerpunkt: Laser and Optics

phy608 - Medical Optics

Module label	Medical Optics
Modulkürzel	phy608
Credit points	6.0 KP
Workload	180 h (Attendance:56 hours, Self study: 124 hours)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Laser and Optics
Zuständige Personen	• Neu, Walter (module responsibility) • Neu, Walter (Prüfungsberechtigt)
Prerequisites	Medizin for Scientist , Optics, Laser Physics
Skills to be acquired in this module	To provide advanced knowledge in the eld 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.
Module contents	Physiology and psychophysics of vision, theory of imaging systems, ophthalmic optics, lighting technology, photometry, vision in the workplace and in trac, optical measurements on patients, diagnostic and therapeutic laser applications, radiation protection (infrared, UV, laser), microscopy, di raction and subdi raction limited methods, optical spectroscopy, uorescence methods.
Literaturempfehlungen	Media: Lecture script, transparencies, blackboard, electronic media, presentation, lecture practical demonstrations Literature: Bille, J., Schlegel, W.: Medizinische Physik 3. Medizinische Laserphysik. Springer, Berlin, 2005. ISBN: 3540266305 Faller, A., Schünke, M.: Der K¨orper des Menschen. Thieme Verlag, 2004. Glaser, R.: Biophysics. Springer-Verlag, 2001 Dössel, O.: Bildgebende Verfahren in der Medizin. Springer-Verlag, 2000. Hoppe,W., Lohmann, W., Markl, H., Ziegler, H. (Hrsg.): Biophysik. Springer-Verlag 1982 J. Kiefer: Biological Radiation Effects, Springer Verlag 1990
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	jährlich
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

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

phy632 - Spectrophysics

Module label	Spectrophysics
Modulkürzel	phy632
Credit points	6.0 KP
Workload	180 h (Attendance: 28 hrs, Self study: 62 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Laser and Optics
Zuständige Personen	• Neu, Walter (module responsibility) • Koch, Sandra (Prüfungsberechtigt) • Neu, Walter (Prüfungsberechtigt) • Schellenberg, Markus (Prüfungsberechtigt)
Prerequisites	Atomic and Molecular Physics, Optical systems
Skills to be acquired in this module	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.
Module contents	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
Literaturempfehlungen	A. Thorne, U. Litzen, S. Johansson: Spectrophysics. Principles and Applications. Springer, 1999. ISBN 978-3540651178; J.M. Hollas, M.J. Hollas: Modern Spectroscopy. Wiley, 2003. ISBN 978 0470844168; S. Svanberg: Atomic and molecular spectroscopy. Basic aspects and practical applications. Springer, 2001.; W. Demtröder, Laser Spectroscopy Vol. 1and2, Springer, 5nd ed. 2014 and 4th ed., 2008; Saleh and Teich, Fundamentals of Photonics (Wiley); Recent publications on specific topic
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	jährlich
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

Form of instruction	Lecture
SWS	4
Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy634 - Biophotonics and Spectroscopy

Module label	Biophotonics and Spectroscopy
Modulkürzel	phy634
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Laser and Optics
Zuständige Personen	• Neu, Walter (module responsibility) • Koch, Sandra (Prüfungsberechtigt) • Neu, Walter (Prüfungsberechtigt) • Schellenberg, Markus (Prüfungsberechtigt)
Prerequisites	Basics in optics and laser physics, in particular, fundamentals of optics and photonics; atomic and molecular physics; spectrophysics
Skills to be acquired in this module	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.
Module contents	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
Literaturempfehlungen	R. Noll: Laser-Induced Breakdown Spectroscopy. Fundamentals and Applications. Springer, Berlin, 2012. ISBN: 978-3-642-20667-2; S. Musazzi, U. Perini (Eds.): Laser-Induced Breakdown Spectroscopy. Theory and Applications. Springer Series in Optical Sciences, Berlin, 2014. ISBN: 978-3-642-45084-6; Braun, M., Gilch, P., Zinth, W.: Ultrashort Laser Pulses in Biology and Medicine. Springer Berlin; 2007. ISBN-13: 978-3540735656; S. Svanberg: Atomic and molecular spectroscopy. Basic aspects and practical applications. Springer, 2004.; W. Demtröder, Laser Spectroscopy Vol. 1 and 2, Springer, 5nd ed. 2014 and 4th ed., 2008; B. Di Bartolo, John Collins (Eds.): Biophotonics: Spectroscopy, Imaging, Sensing, and Manipulation. Springer Netherlands, 2011. ISBN: 978-90-481-9976-1; W. Fritzsche, J. Popp (Eds.): Optical Nano- and Microsystems for Bioanalytics. Springer Series on Chemical Sensors and Biosensors, Berlin, 2012. ISBN: 978-3-642-25497-0; Recent publications on specific topics
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	Sommer- oder Wintersemester
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

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

phy637 - Laser Design and Beam Guiding

Module label		Laser Design and Beam Guiding	
Modulkürzel		phy637	
Credit points		6.0 KP	
Workload		180 h (Attendance: 56 hrs, Self study: 124 hrs)	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > Schwerpunkt: Laser and Optics	
Zuständige Personen		• Neu, Walter (module responsibility) • Neu, Walter (Prüfungsberechtigt) • Huke, Philipp (Prüfungsberechtigt)	
Prerequisites		basic knowledge on optics and laser physics	
Skills to be acquired in this module		Students acquire advanced knowledge for the design of lasers and laser systems, they also understand the propagation of laser beams and their forming.	
Module contents		design of different laser types; physics of active and passive laser components; beams and resonators; lab work	
Literaturempfehlungen		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	
Links			
Languages of instruction		German, English	
Duration (semesters)		1 Semester	
Module frequency		Sommersemester	
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			KL
Form of instruction	Lecture		
SWS	4		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	56 h		

phy638 - Laser material processing

Module label	Laser material processing
Modulkürzel	phy638
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Laser and Optics
Zuständige Personen	• Neu, Walter (module responsibility) • Schüning, Thomas (module responsibility) • Neu, Walter (Prüfungsberechtigt) • Schüning, Thomas (Prüfungsberechtigt)
Prerequisites	Knowledge in physics, optics, production engineering
Skills to be acquired in this module	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.
Module contents	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.
Literaturempfehlungen	Script William M. Steen: Laser Material Processing, Springer, 2010 J. Down, W. Schulz: The Theory of Laser Materials Processing, Springer, 2017
Links	
Languages of instruction	
Duration (semesters)	1 Semester
Module frequency	jährlich
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

Form of instruction	Lecture
SWS	4
Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy682 - Advanced Engineering Topics in Laser and Optics

Module label	Advanced Engineering Topics in Laser and Optics
Modulkürzel	phy682
Credit points	6.0 KP
Workload	180 h (Overall workload of 180 h)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Laser and Optics
Zuständige Personen	• Neu, Walter (module responsibility) • Neu, Walter (Prüfungsberechtigt) • Teubner, Ulrich (Prüfungsberechtigt) • Huke, Philipp (Prüfungsberechtigt)
Prerequisites	Related to selected course/s
Skills to be acquired in this module	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.
Module contents	Photonics, Optics, Metrology
Literaturempfehlungen	Related to selected course/s
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	Sommer- oder Wintersemester
Module capacity	unlimited
Reference text	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.

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

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
Präsenzzeit Modul insgesamt				126 h

phy683 - Advanced Topics in Laser and Optics

Module label	Advanced Topics in Laser and Optics
Modulkürzel	phy683
Credit points	6.0 KP
Workload	180 h (180 h)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Laser and Optics
Zuständige Personen	• Neu, Walter (module responsibility) • Englert, Lars (Prüfungsberechtigt) • Huke, Philipp (Prüfungsberechtigt) • Lienau, Christoph (Prüfungsberechtigt) • Neu, Walter (Prüfungsberechtigt)
Prerequisites	Related to selected course/s
Skills to be acquired in this module	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.
Module contents	Photonics, Optics, Metrology
Literaturempfehlungen	Related to selected course/s
Links	
Languages of instruction	English , German
Duration (semesters)	1 Semester
Module frequency	Sommer- oder Wintersemester
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

Form of instruction	Lecture
SWS	4
Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy965 - Engineering Scientific Instrumentation

Module label	Engineering Scientific Instrumentation
Modulkürzel	phy965
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Laser and Optics
Zuständige Personen	• Huke, Philipp (module responsibility) • Huke, Philipp (Prüfungsberechtigt)
Prerequisites	• Basic tools in physics and engineering • Knowledge about current research areas • Basics in optics and spectroscopy • Advanced Metrology
Skills to be acquired in this module	Understanding the evolution of a scienti c 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.
Module contents	Relevant scienti c questions often require large scientific facilities like CERN or the ELT to conduct their experiment. The evolution of a scienti c project from a question to a real experiment is a complex process between large teams of engineers and scientists. In this course students will learn: a. How to derive speci cation from a scienti c question b. Translate these speci cations to engineering c. Develop rst simulations of the experiment d. Develop the physical design of an instrument including d.1. Trade-o studies d.2. Management tools for the communication d.3. Engineering tools for the instrument e. Create a model of the instrument f. Conduct the experiment in the virtual environment Example project(s) from astrophysics
Literaturempfehlungen	White/Blue books of Instruments
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		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
Präsenzzeit Modul insgesamt				56 h

phy966 - Intense Light Physics

Module label	Intense Light Physics
Modulkürzel	phy966
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Laser and Optics
Zuständige Personen	• Teubner, Ulrich (module responsibility) • Teubner, Ulrich (Prüfungsberechtigt)
Prerequisites	Basics in optics and laser physics, in particular, Fundamentals of Optics and Photonics; Atomic Physics, Electrodynamics
Skills to be acquired in this module	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
Module contents	Femtosecond and high power laser systems and its application, absorption of intense laser light, basics of laser matter interaction at high intensity, diagnostics, applications in micro machining, laser generated ultrashort radiation such as high-order laser harmonics and femtosecond K-a-sources and keV and MeV electron and ion sources and their application to micro fabrication micro and nano analysis.; atto physics, strong field physics
Literaturempfehlungen	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
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	jährlich
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		experimental work and laboratory reports or max. 2hr written examination or max 1h oral

Form of instruction	Lecture
SWS	2
Frequency	SoSe oder WiSe
Workload Präsenzzeit	28 h

phy600 - Photonics

Module label		Photonics	
Modulkürzel		phy600	
Credit points		6.0 KP	
Workload		180 h (Attendance: 56 hrs, Self study: 124 hrs)	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > Schwerpunkt: Laser and Optics	
Zuständige Personen		• Teubner, Ulrich (module responsibility) • Teubner, Ulrich (Prüfungsberechtigt) • Silies, Martin (Prüfungsberechtigt)	
Prerequisites		Basic knowledge on optics, electrodynamics and atomic physics	
Skills to be acquired in this module		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, diffrent laser types, light emitters, detectors, modulators. The students acquire skills in working with lasers and optoelectronic components.	
Module contents		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	
Literaturempfehlungen		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	
Links			
Languages of instruction		German, English	
Duration (semesters)		1 Semester	
Module frequency		jährlich	
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			2 hr written examination or 30 min oral examination or experimental work or homework or presentation
Form of instruction	Lecture		
SWS	4		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	56 h		

phy624 - Optoelectronics

Module label	Optoelectronics
Modulkürzel	phy624
Credit points	6.0 KP
Workload	180 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Laser and Optics
Zuständige Personen	• Silies, Martin (module responsibility)
Prerequisites	basic knowledge on optics and solid-state physics
Skills to be acquired in this module	The students get a deeper knowledge in modern applications in the field of optics and electronics, especially at the cross-section of both topics, i.e., optoelectronics. Several applications of optoelectronic will be taught enabling the students to understand basic optoelectronic devices such as photodiodes, solar cells, CCD cameras or fiber-optical systems. In the first part of the lecture a theoretical background will be enabled while in the second part the understanding is deepened in a laboratory work.
Module contents	Basic knowledge of optics and solid-state physics; Understanding of the working principle of Transistors, LEDs, Solar cells, CCD sensors. Knowledge about Electro- and acousto-optical manipulation of light, Fiber Optics In the second part, the accessed knowledge from the lecture is applied in a laboratory project.
Literaturempfehlungen	Safa O. Kasap Optoelectronics and Photonics: Principles & Practices, Pearson Education, ISBN 0273774174 Vladimir Protopopov: Practical Opto-Electronics: An Illustrated Guide for the Laboratory, Springer, ISBN 3319045121
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	jährlich
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		1 examination: Exam (30 - 60 minutes) or oral exam (15 - 30 minutes)

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		4	SoSe	56 selfstudy 124hours
Exercises			SoSe oder WiSe	0
Präsenzzeit Modul insgesamt				56 h

Schwerpunkt: Renewable Energies

inf511 - Smart Grid Management

Module label	Smart Grid Management
Modulkürzel	inf511
Credit points	6.0 KP
Workload	180 h
Verwendbarkeit des Moduls	• Master's Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik • Master's Programme Computing Science (Master) > Angewandte Informatik • Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Environmental Modelling (Master) > Mastermodule • Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Lehnhoff, Sebastian (module responsibility) • Lehrenden, Die im Modul (Prüfungsberechtigt)
Prerequisites	No participant requirements
Skills to be acquired in this module	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 unforeseable 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. **Professional competence** The students: • understand the existing structures and the technical basis of energy systems producing, transferring and distributing electricity and their interaction and dependency on each other. • develop an understanding for necessary IT- and process control technology components, methods and processes to control and operate electrical energy systems. • 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. • estimate the influence of distributed control concepts and algorithms for decentralised plants and consumers in the so called Smart Grid energy systems. **Methodological competence** The students: • analyse the safety, reliability, realtime capability and flexibility of Smart Grid energy systems • use advanced mathemtical methods to calculate networks **Social competence** The students: • create solutions in small teams • discuss their solutions **Self-competence** The students: • reflect their own use of electricity as a limited resource
Module contents	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 permissable 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)

Literaturempfehlungen	Suggested reading: • Crastan V.: "Elektrische Energieversorgung II", Springer 2004 • Heuck K., Dettman K. D., Schulz D.: "Elektische Energieversorgung I", 7. Aufl., Vieweg 2007 • Konstantin, P.: "Praxisbuch Energiewirtschaft", Springer 2006 • Schwab, A.: "Elektroenergiesysteme, Springer 2009
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	jährlich
Module capacity	unlimited
Teaching/Learning method	1VL + 1Ü
Previous knowledge	none

Examination	Prüfungszeiten	Type of examination
Final exam of module	At the end of the semester	written or oral exam

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		3	SoSe	42
Exercises		1	SoSe	14
Präsenzzeit Modul insgesamt				56 h

phy609 - Photovoltaic Physics

Module label	Photovoltaic Physics
Modulkürzel	phy609
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Kühn, Martin (module responsibility) • Gütay, Levent (Prüfungsberechtigt) • Knipper, Martin (Prüfungsberechtigt)
Prerequisites	Solid-state-Pysics, semi-conductor Physics, Module Renewable Energy Technologies I
Skills to be acquired in this module	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
Module contents	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 electronical 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
Literaturempfehlungen	S. Hegedus, A. Luque, Handbook of Photovoltaic Science and Engineering, published John Wiley and Sons (2nd Edition 2011); Christiana Honsberg and Stuart Bowden, PVCDROM, http://www.pveducation.org/pvcdrom/instructions, Access date 2.10.2014; lecture notes for the respective courses
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Sommersemester
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		1 Exam

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

phy616 - Computational Fluid Dynamics 1 / 2

Module label	Computational Fluid Dynamics 1 / 2
Modulkürzel	phy616
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master • Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Environmental Modelling (Master) > Mastermodule • Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Lukassen, Laura (module responsibility) • Avila Canellas, Kerstin (Prüfungsberechtigt) • Lukassen, Laura (Prüfungsberechtigt) • Peinke, Joachim (Prüfungsberechtigt) • Stoevesandt, Bernhard (Prüfungsberechtigt)
Prerequisites	Fluid Dynamics I
Skills to be acquired in this module	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 fluiddynamics. 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.
Module contents	CFD I: The Navier-Stokes equations, filtering / averaging of Navier- Stokes equations, introduction to numerical methods, finite- differences, finite-volume methods, linear equation systems, NS-solvers, RANS, URANS, LES, DNS, turbulent flows, incompressible flows, compressible flows, efficiency and accuracy. CFD II: Introduction to different CFD models, such as OpenFOAM and PALM. Application of these CFD models to defined problems from rotor aerodynamics and the atmospheric boundary layer.
Literaturempfehlungen	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)
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Sommersemester
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		• 1 Klausur oder • 1 Referat oder • 1 mündliche Prüfung oder • 1 fachpraktische Übung

Form of instruction	VA-Auswahl Vorlesungen oder Praktikum oder Seminar
SWS	4

Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy641 - Energy Resources & Systems

Module label	Energy Resources & Systems
Modulkürzel	phy641
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self-study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Environmental Modelling (Master) > Mastermodule • Master's Programme European Master in Renewable Energy (EUREC) (Master) > Mastermodule • Master's Programme Sustainability Economics and Management (Master) > Supplementary Modules • Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Agert, Carsten (module responsibility) • Knipper, Martin (module responsibility) • Knipper, Martin (Prüfungsberechtigt) • Torio, Herena (Prüfungsberechtigt) • Schmidt, Thomas (Prüfungsberechtigt)
Prerequisites	
Skills to be acquired in this module	After successful completion of the module students should be able to: • characterize the global energy system and analyze the structure and constraints of today's energy system, • explain the availability and connection between solar and wind energy, • identify the problems and challenges of energy supply due to fluctuating energy resources with varying and seasonal load profiles, • relate the solar irradiance conversion process as well as the atmospheric radiation balance of the earth to Wind Energy Meteorology.
Module contents	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. Energy Meteorology (Lecture - 90 h workload) Section I: Solar Irradiance • Radiation laws, • Solar geometry, • Interaction of solar irradiance with the atmosphere, • Radiation climatology, • Solar radiation model, • Statistical properties of solar irradiance, • Measuring devices to ascertain solar radiation balance, • Satellite-supported data acquisition to assess solar irradiance, Section II: Wind Flow • Origin and potential of atmospheric energy movements, Heat balance of the atmosphere, • Physical laws of atmospheric flow, • Wind circulation in the atmosphere, local winds, • Wind flow in atmospheric layers (vertical structure, Ekman Layer), • Assessment of wind potential (European Wind Atlas: model, concept, • Wind Measurements, Energy Systems (Lecture - 90 h workload) • Definitions, separation electrical - thermal energy use, • Resources and reserves, • Energy system analysis: Efficiencies at various levels of the energy chain; Exergy analysis, • Energy scenarios, • Climate change,

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

Literaturempfehlungen	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 - 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/) • United Nations: 2013 Energy Statistics Yearbook (2016) (unstats.un.org/unsd/energy/yearbook/)
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Winter semester
Module capacity	unlimited
Type of module	Pflicht / Mandatory
Module level	MM (Mastermodul / Master module)
Teaching/Learning method	Lectures, Exercises

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

Module label	Wind Energy Physics, Data & Analysis
Modulkürzel	phy644
Credit points	6.0 KP
Workload	180 h (attendance: 2*28 hrs, self-study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies
Zuständige Personen	• Kühn, Martin (module responsibility) • Avila Canellas, Kerstin (Prüfungsberechtigt) • Kühn, Martin (Prüfungsberechtigt) • Peinke, Joachim (Prüfungsberechtigt) • Steinfeld, Gerald (Prüfungsberechtigt) • Schmidt, Andreas Hermann (Prüfungsberechtigt) • Torio, Herena (Prüfungsberechtigt)
Prerequisites	The module starts in the winter term: Wind Energy Physics has to be taken before participating in Wind Physics Measurement Project
Skills to be acquired in this module	After successful completion of the module students should be able to: - Evaluate wind energy related measurements, • Interprete such measurements gained in the field of wind energy applications, - Critically evaluate measured data
Module contents	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 conver sion, dimensional analysis, (pitheorem), and wind turbine performance, design of wind turbines, electrical systems. The sequentially following WPhyMPr adresses 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: 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
Literaturempfehlungen	R. Gasch , J. Twele : Wind Power Plants Fundamentals, Design, Construction and Operation, 2nd Ed., Springer Verlag, 2012, ISBN: 978 3 642 22937 4 S. Emeis : Wind Energy Meteorology: Atmospheric Physics for Wind Power Generation, Springer, 2012 Evaluation of site specific wind conditions; MEASNET Guideline; Version 1; November 2009; free available in the internet: http://www.measnet.com/wpcontent/ uploads/2012/04/Measnet_SiteAssessment_V10.pdf IEC 61400 12 1:2005 Power performance measurements of electricity producing wind turbines; guideline
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Sommer- und Wintersemester
Module capacity	unlimited

Reference text		The module starts in the winter term: Wind Energy Phyics has to be taken before participating in Wind Physics Measurement Project
Examination	Prüfungszeiten	Type of examination
Final exam of module		1 Exam
Form of instruction	Lecture	
SWS	4	
Frequency	SoSe oder WiSe	
Workload Präsenzzeit	56 h	

phy646 - Wind Physics Student's Lab

Module label	Wind Physics Student's Lab
Modulkürzel	phy646
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies
Zuständige Personen	• Schmidt, Andreas Hermann (Prüfungsberechtigt) • Kühn, Martin (module responsibility)
Prerequisites	Basic computer knowledge; mechanics; mathematical methods for physics and engineering; basic knowledge of wind energy utilization; previous knowledge of metrology, basic knowledge of aerodynamics
Skills to be acquired in this module	The "Wind Physics Student's Lab" aims to foster the learning process by own research activities of the students in wind physics and additionally to build up skills for scientific and experimental work and scientific writing. Therefore, this course is also intended as preparation for the master thesis. The course is organized as seminar with integrated work in the laboratory. The students will investigate an individual, self-formulated research question and will be guided by the supervisors through the research-based learning process. The work in groups and discussion of solutions aims to improve skills in team working. In order to introduce the students to current wind energy research, the course is offered in three versions. These versions represent the work of the three research groups at ForWind - University Oldenburg.
Module contents	Content of Wind2Grid-Seminar The seminar consists of three main phases with different learning steps: 1st phase: Class-room seminar building up basic competences identification of the technical tasks introduction to current research introduction to the learning platform investigating standard situations and functional interaction by means of the experimental system defining an own research question defining an experimental strategy planning the experiment 2nd phase: Laboratory work (1 week) 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 The seminar "Wind turbine rotor in turbulent inflow" is connected to the scientific work of the research group Turbulence, Wind Energy and Stochastics (TWIST). 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: 1st phase: Class-room seminar - building up basic competences - identification of the technical and/or scientific tasks - introduction to current research - introduction to the experiment related to the seminar • investigating standard situations and functional interaction by means of the experimental system • defining own research questions • defining an experimental strategy • planning the experiment 2nd phase: Laboratory work

- 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

Literaturempfehlungen	English Language: Robert Gasch, Wind Power Plants - Fundamentals, Design, Construction and Operation, 2nd Ed., 2012, Springer-Verlag; ISBN: 978-3-642-22937-4 German Language: Robert Gasch, Windkraftanlagen - Grundlagen und Entwurf, 9th Ed., 2016, Springer + Vieweg; ISBN: 978-3-658-12360-4 German Language: CEwind eG / Alois Schaffarczyk, Einführung in die Windenergietechnik; 1st Ed. 2012, Carl Hanser Verlag, Munich English Language: Erich Hau, Wind Turbines: Fundamentals, Technologies, Application, Economics, 3rd Ed., 2013, Springer-Verlag; ISBN 978-3-642-27151-9 German Language: Erich Hau, Windkraftanlagen. Grundlagen, Technik, Einsatz, Wirtschaftlichkeit. 5th Ed., 2014, Springer-Verlag; ISBN: 978-3-642-28877-7
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Sommer- und Wintersemester
Module capacity	unlimited
Reference text	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.

Examination	Prüfungszeiten	Type of examination
Final exam of module		Portfolio

Form of instruction	Seminar
SWS	4
Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy647 - Future Power Supply Systems

Module label	Future Power Supply Systems
Modulkürzel	phy647
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Environmental Modelling (Master) > Mastermodule • Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Agert, Carsten (Prüfungsberechtigt) • Torio, Herena (module responsibility) • Agert, Carsten (module responsibility)
Prerequisites	Knowledge from module RE technology I, Mathematics
Skills to be acquired in this module	After successful completion of the module students should be able to • explain the management, power balancing and the provision of ancillary services within future electricity grid configurations with high shares of fluctuating and distributed generation • perform power system simulation with related software tools • describe different grid-designs, including mini- and microgrids • 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. • 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.
Module contents	Future Power Supply Systems: • Technology and characteristics of conventional power plants based e. g. on coal, gas, and nuclear, • Fundamentals, structure, technologies and operation of (AC-) electricity grids (incl. balancing power, voltage management, etc.), • 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, • Interactions between technology and economics: The different electricity markets (Futures Market, Day-Ahead-Market, Intraday-Market, Balancing Power Market, Self-Consumption) and their links to the physical world, • "Smart City", "Smart Grid", "Smart Home", • Mini- and Micro-Grids, • Energy scenarios and modelling, • Chemical energy carriers in the energy system: power-togas (e.g. methane) and power-to-liquids (e.g.methanol)
Literaturempfehlungen	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
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Sommersemester
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		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.
Form of instruction	Lecture	
SWS	4	
Frequency	SoSe oder WiSe	
Workload Präsenzzeit	56 h	

phy648 - Wind Resources and their Applications

Module label	Wind Resources and their Applications
Modulkürzel	phy648
Credit points	6.0 KP
Workload	180 h (Attendance: 72 hrs, Self study: 108 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Environmental Modelling (Master) > Mastermodule • Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Kühn, Martin (module responsibility) • Steinfeld, Gerald (Prüfungsberechtigt) • Waldl, Hans-Peter (Prüfungsberechtigt)
Prerequisites	Knowledge in Basics Wind Energy, Fluid Dynamics I, Matlab
Skills to be acquired in this module	assess different aspects of wind energy farms by modelling, comparison, explanation of wind energy potential, wind energy farm's output, power curves, wind energy project development, assess in detail in uences of meteorological/ climatological aspects on the performance of wind power systems, summarize physical processes governing atmospheric wind flows, value atmospheric boundary layer flow relevant for wind power conversion, argue methods for wind resource assessment and forecasting
Module contents	Advanced Wind Energy Meteorology (Lecture -90 h workload) Atmospheric Boundary Layer (turbulence, vertical structure, special BL effects) Atmospheric Flow Modelling: Linear models, RANS and LES models Wind farm modelling Offshore-Specific Conditions Resource Assessment and Wind Power Forecasting Wind Measurements and Statistics Wind Energy Applications - from Wind Resource to Wind Farm Operations (Lecture - 90 h workload) Evaluation of Wind Resources Weibull Distribution Wind velocity measurements to determine energy yield Basics of Wind Atlas Analysis and Application Program (WAsP) Method, Partial models using WAsP Measure-Correlate-Predict (MCP) Method of long term corrections of wind measurement data in correlation to long term reference data Conditions for stable, neutral and instable atmospheric conditions Wind yield from wind distribution and the power curve Basics in appraising the yearly wind yield from a wind turbine. Wake Effect and Wind Farm Recovery of original wind fields in the downstream of wind turbines Basics of Riso Models Spacing and effciency in wind farms Positive and Negative Effects of Wind Farms Wind Farm Business Income from the energy yield from wind farms Profit optimization by increase of energy production Wind farm project development Wind farm operation and Surveillance of power production vs. wind climate, power curves, and turbine availability
Literaturempfehlungen	Advanced Wind Energy Meteorology Holton, J.R. and G. J. Hakim, 2013: An Introduction to Dynamic Meteorology, 5th Edition, Academic Press, New York Stull, R.B., 1988: An Introduction to Boundary Layer Meteorology. Kluwer Academic Pub. Wind Energy Applications - from Wind Resource to Wind Farm Operations Burton, T., N. Jenkins, D. Sharpe and E. Bossanyi, 2011: Wind Energy Handbook, Second Edition, John Wiley. Gasch, R. and J. Twele, 2012: Wind Power Plants: Fundamentals, Design, Construction and Operation; Second Edition, Springer http://www.av8n.com/how/htm/airfoils.html, Last access: 4/2016 http://www.windpower.org/en/, Last access: 4/2016
Links	
Language of instruction	English

Duration (semesters)		1 Semester	
Module frequency		Sommersemester	
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			1 Exam
Form of instruction	Lecture		
SWS	4		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	56 h		

phy649 - Design of Wind Energy Systems

Module label	Design of Wind Energy Systems
Modulkürzel	phy649
Credit points	6.0 KP
Workload	180 h (Attendance: 72 hrs, Self study: 108 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Kühn, Martin (module responsibility) • Kühn, Martin (Prüfungsberechtigt) • Schmidt, Andreas Hermann (Prüfungsberechtigt)
Prerequisites	Basics in Wind Energy Utilisation
Skills to be acquired in this module	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: estimate the site specific energy yield, calculate the aerodynamics of wind turbines using the blade element momentum theory, model wind fields to obtain specfic design situations for wind turbines, estimate the influence of dynamics of a wind turbine, especially in the context of fatigue loads, transfer their knowledge to more complex topics such as simulation and measurements of dynamic loads, calculate the economic aspects of wind turbine Aeroelastic Simulation of Wind turbines: student who has met the objectives of the course will be able to: understand the basic concept of an aero-servo-elastic computer code to determine the unsteady aerodynamic loads, derive and validate the required parameters to model the aero-hydro-elastic response of a wind turbine, identify and interpret the required empirical parameters to correct the blade element momentum (BEM) method with respect to dynamic in flow, unsteady airfoil aerodynamics (dynamic stall), yawed flow, dynamic wake modeling, explain the effects of the different models on the resulting time series and validate the code, interpret design standards for on- and offshore wind turbines, select the required load cases according to sitespecific environmental data, identify the dimensioning load cases and calculate design loads for different main components of a wind turbine.
Module contents	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. Aeroelastic Simulation of Wind turbines: The course focuses on the practical implications and handson experience of the aero-hydro-servo-elastic modelling and simulation of wind turbines. The subjects are similar but the treatment is complementary to the parallel course `Design of Wind Energy Systems', which deals with the underlying theoretical background: advanced wind field modelling for fatigue and extreme event loading, modelling of wind farm flow and wake effects, rotor aerodynamics (e.g. stationary or dynamic effects, comparison of Blade Element Momentum theory and more advanced methods like free vortex methods or CFD), structural dynamics and dynamic modelling of wind turbine structures (modelling by ordinary or partial differential equations, stochastics, multi body system modelling), advanced control of wind turbines, design standards, design loads and design aspects of off-shore and onshore wind turbines. The students analyse in pairs a model of an entire wind turbine with the aid of a typical wind turbine design tool like GH Bladed, Flex5 or

		Aerodyn/FAST.	
Literaturempfehlungen		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	
Links			
Language of instruction		English	
Duration (semesters)		1 Semester	
Module frequency		Wintersemester	
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			Exam or presentation or oral exam or homework or practical report
Form of instruction	Lecture		
SWS	4		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	56 h		

phy687 - Advanced Engineering Topics in Renewable Energies

Module label	Advanced Engineering Topics in Renewable Energies
Modulkürzel	phy687
Credit points	6.0 KP
Workload	180 h (Overall workload of 180 h)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies
Zuständige Personen	• Kühn, Martin (module responsibility) • Avila Canellas, Kerstin (Prüfungsberechtigt) • Holtorf, Hans-Gerhard (Prüfungsberechtigt) • Feudel, Ulrike (Prüfungsberechtigt) • Kühn, Martin (Prüfungsberechtigt) • Steinfeld, Gerald (Prüfungsberechtigt) • Peinke, Joachim (Prüfungsberechtigt) • Stoevesandt, Bernhard (Prüfungsberechtigt)
Prerequisites	Related to selected course/s
Skills to be acquired in this module	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.
Module contents	E.g. metrology, data logging, measurement methodology, construction, monitoring, control engineering, remote sensing.
Literaturempfehlungen	Related to selected course/s
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Sommer- oder Wintersemester
Module capacity	unlimited
Reference text	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.

Examination	Prüfungszeiten	Type of examination
Final exam of module		Related to selected course/s

Form of instruction	Lecture oder Seminar mit Praktikum *Hier ist ein Kommentar*
SWS	4
Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy689 - Advanced Topics in Renewable Energies

Module label	Advanced Topics in Renewable Energies
Modulkürzel	phy689
Credit points	6.0 KP
Workload	180 h (Overall workload of 180 h)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies
Zuständige Personen	• Kühn, Martin (module responsibility) • Avila Canellas, Kerstin (Prüfungsberechtigt) • Feudel, Ulrike (Prüfungsberechtigt) • Holtorf, Hans-Gerhard (Prüfungsberechtigt) • Kühn, Martin (Prüfungsberechtigt) • Peinke, Joachim (Prüfungsberechtigt) • Wächter, Matthias (Prüfungsberechtigt) • Stoevesandt, Bernhard (Prüfungsberechtigt) • Steinfeld, Gerald (Prüfungsberechtigt) • Wark, Michael (Prüfungsberechtigt) • Steinberger-Wilckens, Robert (Prüfungsberechtigt)
Prerequisites	Related to selected course/s
Skills to be acquired in this module	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.
Module contents	Photonics, Optics, Metrology
Literaturempfehlungen	Related to selected course/s
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	Sommer- oder Wintersemester
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		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
Präsenzzeit Modul insgesamt				84 h

phy984 - Semiconducting Materials for Solar Energy

Module label		Semiconducting Materials for Solar Energy	
Modulkürzel		phy984	
Credit points		6.0 KP	
Workload		180 h	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies	
Zuständige Personen			
Prerequisites			
Skills to be acquired in this module			
Module contents			
Literaturempfehlungen			
Links			
Languages of instruction		German, English	
Duration (semesters)		1 Semester	
Module frequency			
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			KL
Form of instruction	Seminar		
SWS	2		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	28 h		

phy987 - Control of Wind Turbines and Wind Farms

Module label	Control of Wind Turbines and Wind Farms
Modulkürzel	phy987
Credit points	6.0 KP
Workload	180 h (Attendance: 72 hrs, Self study: 108 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Kühn, Martin (module responsibility) • Kühn, Martin (Prüfungsberechtigt) • Petrovic, Vlaho (Prüfungsberechtigt)
Prerequisites	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 parllel
Skills to be acquired in this module	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	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	jährlich
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

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

phy967 - Advanced Laboratories in Renewable Energies

Module label	Advanced Laboratories in Renewable Energies		
Modulkürzel	phy967		
Credit points	6.0 KP		
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)		
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies		
Zuständige Personen	• Kühn, Martin (module responsibility) • Avila Canellas, Kerstin (Prüfungsberechtigt) • Hölling, Michael (Prüfungsberechtigt) • Kühn, Martin (Prüfungsberechtigt)		
Prerequisites			
Skills to be acquired in this module	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 eld of Experimental Physics applied in the eld of renewable Energy. The Adv. Labs are research oriented.		
Module contents	Each student performs 3 labs selected form 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.		
Literaturempfehlungen			
Links			
Languages of instruction	German, English		
Duration (semesters)	1 Semester		
Module frequency			
Module capacity	unlimited		
Examination	Prüfungszeiten		Type of examination
Final exam of module			labs with 3 protocols plus Homework tasks
Form of instruction	Practical training		
SWS	0		
Frequency	SoSe oder WiSe		

pre022 - Solar Energy

Module label	Solar Energy
Modulkürzel	pre022
Credit points	6.0 KP
Workload	180 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Environmental Modelling (Master) > Mastermodule • Master's Programme Sustainability Economics and Management (Master) > Supplementary Modules • Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Agert, Carsten (module responsibility) • Torio, Herena (module responsibility) • Torio, Herena (Prüfungsberechtigt) • Knipper, Martin (Prüfungsberechtigt) • Gütay, Levent (Prüfungsberechtigt)
Prerequisites	
Skills to be acquired in this module	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

Literaturempfehlungen

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	German, English
Duration (semesters)	1 Semester
Module frequency	Wintersemester
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		
	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

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

pre113 - Photovoltaic Systems

Module label	Photovoltaic Systems
Modulkürzel	pre113
Credit points	6.0 KP
Workload	180 h (180 Stunden)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Agert, Carsten (Prüfungsberechtigt) • Knipper, Martin (Prüfungsberechtigt) • Knipper, Martin (module responsibility) • Agert, Carsten (module responsibility)
Prerequisites	
Skills to be acquired in this module	

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-hybrid
by 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

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

Quality indicators for PV Systems and their regional differences

- PV on-grid,
- PV off-grid / stand alone,
- PV-pumping,
- 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, 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 Grudlagen, 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

Links		
Language of instruction	English	
Duration (semesters)	1 Semester	
Module frequency		
Module capacity	unlimited	
Examination	Prüfungszeiten	Type of examination
Final exam of module	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
Präsenzzeit Modul insgesamt				56 h

pre114 - Solar Energy Meteorology

Module label	Solar Energy Meteorology
Modulkürzel	pre114
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Torio, Herena (module responsibility) • Agert, Carsten (module responsibility) • Schmidt, Thomas (Prüfungsberechtigt) • Lezaca Galeano, Jorge Enrique (Prüfungsberechtigt)
Prerequisites	Successful participation in “Energy Meteorology 5.06.M117
Skills to be acquired in this module	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 Joh Wiley and Sons (2nd Edition 2011)
- MSG Cloud Physical Properties (CPP) by KNMI http://msgcpp.knmi.nl/mediawiki/index.ph /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://nsrdb.nrel.gov/
- re.jrc.ec.europa.eu/pvgis/

Links			
Language of instruction		English	
Duration (semesters)		1 Semester	
Module frequency		Annual, summer semester	
Module capacity		unlimited	
Examination	Prüfungszeiten	Type of examination	
Final exam of module	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
Präsenzzeit Modul insgesamt				56 h

phy964 - Advanced Computing

Module label	Advanced Computing
Modulkürzel	phy964
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Acoustics • Master's Programme Engineering Physics (Master) > Schwerpunkt: Biomedical Physics • Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies
Zuständige Personen	• Kühn, Martin (module responsibility) • Doclo, Simon (module responsibility)
Prerequisites	Basic knowledge in computing, knowledge in undergraduate mathematics and physics
Skills to be acquired in this module	Learning of advanced programming concepts and their application in biomedical physics, acoustics, laser and optics, and renewable energies.
Module contents	Advanced programming concepts for C, python and Matlab; Arti cial Intelligence and Data Science; Visual Computing; Software Engineering
Literaturempfehlungen	
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		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
Präsenzzeit Modul insgesamt				112 h

pre200 - Selected Renewable Energy Technologies

Module label	Selected Renewable Energy Technologies
Modulkürzel	pre200
Credit points	6.0 KP
Workload	180 h ( )
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Environmental Modelling (Master) > Mastermodule • Master's Programme Sustainability Economics and Management (Master) > Supplementary Modules • Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Günther, Andreas (module responsibility) • Torio, Herena (module responsibility) • Wark, Michael (module responsibility) • Torio, Herena (Prüfungsberechtigt) • Pehlken, Alexandra (Prüfungsberechtigt) • Wark, Michael (Prüfungsberechtigt) • Steinberger-Wilckens, Robert (Prüfungsberechtigt)
Prerequisites	
Skills to be acquired in this module	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

Literaturempfehlungen		
Links		
Language of instruction	English	
Duration (semesters)	1 Semester	
Module frequency	Wintersemester	
Module capacity	unlimited	
Examination	Prüfungszeiten	Type of examination
Final exam of module	At the end of the semester	Written exam (2x)
Form of instruction	VA-Auswahl	
SWS	4	
Frequency	SoSe oder WiSe	
Workload Präsenzzeit	56 h	

European Wind Energy Master

phy616 - Computational Fluid Dynamics 1 / 2

Module label	Computational Fluid Dynamics 1 / 2
Modulkürzel	phy616
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master • Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies • Master's Programme Environmental Modelling (Master) > Mastermodule • Sustainable Renewable Energy Technologies (Master) > Mastermodule
Zuständige Personen	• Lukassen, Laura (module responsibility) • Avila Canellas, Kerstin (Prüfungsberechtigt) • Lukassen, Laura (Prüfungsberechtigt) • Peinke, Joachim (Prüfungsberechtigt) • Stoevesandt, Bernhard (Prüfungsberechtigt)
Prerequisites	Fluid Dynamics I
Skills to be acquired in this module	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 fluiddynamics. 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.
Module contents	CFD I: The Navier-Stokes equations, filtering / averaging of Navier- Stokes equations, introduction to numerical methods, finite- differences, finite-volume methods, linear equation systems, NS-solvers, RANS, URANS, LES, DNS, turbulent flows, incompressible flows, compressible flows, efficiency and accuracy. CFD II: Introduction to different CFD models, such as OpenFOAM and PALM. Application of these CFD models to defined problems from rotor aerodynamics and the atmospheric boundary layer.
Literaturempfehlungen	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)
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Sommersemester
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		• 1 Klausur oder • 1 Referat oder • 1 mündliche Prüfung oder • 1 fachpraktische Übung

Form of instruction	VA-Auswahl Vorlesungen oder Praktikum oder Seminar

SWS	4
Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy659 - Introduction to Micro Meteorology for Wind Energy

Module label		Introduction to Micro Meteorology for Wind Energy	
Modulkürzel		phy659	
Credit points		5.0 KP	
Workload		150 h	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
Zuständige Personen			
Prerequisites			
Skills to be acquired in this module			
Module contents			
Literaturempfehlungen			
Links			
Language of instruction		German	
Duration (semesters)		1 Semester	
Module frequency			
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			KL
Form of instruction	VA-Auswahl Das Modul wird an der Patnerhochschule angeboten.		
SWS	4		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	56 h		

phy670 - Fluiddynamics II/Wind Energy Meterology

Module label	Fluiddynamics II/Wind Energy Meterology
Modulkürzel	phy670
Credit points	6.0 KP
Workload	180 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master
Zuständige Personen	
Prerequisites	
Skills to be acquired in this module	
Module contents	
Literaturempfehlungen	
Links	
Language of instruction	German
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

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

phy673 - Diffusions and Stochastic Differential Equations

Module label		Diffusions and Stochastic Differential Equations	
Modulkürzel		phy673	
Credit points		5.0 KP	
Workload		150 h	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
Zuständige Personen			
Prerequisites			
Skills to be acquired in this module			
Module contents			
Literaturempfehlungen			
Links			
Language of instruction		German	
Duration (semesters)		1 Semester	
Module frequency			
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			KL
Form of instruction	Vorlesung und Übung Das Modul wird an der Patnerhochschule angeboten.		
SWS	4		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	56 h		

phy674 - Turbulent Flows

Module label		Turbulent Flows	
Modulkürzel		phy674	
Credit points		5.0 KP	
Workload		150 h	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
Zuständige Personen			
Prerequisites			
Skills to be acquired in this module			
Module contents			
Literaturempfehlungen			
Links			
Language of instruction		German	
Duration (semesters)		1 Semester	
Module frequency			
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			KL
Form of instruction	Vorlesung und Übung Das Modul wird an der Patnerhochschule angeboten.		
SWS	4		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	56 h		

phy684 - Wind Turbine Technology and Aerodynamics

Module label	Wind Turbine Technology and Aerodynamics
Modulkürzel	phy684
Credit points	10.0 KP
Workload	300 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master
Zuständige Personen	
Prerequisites	
Skills to be acquired in this module	
Module contents	
Literaturempfehlungen	
Links	
Language of instruction	German
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		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
Präsenzzeit Modul insgesamt				84 h

phy688 - Planning and Development of Wind Farms

Module label		Planning and Development of Wind Farms	
Modulkürzel		phy688	
Credit points		5.0 KP	
Workload		150 h	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
Zuständige Personen			
Prerequisites			
Skills to be acquired in this module			
Module contents			
Literaturempfehlungen			
Links			
Language of instruction		German	
Duration (semesters)		1 Semester	
Module frequency			
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			KL
Form of instruction	VA-Auswahl Das Modul wird an der Patnerhochschule angeboten.		
SWS	4		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	56 h		

phy692 - Research Project EWEM

Module label		Research Project EWEM	
Modulkürzel		phy692	
Credit points		9.0 KP	
Workload		270 h	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
Zuständige Personen			
Prerequisites			
Skills to be acquired in this module			
Module contents			
Literaturempfehlungen			
Links			
Languages of instruction			
Duration (semesters)		1 Semester	
Module frequency			
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			BE
Form of instruction	Seminar		
Frequency			

phy991 - Stochastic Processes

Module label	Stochastic Processes
Modulkürzel	phy991
Credit points	5.0 KP
Workload	150 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master
Zuständige Personen	
Prerequisites	
Skills to be acquired in this module	
Module contents	
Literaturempfehlungen	
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Exercises		2	SoSe oder WiSe	28
Seminar		2	SoSe oder WiSe	28
Präsenzzeit Modul insgesamt				84 h

phy992 - Time Series Analysis

Module label	Time Series Analysis
Modulkürzel	phy992
Credit points	5.0 KP
Workload	150 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master
Zuständige Personen	
Prerequisites	
Skills to be acquired in this module	
Module contents	
Literaturempfehlungen	
Links	
Language of instruction	German
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

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

phy993 - Advanced Time Series Analysis

Module label	Advanced Time Series Analysis
Modulkürzel	phy993
Credit points	10.0 KP
Workload	300 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master
Zuständige Personen	
Prerequisites	
Skills to be acquired in this module	
Module contents	
Literaturempfehlungen	
Links	
Language of instruction	German
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		4	SoSe oder WiSe	56
Exercises		2	SoSe oder WiSe	28
Präsenzzeit Modul insgesamt				84 h

phy994 - Optimization and Data Fitting

Module label	Optimization and Data Fitting
Modulkürzel	phy994
Credit points	5.0 KP
Workload	150 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master
Zuständige Personen	
Prerequisites	
Skills to be acquired in this module	
Module contents	
Literaturempfehlungen	
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		2	SoSe oder WiSe	28
Practical training		2	SoSe oder WiSe	28
Präsenzzeit Modul insgesamt				56 h

phy995 - Physics of Sustainable Energy

Module label		Physics of Sustainable Energy	
Modulkürzel		phy995	
Credit points		5.0 KP	
Workload		150 h	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
Zuständige Personen			
Prerequisites			
Skills to be acquired in this module			
Module contents			
Literaturempfehlungen			
Links			
Language of instruction		German	
Duration (semesters)		1 Semester	
Module frequency			
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			KL
Form of instruction	Lecture		
SWS	4		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	56 h		

phy996 - Offshore Wind Energy

Module label		Offshore Wind Energy	
Modulkürzel		phy996	
Credit points		10.0 KP	
Workload		300 h	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
Zuständige Personen			
Prerequisites			
Skills to be acquired in this module			
Module contents			
Literaturempfehlungen			
Links			
Language of instruction		English	
Duration (semesters)		1 Semester	
Module frequency			
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			KL
Form of instruction	Lecture		
SWS	6		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	84 h		

phy997 - Wind Turbine Measurement Techniques

Module label		Wind Turbine Measurement Techniques	
Modulkürzel		phy997	
Credit points		10.0 KP	
Workload		300 h	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
Zuständige Personen			
Prerequisites			
Skills to be acquired in this module			
Module contents			
Literaturempfehlungen			
Links			
Language of instruction		German	
Duration (semesters)		1 Semester	
Module frequency			
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			KL
Form of instruction	Lecture		
SWS	6		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	84 h		

phy998 - Probabilistic Methods in Wind Energy

Module label	Probabilistic Methods in Wind Energy
Modulkürzel	phy998
Credit points	5.0 KP
Workload	150 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master
Zuständige Personen	
Prerequisites	
Skills to be acquired in this module	
Module contents	
Literaturempfehlungen	
Links	
Language of instruction	German
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

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

phy621 - Advanced Engineering Topics in Wind Energy

Module label		Advanced Engineering Topics in Wind Energy	
Modulkürzel		phy621	
Credit points		5.0 KP	
Workload		150 h	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
Zuständige Personen			
Prerequisites			
Skills to be acquired in this module			
Module contents			
Literaturempfehlungen			
Links			
Languages of instruction		German, English	
Duration (semesters)		1 Semester	
Module frequency			
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			KL
Form of instruction	VA-Auswahl		
SWS	2		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	28 h		

phy622 - Advanced Topics in Wind Energy

Module label		Advanced Topics in Wind Energy	
Modulkürzel		phy622	
Credit points		5.0 KP	
Workload		150 h	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
Zuständige Personen			
Prerequisites			
Skills to be acquired in this module			
Module contents			
Literaturempfehlungen			
Links			
Language of instruction		German	
Duration (semesters)		1 Semester	
Module frequency			
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			KL
Form of instruction	VA-Auswahl		
SWS	2		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	28 h		

phy645 - Wind Physics Measurement Project

Module label		Wind Physics Measurement Project	
Modulkürzel		phy645	
Credit points		3.0 KP	
Workload		90 h	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
Zuständige Personen			
Prerequisites			
Skills to be acquired in this module			
Module contents			
Literaturempfehlungen			
Links			
Languages of instruction		German, English	
Duration (semesters)		1 Semester	
Module frequency			
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			KL
Form of instruction	Lecture		
SWS	2		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	28 h		

phy985 - Stochastic Processes in Experiments

Module label		Stochastic Processes in Experiments	
Modulkürzel		phy985	
Credit points		3.0 KP	
Workload		90 h	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
Zuständige Personen			
Prerequisites			
Skills to be acquired in this module			
Module contents			
Literaturempfehlungen			
Links			
Languages of instruction		German, English	
Duration (semesters)		1 Semester	
Module frequency			
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			KL
Form of instruction	Seminar		
SWS	2		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	28 h		

phy629 - Optimization in modern Power Systems

Module label	Optimization in modern Power Systems
Modulkürzel	phy629
Credit points	5.0 KP
Workload	150 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master
Zuständige Personen	
Prerequisites	
Skills to be acquired in this module	
Module contents	
Literaturempfehlungen	
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

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

phy675 - Integration of Wind Power in the Power System

Module label	Integration of Wind Power in the Power System
Modulkürzel	phy675
Credit points	5.0 KP
Workload	150 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master
Zuständige Personen	
Prerequisites	
Skills to be acquired in this module	
Module contents	
Literaturempfehlungen	
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

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

phy981 - HardTech Entrepreneurship

Module label	HardTech Entrepreneurship
Modulkürzel	phy981
Credit points	10.0 KP
Workload	300 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master
Zuständige Personen	
Prerequisites	
Skills to be acquired in this module	
Module contents	
Literaturempfehlungen	
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

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

phy986 - System Safety and Reliability Engineering

Module label	System Safety and Reliability Engineering
Modulkürzel	phy986
Credit points	5.0 KP
Workload	150 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master
Zuständige Personen	
Prerequisites	
Skills to be acquired in this module	
Module contents	
Literaturempfehlungen	
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

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

phy623 - Advanced Wind Energy Meteorology

Module label	Advanced Wind Energy Meteorology
Modulkürzel	phy623
Credit points	3.0 KP
Workload	90 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master
Zuständige Personen	
Prerequisites	
Skills to be acquired in this module	TEST
Module contents	Test
Literaturempfehlungen	
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

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

phy625 - Deep Learning

Module label		Deep Learning	
Modulkürzel		phy625	
Credit points		5.0 KP	
Workload		150 h	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
Zuständige Personen			
Prerequisites			
Skills to be acquired in this module		Kompetenzziele	
Module contents		Inhalt	
Literaturempfehlungen			
Links			
Language of instruction		English	
Duration (semesters)		1 Semester	
Module frequency			
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			KL
Form of instruction	Lecture		
SWS	2		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	28 h		

phy626 - Introduction to Dynamical Systems

Module label		Introduction to Dynamical Systems	
Modulkürzel		phy626	
Credit points		5.0 KP	
Workload		150 h	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
Zuständige Personen			
Prerequisites			
Skills to be acquired in this module			
Module contents			
Literaturempfehlungen			
Links			
Languages of instruction		German, English	
Duration (semesters)		1 Semester	
Module frequency			
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			KL
Form of instruction	Lecture		
SWS	2		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	28 h		

phy988 - Introduction to Machine Learning and Data Mining

Module label		Introduction to Machine Learning and Data Mining	
Modulkürzel		phy988	
Credit points		5.0 KP	
Workload		150 h	
Verwendbarkeit des Moduls		• Master's Programme Engineering Physics (Master) > European Wind Energy Master	
Zuständige Personen			
Prerequisites			
Skills to be acquired in this module			
Module contents			
Literaturempfehlungen			
Links			
Languages of instruction		German, English	
Duration (semesters)		1 Semester	
Module frequency			
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			KL
Form of instruction	Lecture		
SWS	2		
Frequency	SoSe oder WiSe		
Workload Präsenzzeit	28 h		

phy627 - Hydrodynamics II

Module label	Hydrodynamics II
Modulkürzel	phy627
Credit points	5.0 KP
Workload	150 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master
Zuständige Personen	
Prerequisites	
Skills to be acquired in this module	
Module contents	
Literaturempfehlungen	
Links	
Language of instruction	German
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture			SoSe oder WiSe	0
Exercises			SoSe oder WiSe	0
Präsenzzeit Modul insgesamt				0 h

phy628 - Computational Tool for Data Science

Module label	Computational Tool for Data Science
Modulkürzel	phy628
Credit points	3.0 KP
Workload	90 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master
Zuständige Personen	
Prerequisites	
Skills to be acquired in this module	
Module contents	
Literaturempfehlungen	
Links	
Language of instruction	German
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture			SoSe oder WiSe	0
Exercises			SoSe oder WiSe	0
Präsenzzeit Modul insgesamt				0 h

phy629 - Advanced CFD

Module label	Advanced CFD
Modulkürzel	phy629
Credit points	5.0 KP
Workload	150 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master
Zuständige Personen	
Prerequisites	
Skills to be acquired in this module	
Module contents	
Literaturempfehlungen	
Links	
Language of instruction	German
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture			SoSe oder WiSe	0
Exercises			SoSe oder WiSe	0
Präsenzzeit Modul insgesamt				0 h

phy657 - Energy Economics

Module label	Energy Economics
Modulkürzel	phy657
Credit points	5.0 KP
Workload	150 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > European Wind Energy Master
Zuständige Personen	
Prerequisites	
Skills to be acquired in this module	
Module contents	
Literaturempfehlungen	
Links	
Language of instruction	German
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture			SoSe oder WiSe	0
Exercises			SoSe oder WiSe	0
Präsenzzeit Modul insgesamt				0 h

Schwerpunkt: Acoustics

phy605 - Digital Signal Processing

Module label	Digital Signal Processing
Modulkürzel	phy605
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Acoustics
Zuständige Personen	• Doclo, Simon (module responsibility) • Doclo, Simon (Prüfungsberechtigt)
Prerequisites	
Skills to be acquired in this module	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.
Module contents	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.
Literaturempfehlungen	A. V. Oppenheim, R. W. Schafer, “Discrete-Time Signal Processing”, Prentice Hall, 2013. J. G. Proakis, D. G. Manolakis, “Digital Signal Processing – Principles, Algorithms and Applications”, Prentice Hall, 2013. S. Haykin, ”Adaptive Filter Theory“, Pearson, 2013. P. P. Vaidyanathan, ”Multirate systems and filter banks“, Prentice Hall, 1993. K.-D. Kammeyer, K. Kroschel, ”Digitale Signalverarbeitung: Filterung und Spektralanalyse mit MATLAB Übungen“, Broschiert, 2018
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited
Teaching/Learning method	Vorlesung: 2 SWS, Übung: 2 SWS
Previous knowledge	Basic knowledge about continuous-time signals and systems and statistics. In addition, Matlab programming skills are required.

Examination	Prüfungszeiten	Type of examination
Final exam of module		Max. 180 min. Klausur oder 30 min. mündliche Prüfung

Form of instruction	Lecture
SWS	4
Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy677 - Speech processing

Module label	Speech processing
Modulkürzel	phy677
Credit points	6.0 KP
Workload	180 h (180 h (Präsenzzeit 56h, Selbststudium: 124h))
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Acoustics
Zuständige Personen	• Doclo, Simon (module responsibility) • Doclo, Simon (Prüfungsberechtigt) • Enzner, Gerald (Prüfungsberechtigt) • Kollmeier, Birger (Prüfungsberechtigt) • Meyer, Bernd (Prüfungsberechtigt)
Prerequisites	Introductory signals and systems lecture
Skills to be acquired in this module	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.
Module contents	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.
Literaturempfehlungen	M. R. Schroeder, Computer Speech: Recognition, Compression, Synthesis, Springer, 2013. J. R. Deller, J. H. L. Hansen, J. G. Proakis: Discrete-Time Processing of Speech Signals, Wiley-IEEE Press, 1999. P. Vary, R. Martin: Digital Speech Transmission, Wiley, 2006. J. Benesty, M. M. Sondhi, Y. Huang: Handbook of Speech Processing, Springer, 2008. D. Yu, L. Deng: Automatic Speech Recognition: A Deep Learning Approach, Springer, 2015.
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	jährlich
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

Form of instruction	Lecture
SWS	4
Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy679 - Acoustics

Module label	Acoustics
Modulkürzel	phy679
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Acoustics
Zuständige Personen	• van de Par, Steven (module responsibility) • Ewert, Stephan (Prüfungsberechtigt) • Kollmeier, Birger (Prüfungsberechtigt) • van de Par, Steven (Prüfungsberechtigt)
Prerequisites	Introductory acoustics lecture
Skills to be acquired in this module	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.
Module contents	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.
Literaturempfehlungen	G. Müller, M. Möser: Akustische Messtechnik, Springer, 2017; H. Kuttruff: Room Acoustics, CRC Press, 2016; M. Vorländer: Auralization: Fundamentals of Acoustics, Modelling, Simulation, Algorithms and Acoustic Virtual Reality, Springer, 2020
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	jährlich
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

Form of instruction	Lecture
SWS	4
Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy685 - Advanced Engineering Topics in Biomedical Physics & Acoustics

Module label	Advanced Engineering Topics in Biomedical Physics & Acoustics
Modulkürzel	phy685
Credit points	6.0 KP
Workload	180 h (Overall workload of 180 h)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Acoustics • Master's Programme Engineering Physics (Master) > Schwerpunkt: Biomedical Physics
Zuständige Personen	• Doclo, Simon (module responsibility) • Poppe, Björn (module responsibility) • Anemüller, Jörn (Prüfungsberechtigt) • Biehs, Svend-Age (Prüfungsberechtigt) • Blau, Matthias (Prüfungsberechtigt) • Brand, Thomas (Prüfungsberechtigt) • Dietz, Mathias (Prüfungsberechtigt) • Doclo, Simon (Prüfungsberechtigt) • Enzner, Gerald (Prüfungsberechtigt) • Ewert, Stephan (Prüfungsberechtigt) • Hohmann, Volker (Prüfungsberechtigt) • Kollmeier, Birger (Prüfungsberechtigt) • Lücke, Jörg (Prüfungsberechtigt) • Meyer, Bernd (Prüfungsberechtigt) • Oetjen, Arne (Prüfungsberechtigt) • Poppe, Björn (Prüfungsberechtigt) • Siedenburg, Kai (Prüfungsberechtigt) • Töpken, Stephan (Prüfungsberechtigt) • Uppenkamp, Stefan (Prüfungsberechtigt) • van de Par, Steven (Prüfungsberechtigt)
Prerequisites	Related to selected course/s
Skills to be acquired in this module	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.
Module contents	Photonics, Optics, Metrology,
Literaturempfehlungen	Related to selected course/s
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Sommer- oder Wintersemester
Module capacity	unlimited
Reference text	This module o ers 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.

Examination	Prüfungszeiten	Type of examination
Final exam of module		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
Präsenzzeit Modul insgesamt				126 h

phy686 - Advanced Topics in Biomedical Physics & Acoustics

Module label	Advanced Topics in Biomedical Physics & Acoustics
Modulkürzel	phy686
Credit points	6.0 KP
Workload	180 h (Overall workload of 180 h)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Acoustics • Master's Programme Engineering Physics (Master) > Schwerpunkt: Biomedical Physics
Zuständige Personen	• Doclo, Simon (module responsibility) • Poppe, Björn (module responsibility) • Anemüller, Jörn (Prüfungsberechtigt) • Bitzer, Jörg (Prüfungsberechtigt) • Blau, Matthias (Prüfungsberechtigt) • Brand, Thomas (Prüfungsberechtigt) • Dietz, Mathias (Prüfungsberechtigt) • Doclo, Simon (Prüfungsberechtigt) • Enzner, Gerald (Prüfungsberechtigt) • Ewert, Stephan (Prüfungsberechtigt) • Hohmann, Volker (Prüfungsberechtigt) • Lücke, Jörg (Prüfungsberechtigt) • Kollmeier, Birger (Prüfungsberechtigt) • Meyer, Bernd (Prüfungsberechtigt) • Poppe, Björn (Prüfungsberechtigt) • Oetjen, Arne (Prüfungsberechtigt) • Siedenburg, Kai (Prüfungsberechtigt) • Töpken, Stephan (Prüfungsberechtigt) • van de Par, Steven (Prüfungsberechtigt) • Uppenkamp, Stefan (Prüfungsberechtigt)
Prerequisites	Related to selected course/s
Skills to be acquired in this module	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.
Module contents	Photonics, Optics, Metrology,
Literaturempfehlungen	Related to selected course/s
Links	Depending on selected courses
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Sommer- oder Wintersemester
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		Related to selected course/s

Form of instruction	Comment	SWS	Frequency	Workload of compulsory attendance
Lecture		4	SoSe oder WiSe	56
Seminar			SoSe oder WiSe	0
Präsenzzeit Modul insgesamt				56 h

phy694 - Machine Learning II

Module label	Machine Learning II
Modulkürzel	phy694
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Acoustics
Zuständige Personen	• Lücke, Jörg (module responsibility) • Lücke, Jörg (Prüfungsberechtigt)
Prerequisites	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.
Skills to be acquired in this module	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.
Module contents	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.
Literaturempfehlungen	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)
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	Sommersemester
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		KL

Form of instruction	Lecture
SWS	4
Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy696 - Advanced Topics Speech and Audio Processing

Module label	Advanced Topics Speech and Audio Processing
Modulkürzel	phy696
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Acoustics
Zuständige Personen	• Doclo, Simon (module responsibility) • Doclo, Simon (Prüfungsberechtigt) • Gerkmann, Timo (Prüfungsberechtigt)
Prerequisites	Basic principles of signal processing (preferably successfully completed the course Signal- und Systemtheorie and/or Blockpraktikum Digitale Signalverarbeitung)
Skills to be acquired in this module	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.
Module contents	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).
Literaturempfehlungen	J. Benesty, M. M. Sondhi, Y. Huang: Handbook of Speech Processing, Springer, 2008.; P. Vary, R. Martin: Digital Speech Transmission, Wiley, 2006.; P. Loizou: Speech Enhancement: Theory and Practice, CRC Press, 2007.; S. Vaseghi: Advanced Digital Signal Processing and Noise Reduction, Wiley, 2006.; S. Haykin: Adaptive Filter Theory, Prentice Hall, 2013.
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	jährlich
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		Exam or presentation or oral exam or homework or practical report

Form of instruction	Lecture
SWS	4
Frequency	SoSe oder WiSe
Workload Präsenzzeit	56 h

phy960 - Psychoacoustics

Module label	Psychoacoustics
Modulkürzel	phy960
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Acoustics
Zuständige Personen	• van de Par, Steven (module responsibility) • van de Par, Steven (Prüfungsberechtigt)
Prerequisites	Introductory acoustics lecture
Skills to be acquired in this module	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).
Module contents	*Applied psychophysics* 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). *Auditory Scene Analysis in Speech and Music* 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
Literaturempfehlungen	H. Fastl, E. Zwicker: Psychoacoustics: Facts and Models, Springer, 2007. A.S. Bregman: Auditory Scene Analysis, MIT press, 1990. P. Damaske: Acoustics and Hearing, Springer, 2008.
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	jährlich
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		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
Exercises		2	SoSe oder WiSe	28
Präsenzzeit Modul insgesamt				84 h

phy964 - Advanced Computing

Module label	Advanced Computing
Modulkürzel	phy964
Credit points	6.0 KP
Workload	180 h (Attendance: 56 hrs, Self study: 124 hrs)
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Schwerpunkt: Acoustics • Master's Programme Engineering Physics (Master) > Schwerpunkt: Biomedical Physics • Master's Programme Engineering Physics (Master) > Schwerpunkt: Renewable Energies
Zuständige Personen	• Kühn, Martin (module responsibility) • Doclo, Simon (module responsibility)
Prerequisites	Basic knowledge in computing, knowledge in undergraduate mathematics and physics
Skills to be acquired in this module	Learning of advanced programming concepts and their application in biomedical physics, acoustics, laser and optics, and renewable energies.
Module contents	Advanced programming concepts for C, python and Matlab; Arti cial Intelligence and Data Science; Visual Computing; Software Engineering
Literaturempfehlungen	
Links	
Languages of instruction	German, English
Duration (semesters)	1 Semester
Module frequency	
Module capacity	unlimited

Examination	Prüfungszeiten	Type of examination
Final exam of module		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
Präsenzzeit Modul insgesamt				112 h

Abschlussmodul

mam - Master´s Thesis Module

Module label	Master´s Thesis Module
Modulkürzel	mam
Credit points	30.0 KP
Workload	900 h
Verwendbarkeit des Moduls	• Master's Programme Engineering Physics (Master) > Abschlussmodul
Zuständige Personen	• Brückner, Hans Josef (Prüfungsberechtigt) • Struve, Bert (Prüfungsberechtigt) • Agert, Carsten (Prüfungsberechtigt) • Avila Canellas, Kerstin (Prüfungsberechtigt) • Biehs, Svend-Age (Prüfungsberechtigt) • Brand, Thomas (Prüfungsberechtigt) • Lukassen, Laura (Prüfungsberechtigt) • Dietz, Mathias (Prüfungsberechtigt) • Doclo, Simon (Prüfungsberechtigt) • Ewert, Stephan (Prüfungsberechtigt) • Hohmann, Volker (Prüfungsberechtigt) • Feudel, Ulrike (Prüfungsberechtigt) • Hartmann, Alexander (Prüfungsberechtigt) • Schüning, Thomas (Prüfungsberechtigt) • Lücke, Jörg (Prüfungsberechtigt) • Kollmeier, Birger (Prüfungsberechtigt) • Kühn, Martin (Prüfungsberechtigt) • Neu, Walter (Prüfungsberechtigt) • Kunz-Drolshagen, Jutta (Prüfungsberechtigt) • Lienau, Christoph (Prüfungsberechtigt) • Poppe, Björn (Prüfungsberechtigt) • Peinke, Joachim (Prüfungsberechtigt) • Meyer, Bernd (Prüfungsberechtigt) • Nilius, Niklas (Prüfungsberechtigt) • van de Par, Steven (Prüfungsberechtigt) • Schmidt, Thorsten (Prüfungsberechtigt) • Strybny, Jann (Prüfungsberechtigt) • Teubner, Ulrich (Prüfungsberechtigt) • Uppenkamp, Stefan (Prüfungsberechtigt) • Wark, Michael (Prüfungsberechtigt) • Wollenhaupt, Matthias (Prüfungsberechtigt) • der Masterarbeit, BetreuerIn (module responsibility)
Prerequisites	Master Curriculum Engineering Physics
Skills to be acquired in this module	As a general objective for the Master Thesis, the student shall demonstrate the ability to constructively, critically and independently formulate, discuss and communicate issues at stake, integrating theory and methodology. As specific competency objectives within the Master Thesis, after completion the student shall be able to: - demonstrate knowledge of relevant and latest publications concerning the selected topic - elaborate the Master Thesis on the basis of clearlyformulated, general objectives and specific characteristics of the topic - identify and put to use in an operational manner empirical or other scientific material and methods that are appropriate in relation to the subject - develop a balanced discussion of material, methods, results and possible consequences of these in relation to the eld of Renewable Energy - present the Master Thesis orally and defend the results and conclusions in a critical discussion 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 scienti c as well as keycompetencies described in the next section. Students have understood the scientific problem, they have learned the ropes of the problem, they have selected, acquainted or deepened a set of scientific and methodologies and key-competencies necessary to solve the problem and they have applied those methods.
Module contents	The master thesis module finalizes and concludes the master programme. The student presents the achieved results as a written thesis and defends the results / conclusions to a board of examiners. Within this framework, the students work independently on a current topic from

		the research areas of the working groups. The work is accompanied by a seminar to presentand review results and the progress of the work intermittently. The results will be presented and defendedd in a final colloquium. The publication of thesis results is appreciated.	
Literaturempfehlungen		as required	
Links			
Languages of instruction		German, English	
Duration (semesters)		1 Semester	
Module frequency		jährlich	
Module capacity		unlimited	
Examination	Prüfungszeiten		Type of examination
Final exam of module			Master thesis and colloquium
Form of instruction	Seminar		
Frequency			