Modulhandbuch
Master of Science
in Engineering Physics

Institute of Physics

November 29, 2021

CP →	3	6	9	12	15	18	21	24	27	30	sum
4.→ Semester	**Thesis**										
CP	30										30
3.→ Semester	**Theoretical Methods**		**Advanced Topics in EP**	**Specialization**		**Advanced Research Project**					
CP	6		3	6		15					30
2.→ Semester	**Advanced Physics**		**Engineering Sciences**		**Specialization**		**Specialization**		**Tools and Skills in Engineering Sciences**		
CP	6		6		6		6		6		30
1.→ Semester	**Advanced Physics**		**Advanced Metrology**		**Engineering Sciences**		**Engineering Sciences**		**Specialization**		
CP	6		6		6		6		6		30

Fields of study: Mandatory Advanced Physics Engineering Specialization Thesis $\sum CP = 120$

The field of specialization consists of *Biomedical Physics*, *Acoustics*, *Laser & Optics*, *Renewable Energies*.

Contents

1 Specialization

CP →	3	6	9	12	15	18	21	24	27	30	sum
4.→ Semester	**Thesis**										30
3.→ Semester	**Specialization** **phy646** MI 8-12 5.04.4214 Wind Physics Student's Lab Wind2Grid		**Seminar Advanced Topics in EP** **phy640** FR 10-12 5.04.656 Advanced Topics in EP	**Advanced Physics** **phy633** MO 09-13 5.04.6570 Optics		**Advanced Research Project (Preperation Master Thesis)** **phy691** Blockveranstaltung					30
2.→ Semester	**Advanced Physics** **phy603** MI 12-14 5.04.4071 Fluid Dynamics II	**Engineering Sciences** **phy644** MO 12-14 5.04.4234 Wind Physics Measure-ment Project	**Specialization** **phy649** DI 16-18 DO 12-14 5.04.4235 Design of Wind Energy Systems		**Specialization** **phy648** MI 8-12 5.04.4235 Advanced Wind Energy Meteorology 5.04.4236 Wind Energy Applications - from Wind Resource to Wind Farm Applications		**Specialization** **phy687** Freitags, ganztägig 5.04.4102 Advanced Laboratories in Renewable Energy		**Engineering Sciences** **phy616** DI 12-16 5.04.4072 & 5.04.4074 Computational Fluid Dynamics		30
1.→ Semester	**Advanced Physics** **phy603** DI 12-14 5.04.4070 Fluid Dynamics I	**Engineering Sciences** **phy644** DO 10-12 5.04.4061 Wind Energy Physics	**Engineering Sciences** **phy641** DI 10-12 MI 12-14 5.06.021 & 5.06.022 Energy Ressources & Systems		**Advanced Metrology** **phy631** DI 14-16 FR 12-14 5.04.4660 Advanced Metrology		**Theoretical Methods** **phy611** DI 15-20 HS Leer Modelling and Simulation		**Tools and Skills in Engineering Sciences** **phy681** DO 12-16 2.12.021 and 2.12.022 International Sustainability Management		30
CP											$\Sigma CP = 120$

Renewable Energy (Winter Term)

CP →	3	6	9	12	15	18	21	24	27	30	sum
4.→ Semester	**Thesis**										30
3.→ Semester	**Specialization** **phy637** WE 13:45-17:00 5.04.4664 Laser Design and Beam Guiding		**Seminar Advanced Topics in EP** **phy640** FR 10-12 5.04.656 Advanced Topics in EP	**Engineering Sciences** **phy605** MO 16-18 WE 12-14 5.04.4586 Digital Signal Processing		**Advanced Research Project (Preperation Master Thesis)** **phy691** Blockveranstaltung					30
2.→ Semester	**Advanced Physicss** **phy633** MO 09-13 5.04.6570 Foundamentals of Optics		**Advanced Metrology** **phy631** DI 14-16 FR 12-14 5.04.4660 Advanced Metrology		**Theoretical Methods** **phy611** MO 17-19 + Proj. 5.04.4667 Optical Simulation and Modelling (ZEMAX)		**Engineering Sciences** **phy632** TU 08-10 TU 12-14 5.04.4661 Spectrophysics 5.04.6611 Advanced Optical Spectroscopy		**Engineering Sciences** **phy600** MO 13-17 5.04.4668 Photonics		30
1.→ Semester	**Advanced Physicss** **phy617** MO 12-14 MO 14-16 5.04.4662 & 5.04.4676 Physics with Ultrashort Pulses & Fourier Methods		**Specialization** **phy965** MO 08-12 5.04.4677 Engineering Scientific Instrumentation		**Specialization** **phy634** TU 08-10 TU 12-14 5.04.4667 Biophotonics and Spectroscopy Modern Methods in Optical Microscopy		**Specialization** **phy639** FR 11-15 5.04.4663 Physics with Intense Laser Pulses		**Tools and Skills in Physics and Engineering** **phy681** WE 09-13 5.04.4671 Tools in Advanced Photonics		30
CP											$\sum CP = 120$

Laser and Optics(Summer Term)

CP →	3	6	9	12	15	18	21	24	27	30	sum
4.→ Semester	**Thesis**										30
3.→ Semester	**Specialization** **phy683** MO 14-16, TU 08-10, WE 14-16 5.04.4082 Spectroscopy at the Nanoscale 2.01.369 Selected Topics in Microwave-Microscopy and -Communication Systems 5.04.4883 Chaos, catastrophes, and fractals		**Seminar Advanced Topics in EP** **phy640** FR 10-12 5.04.656 Advanced Topics in EP	**Engineering Sciences** **phy685** TU 10-12 5.04.4669 Laser Material Processing Project		**Advanced Research Project (Preperation Master Thesis)** **phy691** Blockveranstaltung					30
2.→ Semester	**Advanced Physicss** **phy617** MO 12-14, MO 14-16 5.04.4662 & 5.04.4676 Physics with Ultrashort Pulses & Fourier Methods		**Specialization** **phy965** MO 08-12 5.04.4677 Engineering Scientific Instrumentation		**Specialization** **phy634** TU 08-10, TU 12-14 5.04.4667 Biophotonics and Spectroscopy Modern Methods in Optical Microscopy		**Specialization** **phy639** FR 11-15 5.04.4663 Physics with Intense Laser Pulses		**Tools and Skills in Physics and Engineering** **phy681** WE 09-13 5.04.4671 Tools in Advanced Photonics		30
1.→ Semester	**Advanced Physicss** **phy633** MO 09-13 5.04.6570 Foundamentals of Optics		**Advanced Metrology** **phy631** TU 14-16, FR 12-14 5.04.4660 Advanced Metrology		**Theoretical Methods** **phy611** MO 17-19 + Proj. 5.04.4667 Optical Simulation and Modelling (ZEMAX)		**Engineering Sciences** **phy632** TU 08-10, TU 12-14 5.04.4661 Spectrophysics 5.04.6611 Advanced Optical Spectroscopy		**Engineering Sciences** **phy600** MO 13-17 5.04.4668 Photonics		30
CP											$\sum CP = 120$

Laser and Optics (Winter Term)

CP →	3	6	9	12	15	18	21	24	27	30	sum
4.→ Semester	**Thesis**										30
3.→ Semester	**Engineering Sciences phy694** DI 14-16 DO 10-12 5.04.4214 Machine Learning II		**Seminar Advanced Topics in EP phy640** DO 16-18 5.04.656 Advanced Topics in EP	**Engineering Sciences phy685** Advanced Engineering Topics in Biomedical Physics and Acoustics		**Advanced Research Project (Preperation Master Thesis)** **phy691** Blockveranstaltung					30
2.→ Semester	**Specialization phy679** MO 10-12 DO 16-18 5.04.663 Acoustical Metrology and Virtual Acoustics		**Advanced Metrology phy631** DI 14-16 FR 12-14 5.04.4660 Advanced Metrology		**Theoretical Methods phy611** DI 16-18 MI 10-12 5.04.4213 Machine Learning I		**Specialization phyxxx** MO 16-18 MI 16-18 5.04.4218 Auditory scene analysis in speech and music 5.04.4203 Applied Psycophysics		**Specialization phy696** MO 14-16 DO 10-12 5.04.4207 Advanced Topics Speech and Audio Processing		30
1.→ Semester	**Engineering Sciences phy605** MO 16-18 MI 12-14 5.04.4586 Digital Signal Processing		**Advanced Physics phy607** ?? ?? Selected Topics in Advanced Physics or 5.04.4711 Akustik		**Specialization phy611** 5.04.4012 Speech Prozessing		**Advanced Physics** **phy617** ?? ?? ?? ?? 5.04.4662 & 5.04.??? Physics with Ultrashort Pulses & Fourier Methods		**Tools and Skills in Physics and Engineering phy681** FR 10-1 FR 12-14 5.04.811 Fortgeschrittenen-Projektpraktikum Hörtechnik und Audiologie		30
CP											$\sum CP = 120$

Acoustics(Summer Term)

CP →	3	6	9	12	15	18	21	24	27	30	sum
4.→ Semester	**Thesis**										30
3.→ Semester	**Specialization** **phy696** MO 14-16 DO 12-14 5.04.4586 Advanced Topics Speech and Audio Processing		**Seminar Advanced Topics in EP** **phy640** FR 10-12 5.04.656 Advanced Topics in EP	**Specialization** **phy685** DO 10-12 5.04.4586 Advanced Topics in Biomedical Physics and Acoustics (see Stud.IP)		**Advanced Research Project (Preperation Master Thesis)** **phy691** Blockveranstaltung					30
2.→ Semester	**Engineering Sciences** **phy605** MO 16-18 MI 12-14 5.04.4586 Digital Signal Processing		**Advanced Physics** **phy607** ?? ?? Selected Topics in Advanced Physics or 5.04.4711 Akustik		**Specialization** **phy611** 5.04.4012 Speech Prozessing		**Engineering Sciences** **phy694** 5.04.4214 Machine Learning II		**Advanced Physics** **phy617** ?? ?? 5.04.4662 & 5.04.??? Physics with Ultrashort Pulses & Fourier Methods		30
1.→ Semester	**Specialization** **phy679** MO 10-12 DO 16-18 5.04.663 Acoustical Metrology and Virtual Acoustics		**Advanced Metrology** **phy631** DI 14-16 FR 12-14 5.04.4660 Advanced Metrology		**Theoretical Methods** **phy611** DI 16-18 MI 10-12 5.04.4213 Machine Learning I		**Specialization** **phy960** MO 16-18 MI 16-18 5.04.4218 Auditory scene analysis in speech and music 5.04.4203 Applied Psychophysics		**Tools and Skills in Physics and Engineering** **phy681** FR 10-1 FR 12-14 5.04.811 Fortgeschrittenen-Projektpraktikum Hörtechnik und Audiologie		30
CP											$\sum CP = 120$

Acoustics(Winter Term)

DGMP

Deutsche Gesellschaft für Medizinische Physik e.V.

Studiengangszertifikat

Die Deutsche Gesellschaft für Medizinische Physik e.V.

zertifiziert den konsekutiven Bachelor-/Masterstudiengang

„Engineering Physics“

der

Carl von Ossietzky Universität Oldenburg

für die

Fachanerkennung für Medizinische Physik

mit Berechtigung zum Führen der Bezeichnung

"Medizinphysiker (DGMP)"

gemäß der gültigen Weiterbildungsordnung der DGMP vom 09.05.2015
unter den in der Anlage zu diesem Zertifikat genannten Voraussetzungen.

Die Zertifizierung gilt vom 18.1.2018 bis zum 30.9.2022.

Berlin, den 18.1.2018

Prof. Dr. Katia Parodi
Präsidentin der DGMP

SGZ 0021/18

Deutsche Gesellschaft für Medizinische Physik e.V.

Anlage zum Studiengangszertifikat

für den konsekutiven Bachelor-/Masterstudiengang

„Engineering Physics“

der

Carl von Ossietzky Universität Oldenburg

Diese Zertifizierung ist eine Verlängerung der Zertifizierung vom 01.06.2015 und gilt unter den folgenden Voraussetzungen:

1. Die Absolvent/innen haben die Bachelorstudiengänge „Physik“ oder „Engineering Physics“ erfolgreich abgeschlossen und die Veranstaltungen
    - 5.04.341 „Kern- und Teilchenphysik“
    - 5.04.462 „Hochenergiestrahlenphysik “
    - 5.02.271 „Physiologie der Tiere und Menschen”
    - 5.04.317 „Biomedizinische Physik und Neurophysik“
    - 5.04.4666 „Personalized Medicine“
    - 5.04.4207 „Processing and analysis of Biomedical Data“
    - 05.04.4021 „Bildgebende Verfahren“

   belegt.
2. Diese Zertifizierung gilt für das Spezialgebiet (gemäß WBO der DGMP):
    a) N6. Strahlentherapie, falls folgende Veranstaltungen belegt wurden:
    - 05.04.4642 „Medizinische Strahlenphysik“
    - 05.04.4222 „Spezialkurs Strahlenschutzseminar“
    - 05.04.4242 „Selected Topics on Medical Radiation Physics”
    - 05.04.4221 „Grundkurs im Strahlenschutz”

    b) N9. Klinische Audiologie, falls folgende Module belegt wurden:
    - 05.04.4021 „PPAA“
    - 05.04.4203 „Angewandte Psychophysik“
    - 05.04.4586 „Advanced Topics Speech and Audio Processing”
3. Diese Zertifizierung gilt für die Wahlgebiete (gemäß WBO der DGMP):
    a) N6 bzw. N9 mit den unter Pkt. 2 genannten Veranstaltungen sofern sie nicht schon als Spezialgebiet gewählt wurden.
    b) N14. Physikalische Messtechniken in der Medizin, falls mindestens zwei der folgenden Veranstaltungen belegt wurden:

- 05.04.4586 Digital Signal Processing
- 05.04.4012 Informationsverarbeitung und Kommunikation
- 05.04.4052 „Optische Messtechnik“

Es müssen mindestens zwei Gebiete belegt werden mit insgesamt 15 ECTS-Punkten und mindestens 5 ECTS-Punkten pro Gebiet.

4. Die Zertifizierung gilt vom 18.1.2018 bis zum 30.09.2022 bzw. bis zu einer Änderung des Curriculums. Für eine Rezertifizierung ist rechtzeitig ein erneuter Zertifizierungsantrag zu stellen.

Die Absolventen des Studienganges müssen sich bei Beginn der klinischen Tätigkeit zur Weiterbildung anmelden (Anträge unter www.dgmp.de, WBB-Antrag).

Die Kandidaten haben während der i.d.R. dreijährigen berufspraktischen, klinischen Weiterbildungsphase nach Abschluss des Studiums insgesamt mindestens 150 Weiterbildungspunkte (gleich Stunden) im Sinne der kontinuierlichen Fortbildung (CPD) durch den Besuch anerkannter Weiterbildungsveranstaltungen im Spezialgebiet - das auch das Arbeitsgebiet sein muss - nachzuweisen.

Für das Spezialgebiet „Strahlentherapie“ ist die Fachkunde im Strahlenschutz bei Antragstellung nachzuweisen.

Diese Anerkennung gilt auch für Absolventen des konsekutiven Bachelor-/Masterstudiengans „Physik“ der Carl von Ossietzky Universität Oldenburg, wenn die entsprechenden Veranstaltungen erfolgreich bestanden wurden.

2 Mandatory Courses

2.1 Advanced Metrology

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Module title:	Advanced Metrology
Module code:	phy631
Course:	5.04.4660 Advanced Metrology
Term:	Winter
Person in charge:	Prof. Dr. Huke
Lecturer:	Prof. Dr. Huke
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Pflichtmodule
Teaching Methods/ semester periods per week:	Lecture: 4 hrs/week first, 2 hrs/week second half of semester Experimental /Seminar work: 0 hrs/week first, 2 hrs/week second half of semester
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Metrology
Aim/learning outcomes:	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. Experimental setups, simulations and signal analysis from experiments are explained within the context of Laser and optics, Biomedical physics and 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.
Content:	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.
Assessment/type of examination:	Internship report: Between 15 and 30 pages or Written examination: 120 minutes
Literature:	Recent publications on specifc topics D.L. Allen, D.W. Mills: Signal Analysis (Time, Frequency, Scale and Structure) T. Yoshizawa (Ed.): Handbook of Optical Metrology: Principles and Applications, 2nd rev. ed., Crc Pr Inc., 2015

2.2 Seminar Advanced Topics in Engineering Physics

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Module title:	Seminar Advanced Topics in Engineering Physics
Module code:	phy640
Course:	Seminar Advanced Topics in Engineering Physics (WS and SS, 5.04.656)
Term:	Winter and Summer
Person in charge:	Prof. Dr. Neu
Lecturer:	Prof. Dr. Neu, Dr. S. Koch
Language:	German or English on demand
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st - 4th semester
Teaching Methods/ semester periods per week:	Seminar: 2 hrs/week
Workload:	Attendance: 28 hrs, Self study: 62 hrs
Credit points:	3
Prerequisites acc. syllabus:	
Recommended prerequisites:	Participation: 1st - 3rd semester. Presentation: Master thesis work in progress or finished; at least one successfully completed specialization module.
Aim/learning outcomes:	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.
Content:	Current seminar topics
Assessment/type of examination:	1 Written examination: 45 to 90 minutes and regular active and documented participation in the seminar spread over the first three semesters
Literature:	M. Alley: The Craft of Scientific Presentations, Springer, 2nd ed., 2013 Publications according to seminar topics

2.3 Theoretical Methods

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Module title:	Theoretical Methods
Module code:	phy611
Course:	Computer Physics, Density-functional theory, Machine Learning, Modelling and Simulation, Signal Processing
Term:	Winter
Person in charge:	Prof. Dr. Caterina Cocchi
Lecturer:	Prof. Dr. Hartmann, Prof. Dr. Caterina Cocchi, Prof. Dr. Lücke, Prof. Dr. Doclo
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Pflichtmodule
Teaching Methods/ semester periods per week:	Lecture: 2 or 4 hrs/week; Excercises: 1 or 2 hrs/week
Workload:	attendance: 56 hrs, self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Theory modules in Bachelor, e.g., Mathematical Methods; Quantum Structure of Matter
Aim/learning outcomes:	The goal of this module is to extend the training in theoretical methods for engineering physics through the acquisition of solid and in-depth knowledge of advanced concepts and through their practice with computer simulations. Depending on the chosen course, the students will have the opportunity to strengthen their knowledge in quantum material modelling (Density-functional theory), signal processing, fluid dynamics (Modelling and Simulation), computational physics, and machine learning. In this way, they will develop skills to relate the conceptual design of models, their numerical implementation, and the physical analysis of the produced data, with the results of field and/or laboratory measurements.

Content:	<u>Computer Physics</u> Debugging; data structures; algorithms; random numbers; data analysis; percolation; Monte Carlo simulations; finite-size scaling; quantum Monte Carlo; molecular dynamics simulations; event-driven simulations; graphs and algorithms; genetic algorithms; optimization problems. <u>Density-functional theory</u> The many-body problem; the Hartree-Fock approximation; Homogeneous electron gas; Hohenberg-Kohn theorems; Kohn-Sham equations; exchange-correlation potentials; pseudopotentials; basis sets. <u>Machine learning</u> Unsupervised learning methods; algorithms for clustering, classification, component extraction, feature learning, blind source separation and dimensionality reduction; Relations to neural network models; learning in biological systems. <u>Modelling and Simulation</u> Advanced fluid dynamics including 3D, transient and compressible processes; Theory of similarity, range of dimensionless numbers; Potential Theory; Numerical Algorithms and possibilities of independent coding of simplest mathematical models; Introduction of a complete chain of Open-Source-CFD-Tools; Contactless high-resolving measuring techniques in the fluid dynamics. <u>Signal processing</u> System properties; Discrete-time signal processing; Statistical signal processing; Adaptive filters.
Assessment/type of examination:	1 exam according to selected course

Literature:

Computer Physics

- 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- Scientic, 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.

Density-functional theory

- R. Martin, Electronic Structure, Cambridge University Press (2004);
- F. Bechstedt, Many-body approach to electronic excitations, Springer (2015);
- F. Giustino, Materials modelling using density functional theory, Oxford University Press (2014).

Machine learning

- C. M. Bishop, Pattern Recognition and Machine Learning, Springer 2006;
- D. MacKay, Information Theory, Inference, and Learning Algorithms, Cambridge University Press, 2003.

Modelling and Simulation

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

Signal processing

- 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 lter banks, Prentice Hall, 1993;
- K.-D. Kammeyer, K. Kroschel, Digitale Signalverarbeitung: Filterung und Spektralanalyse mit MATLAB-Übungen, Broschiert, 2018;

2.4 Tools and Skills in Engineering Sciences

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Module title:	Tools and Skills in Engineering Sciences
Module code:	phy681
Course:	Workshop Management
Term:	Summer
Person in charge:	Prof. Dr. Huke
Lecturer:	Prof. Dr. Huke et.al.
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Pflichtmodule
Teaching Methods/ semester periods per week:	Seminar: 2hrs/week; Excersise: 2hrs/week
Workload:	Attendance: 28 hrs, Self study: 152 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	
Aim/learning outcomes:	The aim of the module is that the students are qualified to plan, setup, conduct and successfully complete scientific or industrial-driven projects. Therefore, the students use the (physical) understanding of the process in question, derive and realize a solution with their necessary engineering skills and document the results properly
Content:	Projects may include design of laser systems (solid-state, gas, diode lasers with ultrashort-pulses, tunability, low-noise frequency-stabilization) as well as conceptual setups in photonics and fiber technologies. One of the major topics is planning, management and conduction of a project from idea to realization.
Assessment/type of examination:	Internship report: Between 15 and 30 pages
Literature:	- Projektportfolio-Management : Strategisches und operatives Multi-Projektmanagement in der Praxis; Matthias Hirzel [Hrsg.] ; Wolfgang Alter [Hrsg.] ; Cornelia Niklas [Hrsg.] 4., überarbeitete und erweiterte Auflage., Wiesbaden : Springer Gabler, 2019 - Project management 2.0 : leveraging tools, distributed collaboration, and metrics for project success Harold Kerzner Hoboken, New Jersey: John Wiley & Sons, Inc, 2015 - The Decision Book: Fifty models for strategic thinking (New Edition) (English Edition) Lasers, Siegman, 13. Auflage, ISBN: 978-0935702118

2.5 Advanced Research Project (Preparation Master Thesis)

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Module title:	Advanced Research Project
Module code:	phy691
Course:	Advanced Research Project
Term:	Winter or Summer
Person in charge:	Prof. Dr. Neu
Lecturer:	Acc
Language:	English
Location	Acc. selected course
Curriculum allocation:	Master Engineering Physics (Master); Pflichtmodule
Teaching Methods/ semester periods per week:	Project work / 40 hours/week
Workload:	Attendance: 320 hrs, Self study: 130 hrs
Credit points:	15
Prerequisites acc. syllabus:	
Recommended prerequisites:	Sound knowledge in the specialisation field of Master thesis
Aim/learning outcomes:	Students are able to search for and to state an adequate research problem in the field of the working group or industry (problem should be related to the topics covered in the masters programme). They are capable to derive research questions based on the statement of the problem and prepare an elaborated research proposal yielding lab work that serves as the preliminary study for the Master's Thesis. Students are in a position to develop the specialised bases (detailed theoretical background of the topic, ample and critically annotated literature review, research objectives and research question(s), fully developed methods section, sketched workplan) of the Master's Thesis Project in terms of content and style in such a way that they form a sound basis for a successful Master's Thesis. Students gain expertise in workflow optimization, data collection and data analysis. Independent management and transformation of a complex and unpredictable problem from the general field of study contexts of the Master degree program "Engineering Physics" (including related subject areas) utilizing scientific state-of-the-art research methods.
Content:	Independent research for the definition of a physics and engineering solution to a problem in the choosen 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

Assessment/type of examination:	home work: between 15 and 30 pages or presentation: between 20 and 45 minutes
Literature:	Acc. Research field, Recent publications on specific topics

2.6 Thesis

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Module title:	Master Thesis
Module code:	MAM
Course:	Master Thesis
Term:	Summer or Winter
Person in charge:	Supervising tutor
Lecturer:	Supervising tutor
Language:	German or English
Location	
Curriculum allocation:	Master Engineering Physics, 4. Semester
Teaching Methods/ semester periods per week:	Seminar, Laboratory and self studies
Workload:	900
Credit points:	30 including 3 CP (Seminar) and 2 CP (Colloquium)
Prerequisites acc. syllabus:	Master Curriculum Engineering Physics
Recommended prerequisites:	
Aim/learning outcomes:	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 clearly formulated, 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 field 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 scientific as well as key-competencies 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.

Content:	The master thesis module finalizes and concludes the master programme. The student presents the achieved results as a written thesis and defends the results / conclusions to a board of examiners. Within this framework, the students work independently on a current topic from the research areas of the working groups. The work is accompanied by a seminar to present and review results and the progress of the work intermittently. The results will be presented and defendedd in a final colloquium. The publication of thesis results is appreciated.
Assessment/type of examination:	Master Thesis and colloquium
Literature:	As required

3 Advanced Physics

3.1 Advanced Nuclear and Particle Physics

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Module title:	Advanced Nuclear and Particle Physics
Module code:	phy602
Course:	High-Energy Radiation Physics (WS, 5.04.4642) und Space Environment (WS, 5.04.776)
Term:	Winter
Person in charge:	Prof. Dr. B. Poppe
Lecturer:	Prof. Dr. B. Poppe, Dr. Hui Khee Looe, Dr. G. Drolshagen
Language:	German (5.04.4642) and Englisch (5.04.776)
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Advanced Physics
Teaching Methods/ semester periods per week:	each lecture: 2hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Basic lectures in physics / engineering

Aim/learning outcomes:	**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.
Content:	**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.

Assessment/type of examination:	written exam Max. 180 min. or oral exam 30 min.
Literature:	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

3.2 Fluiddynamics

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Module title:	Fluid Dynamics
Module code:	phy603
Course:	Fluid Dynamics I (WS, 5.04.4070) und Fluid Dynamics II (SS, 5.04.4071)
Term:	Term: Winter and Summer
Person in charge:	Prof. Dr. Peinke
Lecturer:	Jun. Prof- Laura Lukassen (winter) Prof. Dr. Peinke (summer)
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Advanced Physics
Teaching Methods/ semester periods per week:	Lecture: 2hrs/week; Excersise: 2hrs/week
Workload:	Attendance: 84 hrs, Self study: 96 hrs
Credit points:	6
Prerequisites acc. syllabus:	Fluid Dynamics I has to be taken before Fluid Dynamics II
Recommended prerequisites:	
Aim/learning outcomes:	Fundamental knowledge and comprehension on the movement of fluids
Content:	**Fluid Dynamics I:** Basic equations: Navier-Stokes-equation, Continuity- equation, Bernoulli- equation; Vortex- equation – and Energy balance equations; laminar flows and stability analysis; exact solutions, application of basic equations **Fluid Dynamics II:** Reynolds-equation, „closing problem“ of turbulence: Turbulence models: Cascade models, Stochastic models
Assessment/type of examination:	max 180 minutes written exam or 30 min oral exam or presentation between 20 and 45 minutes
Literature:	J. Spurk, N. Aksel: Fluid Mechanics, Springer D. J. Tritton: Physical fluid dynamics. Clarendon Press, Oxford, 2003 G. K. Batchelor: An introduction to fluid dynamics. Cambridge University Press, Cambridge, 2002 U. Frisch: Turbulence: the legacy of A. N. Kolmogorov. Cambridge University Press, Cambridge, 2001 J. Mathieu, J. Scott: An introduction to turbulent flow. Cam- bridge University Press, Cambridge, 2000 P.A. Davidson: turbulence Oxford 2004

3.3 Optics

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Module title:	Optics
Module code:	Phy633
Course:	Applied Photonics II - Fundamentals of Optics (WS, 5.04.657)
Term:	Winter
Person in charge:	Prof. Dr. Teubner
Lecturer:	Prof. Dr. Ulrich Teubner
Language:	German or English depending on demand
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master; Advanced Physics
Teaching Methods/ semester periods per week:	Lecture plus Lab Part: 4 hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Electrodynamics
Aim/learning outcomes:	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.
Content:	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)
Assessment/type of examination:	max 180 min written exam or 30 min oral exam or Lab work with report
Literature:	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

3.4 Fourier Methods

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Module title:	Fourier Methods
Module code:	phy617
Course:	Physics with Ultrashort Pulses (SS, 5.04.4662) und Fourier Methods (WS, 5.04.xxxx)
Term:	
Person in charge:	Prof. Dr. Ulrich Teubner
Lecturer:	Prof. Dr. Ulrich Teubner
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Advanced Physics
Teaching Methods/ semester periods per week:	Lecture 2hrs/week; Exersise: 2hrs/week
Workload:	Attendance: 56hrs,Self Study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	
Aim/learning outcomes:	**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.

Content:	The course consists of two parts, both strongly related to Fourier physics: **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 **Fouriertechniken in der Physik:** 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
Assessment/type of examination:	2 * 3 hours written or 2 * 30 minutes oral exams
Literature:	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: "Springer-Handbook 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.

3.5 Audiologie und Akustik

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Module title:	Audiologie und Akustik
Module code:	phy950
Course:	Psychophysik und Audiologie / Akustik
Term:	
Person in charge:	Steven van de Par, Birger Kollmeier
Lecturer:	Steven van de Par, Birger Kollmeier
Language:	Deutsch
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Advanced Physics
Teaching Methods/ semester periods per week:	Lecture: 3hrs/week; Excersise: 1hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Einführendes Akustik Modul
Aim/learning outcomes:	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.
Content:	**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.

Assessment/type of examination:	one or two examination, totaling to 180 min. written exam or 30 min. oral exam
Literature:	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

3.6 Selected Topics in Advanced Physics

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Module title:	Selected Topics in Advanced Physics
Module code:	phy607
Course:	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.
Term:	winter or summer
Person in charge:	Prof. Dr. Walter Neu
Lecturer:	Related to selected course/s
Language:	Related to selected course/s
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Advanced Physics
Teaching Methods/ semester periods per week:	Related to selected course/s
Workload:	Overall workload of 180 h
Credit points:	3 + 3 or 6
Prerequisites acc. syllabus	
Recommended prerequisites:	Related to selected course/s
Aim/learning outcomes:	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.
Content:	Photonics, Optics, Metrology,
Assessment/type of examination:	Related to selected course/s
Literature:	Related to selected course/s

4 Biomedical Physics

4.1 Engineering Sciences

4.1.1 Grundlagen der Physiologie

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Module title:	Grundlagen der Physiologie
Module code:	bio279
Course:	Physiologie der Tiere und des Menschen (WS, 5.02.271)
Term:	Winter
Person in charge:	Dominik Heyers
Lecturer:	Dominik Heyers, Christine Köppl, Karin Dedek
Language:	Deutsch
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Biomedical Physics Master of Education (Sonderpädagogik) Biologie (Master of Education) ; Mastermodule
Teaching Methods/ semester periods per week:	lecture 4 hrs/week
Workload:	Attendance: 56 hrs, Self Study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	
Aim/learning outcomes:	biologische Fachkenntnisse Kenntnisse biologischer Arbeitstechniken biologierelevante naturwissenschaftliche/mathematische Grundkenntnisse Statistik und wissenschaftliches Programmieren Abstraktes, logisches, analytisches Denken vertiefte Fachkompetenz in biologischem Spezialgebiet Selbstständiges Lernen und (forschendes) Arbeiten Teamfähigkeit Vermittlung grundlegender Kenntnisse und Zusammenhänge der Physiologie mit Schwerpunkt Humanphysiologie. Vermittlung des Zusammenhanges von Struktur und Funktion als wesentliches Basikonzept der Biologie; Vermittlung naturwissenschaftlicher Arbeitsweisen: Hypothesenbildung, Versuchsplanung, Versuchsdurchführung, Datensammlung, Interpretation, Fehleranalyse; Anleitung zum eigenen, forschend-entdeckenden Experimentieren; Schaffen von Experimentiergelegenheiten. Reflektion des Experimentierens als Weg der Erkenntnisgewinnung

Content:	Der Vorlesungsstoff (Vorlesung: 5.02.271 - Physiologie der Tiere und des Menschen) umfasst die Gebiete Allgemeine Zellphysiologie, Sinnesphysiologie, Neuro- und Muskelphysiologie, vegetative Funktionen, Blut und Immunabwehr, Herz und Kreislauf, Regulation des inneren Milieus, sowie Atmung und Ernährung und Verdauung. In der Vorlesung steht die Physiologie des Menschen im Vordergrund. In der sich anschließenden Übung werden eine Reihe von physiologischen Experimenten mit direktem Bezug zur Vorlesung durchgeführt. Anhand von Eigenversuchen sowie Simulationen am Computer erlernen die Teilnehmer Erkenntnisse zum Verständnis der physiologischen Vorgänge des eigenen Körpers.
Assessment/type of examination:	Written examination: 120 minutes
Literature:	Klinke, Pape, Kurtz, Silbernagl: Physiologie, Aufl. 6, 2010 Schmidt, Lang, Heckmann: Physiologie des Menschen mit Pathophysiologie, Aufl. 31, 2011 (sinnvolle Zusatzliteratur, falls verfügbar: Wehner, Gehring: Zoologie)

4.1.2 Personalized Medicine

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Module title:	Personalized Medicine
Module code:	phy614
Course:	Personalized Medicine (SS, 5.04.4666)
Term:	Summer
Person in charge:	Prof. Dr. T. Schmidt.
Lecturer:	Prof. Dr. T. Schmidt
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Biomedical Physics
Teaching Methods/ semester periods per week:	Lecture: 4 hrs/week
Workload:	attendance: 56 hrs, self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus;	
Recommended prerequisites:	Statistics, Computing
Aim/learning outcomes:	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.
Content:	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.
Assessment/type of examination:	Max. 3 hrs written exam or 30 min oral exam. Here, you will find information about the consideration of bonus points for module marks.
Literature:	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;

4.1.3 Processing and Analysis of Biomedical Data

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Module title:	Processing and analysis of biomedical data
Module code:	phy678
Course:	Processing and analysis of biomedical data (WS, 5.04.4207)
Term:	Winter
Person in charge:	Prof. Dr. B. Poppe
Lecturer:	S. Uppenkamp, S. Ewert, V. Hohmann
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Biomedical Physics
Teaching Methods/ semester periods per week:	Lecture: 2hrs/week; Exersise: 2hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Basic signal processing, algebra knowledge
Aim/learning outcomes:	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.
Content:	Normal distributions and significance testing, Monte-Carlo bootstrap techniques, Linear regression, Correlation, Signal-to-noise estimation, Principal component analysis, Confi-dence intervals, Dipole source analysis, Analysis of variance Each technique is explained, tested and discussed in the exercises.
Assessment/type of examination:	Written examination: Between 90 and 180 minutes or Oral examination: Between 20 and 45 minutes
Literature:	Kirkwood B.R. and Sterne A.C., Essential Medical Statistics: 2nd editition. 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

4.1.4 Advanced Engineering Topics in Biomedical Physics and Acoustics

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Module title:	Advanced Engineering Topics in Biomedical Physics and Acoustics
Module code:	phy685
Course:	This module offers special as well as advanced engineering courses in Biomedical Physics and Acoustics. The list of eligible courses will be updated each academic year. Please refer to the courses listed for this module in Stud.IP.
Term:	winter or summer
Person in charge:	Prof. Dr. B. Poppe and Prof. Dr. ir. Doclo
Lecturer:	Depending on selected courses
Language:	Depending on selected courses
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Acoustics Master Engineering Physics (Master); Schwerpunkt: Biomedical Physics
Teaching Methods/ semester periods per week:	Depending on selected courses
Workload:	Overall workload of 180 h
Credit points:	3 + 3 or 6
Prerequisites acc. syllabus	
Recommended prerequisites:	Depending on selected courses
Aim/learning outcomes:	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. The students acquire advanced knowledge and skills related to the engineering areas biomedical physics and acoustics.
Content:	Depending on selected courses
Assessment/type of examination:	Depending on selected courses, one or two examinations
Literature:	Depending on selected courses

4.2 Specialization

4.2.1 Selected Topics on Medical Radiation Physics

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Module title:	Selected Topics on Medical Radiation Physics
Module code:	phy698
Course:	Selected Topics on Medical Radiation Physics (SS, 5.04.4242) and Medizinische Strahlenphysik (SS, 5.04.4642)
Term:	Sommer
Person in charge:	Prof. Dr. B.Poppe
Lecturer:	Dr. A. Rühmann, Prof. Dr. B. Poppe (5.04.4242) Prof. Dr. B. Poppe, Dr. K. Dörner, Dr. H. K. Looe, Dr. N. Chofor (5.04.4242)
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Biomedical Physics
Teaching Methods/ semester periods per week:	Lecture: 2hrs/week; Seminar: 2hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	3 and 3
Prerequisites acc. syllabus:	
Recommended prerequisites:	
Aim/learning outcomes:	5.04.4242: Recent publications in the field of medical radiation physics are selected from peer-review journals and discussed on a weekly basis. The participants will get accustomed to comprehending and presenting key information from the publications in English. 5.04.4642: The course covers from the fundamental to the advanced topics of medical radiation physics. The participants will gain deep understanding on the underlying physics essential for the safe application of ionizing radiations in the medicine for therapeutic purposes.
Content:	5.04.4242: Current topics in medical radiation physics: Intensity modulated techniques, image-guided radiation therapy, radiation measurements, quality assurance etc. 5.04.4642: Interaction of charged and uncharged particles, properties of clinical radiation beams, detectors, cavity theory and dosimetry protocols, medical applications such as radiology and radiation therapy and radiation biology.
Assessment/type of examination:	Written examination: Between 90 and 180 minutes or Oral examination: Between 20 and 45 minutes

Literature:	The publications will be selected during the course. 5.04.4642: F. M. Khan: The Physics of Radiation Therapy. Lippincott Williams and Wilkins, Philadelphia, 2003; H. Krieger: Strahlungsmessung und Dosimetrie, Springer Verlag, Wiesbaden, 2013; H. Krieger, W. Petzhold: Strahlenphysik, Dosimetrie und Strahlenschutz, Band 1 und 2, Teubner, Stuttgart, 1997; IAEA,SyllabusonMedicalPhysics

4.2.2 Imaging and Data Analysis

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Module title:	Imaging and Data Analysis
Module code:	phy954
Course:	5.04.6444 Imaging and Data Analysis in Space Environment Research
Term:	Summer
Person in charge:	Prof. Dr. Poppe
Lecturer:	Prof. Dr. Poppe
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Biomedical Physics
Teaching Methods/ semester periods per week:	Lecture: 4 hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	3 and 3
Prerequisites acc. syllabus:	
Recommended prerequisites:	Knowledge from the courses Astrophysics I and II
Aim/learning outcomes:	The students learn to use modern astronomical instruments for observation (photographic) and spectroscopy, as well as to evaluate the obtained measurement data. They will gain insights into different areas of astrophysics and data processing and will be introduced to cutting-edge research areas. In addition, students learn how a consistent description of astrophysical processes emerges from observational data, theory, and modeling.
Content:	Preparation of observations in a seminar including selection of relevant objects, determination of observation techniques (e.g. high resolution photography or spectroscopy), execution of observations at C2PU ("Centre Pédagogique Planète et Univers, South of France") and evaluation of observations.
Assessment/type of examination:	Written examination: Between 90 and 180 minutes or Oral examination: Between 20 and 45 minutes
Literature:	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, BD Warner, Photometry and Lightcurve Analysis, Springer 2006.

4.2.3 Medizinische Strahlenphysik I

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Module title:	Medizinische Strahlenphysik
Module code:	phy955
Course:	5.04.4221 Grundkurs im Strahlenschutz & 5.04.4021 Bildgebende Verfahren
Term:	Summer
Person in charge:	Prof. Dr. B. Poppe
Lecturer:	Prof. Dr. B. Poppe
Language:	Deutsch
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Biomedical Physics
Teaching Methods/ semester periods per week:	2 Lecture: each 2hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	3 and 3
Prerequisites acc. syllabus:	
Recommended prerequisites:	Medizinische Strahlenphysik I
Aim/learning outcomes:	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.
Content:	5.04.4022 Spezialkurs Strahlenschutzseminar Strahlenschutz in der Tele- und Brachytherapie, Aufbau von Beschleunigern, Dosimetrie, Baulicher und Organisatorischer Strahlenschutz, StrSchG und StrSchV sowie zugehörige DIN Normen 5.04.4021 Bildgebende Verfahren Bildgebende Verfahren: Grundlagen der Bildgebenden Verfahren in der Medizin: CT, MRT, Ultraschall, Nuklearmedizin SPECT, PET sowie grundlegende Rekonstrukltionstechniken
Assessment/type of examination:	2 Written examinations: Between 45 and 90 minutes or Oral examinations: Between 10 and 20 minutes
Literature:	Grundkurs Strahlenschutz: Unterlagen werden zur Verfügung gestellt (Skript) Bildgebende Verfahren: werden in der VL bekannt gegeben.

4.2.4 Medizinische Strahlenphysik II

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Module title:	Medizinische Strahlenphysik
Module code:	phy959
Course:	5.04.4222 Spezialkurs Strahlenschutzseminar
Term:	Summer
Person in charge:	Prof. Dr. B. Poppe
Lecturer:	Prof. Dr. B. Poppe
Language:	Deutsch
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Biomedical Physics
Teaching Methods/ semester periods per week:	2 Lecture: each 2hrs/week
Workload:	Attendance: 58 hrs, Self study: 124 hrs
Credit points:	3 und 3
Prerequisites acc. syllabus:	
Recommended prerequisites:	Medizinische Strahlenphysik I
Aim/learning outcomes:	Die Studierenden werden die grundlegenden Kompetenzen eines Strahlenschutzbeauftragten kennen lernen. Dazu gehören neben den fachlichen Grundlagen im Strahlenschutz insbesondere die Kompetenz sich im deutschen Gesetz und Verwaltungssystem im Bereich des Strahlenschutzes zurecht zu finden.
Content:	Strahlenschutz in der Tele- und Brachytherapie, Aufbau von Beschleunigern, Dosimetrie, Baulicher und Organisatorischer Strahlenschutz, StrSchG und StrSchV sowie zugehörige DIN Normen
Assessment/type of examination:	Written examination: Between 90 and 180 minutes or Oral examination: Between 20 and 45 minutes
Literature:	StrSchG, StrSchV verschiedene DIN Normen

4.2.5 Advanced Computing

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Module title:	Advanced Computing
Module code:	phy964
Course:	???
Term:	Term:
Person in charge:	Prof. Dr. Martin Kühn, Prof. Dr. Simon Doclo
Lecturer:	
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Biomedical Physics Master Engineering Physics (Master); Schwerpunkt: Acoustics Master Engineering Physics (Master); Schwerpunkt: Renewable Energies
Teaching Methods/ semester periods per week:	Lecture: 2hrs/week; Exersise: 2hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Basic knowledge in computing, knowledge in undergraduate mathematics and physics
Aim/learning outcomes:	Learning of advanced programming concepts and their application in biomedical physics, acoustics, laser and optics, and renewable energies.
Content:	Advanced programming concepts for C, python and Matlab; Artificial Intelligence and Data Science; Visual Computing; Software Engineering
Assessment/type of examination:	written exam: max 180 minutes or oral exam: max 30 minutes
Literature:	

4.2.6 Advanced Topics in Biomedical Physics and Acoustics

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Module title:	Advanced Topics in Biomedical Physics and Acoustics
Module code:	phy686
Course:	This module offers special as well as advanced engineering courses in Biomedical Physics and Acoustics. The list of eligible courses will be updated each academic year. Please refer to the courses listed for this module in Stud.IP.
Term:	winter or summer
Person in charge:	Prof. Dr. B. Poppe and Prof. Dr. ir. Doclo
Lecturer:	Depending on selected courses
Language:	Depending on selected courses
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Acoustics Master Engineering Physics (Master); Schwerpunkt: Biomedical Physics
Teaching Methods/ semester periods per week:	Depending on selected courses
Workload:	Overall workload of 180 h
Credit points:	3 + 3 or 6
Prerequisites acc. syllabus	
Recommended prerequisites:	Depending on selected courses
Aim/learning outcomes:	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 specialization skills. The students acquire advanced knowledge and skills related to the specialization areas biomedical physics and acoustics.
Content:	Depending on selected courses
Assessment/type of examination:	Depending on selected courses, one or two examinations
Literature:	Depending on selected courses

5 Acoustics

5.1 Engineering Sciences

5.1.1 Digital Signal Processing

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Module title:	Digital Signal Processing
Module code:	phy605
Course:	Digital Signal Processing (SS, 5.04.4586)
Term:	Term: Summer
Person in charge:	Prof. Dr. Doclo
Lecturer:	Prof. Dr. Doclo
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Theoretical Methods Master Engineering Physics (Master); Schwerpunkt: Acoustics
Teaching Methods/ semester periods per week:	Lecture: 2hrs/week; Exersise: 2hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Basic knowledge about continuous-time signals and systems and statistics. In addition, Matlab programming skills are required.
Aim/learning outcomes:	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.
Content:	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.
Assessment/type of examination:	written exam (max. 3 hours) or 30 minutes oral exam

Literature:	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.

5.1.2 Machine Learning II

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Module title:	Machine Learning II
Module code:	phy694
Course:	Machine Learning II – Learning and inference methods (SS, 5.04.4215)
Term:	Summer
Person in charge:	Prof. Dr. Jörg Lücke
Lecturer:	Prof. Dr. Jörg Lücke
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Acoustics
Teaching Methods/ semester periods per week:	Lecture: 2hrs/week, Exercise: 2hrs/week (incl. prog. laboratory)
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Basic knowledge in higher Mathematics taught as part of first degrees in Physics, Mathematics, Statistics, Engineering or Computer Science (basic linear algebra and analysis) is required. Additionally, programming skills are required (Matlab or python).
Aim/learning outcomes:	The students will deepen their knowledge on mathematical models of data and sensory signals. Building upon 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 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.

Content:	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.
Assessment/type of examination:	written exam (max. 3 hours) or 30 minutes oral exam
Literature:	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)

5.1.3 Advanced Computing

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Module title:	Advanced Computing
Module code:	phy964
Course:	???
Term:	Term:
Person in charge:	Prof. Dr. Martin Kühn, Prof. Dr. Simon Doclo
Lecturer:	
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Biomedical Physics Master Engineering Physics (Master); Schwerpunkt: Acoustics Master Engineering Physics (Master); Schwerpunkt: Renewable Energies
Teaching Methods/ semester periods per week:	Lecture: 2hrs/week; Exersise: 2hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Basic knowledge in computing, knowledge in undergraduate mathematics and physics
Aim/learning outcomes:	Learning of advanced programming concepts and their application in biomedical physics, acoustics, laser and optics, and renewable energies.
Content:	Advanced programming concepts for C, python and Matlab; Artificial Intelligence and Data Science; Visual Computing; Software Engineering
Assessment/type of examination:	written exam: max 180 minutes or oral exam: max 30 minutes
Literature:	

5.1.4 Advanced Engineering Topics in Biomedical Physics and Acoustics

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Module title:	Advanced Engineering Topics in Biomedical Physics and Acoustics
Module code:	phy685
Course:	This module offers special as well as advanced engineering courses in Biomedical Physics and Acoustics. The list of eligible courses will be updated each academic year. Please refer to the courses listed for this module in Stud.IP.
Term:	winter or summer
Person in charge:	Prof. Dr. B. Poppe and Prof. Dr. ir. Doclo
Lecturer:	Depending on selected courses
Language:	Depending on selected courses
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Acoustics Master Engineering Physics (Master); Schwerpunkt: Biomedical Physics
Teaching Methods/ semester periods per week:	Depending on selected courses
Workload:	Overall workload of 180 h
Credit points:	3 + 3 or 6
Prerequisites acc. syllabus	
Recommended prerequisites:	Depending on selected courses
Aim/learning outcomes:	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. The students acquire advanced knowledge and skills related to the engineering areas biomedical physics and acoustics.
Content:	Depending on selected courses
Assessment/type of examination:	Depending on selected courses, one or two examinations
Literature:	Depending on selected courses

5.2 Specialization

5.2.1 Speech Processing

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Module title:	Speech Processing
Module code:	phy677
Course:	Speech Processing (SS, 5.04.4027)
Term:	Summer
Person in charge:	Prof. Dr. Doclo
Lecturer:	Dr. Bernd Meyer
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Acoustics
Teaching Methods/ semester periods per week:	Lecture: 2hrs/week; Exersise: 2hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Introductory signals and systems lecture
Aim/learning outcomes:	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.
Content:	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.
Assessment/type of examination:	written exam (max. 3 hours) or 30 minutes oral exam
Media:	
Literature:	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.

5.2.2 Advanced Topics Speech and Audio Processing

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Module title:	Advanced Topics Speech and Audio Processing
Module code:	Phy696
Course:	Advanced Topics Speech and Audio Processing (WS, 5.04.4586)
Term:	Winter
Person in charge:	Prof. Dr. ir. Doclo
Lecturer:	Prof. Dr. S. Doclo, Prof. Dr.-Ing. T. Gerkmann
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Acoustics
Teaching Methods/ semester periods per week:	Lecture: 2hrs/week, Exercise: 2hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Basic principles of discrete-time signal processing (preferably completed the course Digital Signal Processing). In addition, Matlab programming skills are required.
Aim/learning outcomes:	The students gain in-depth knowledge about speech and audio processing methods and systems. The students gain practical insights by implementing and evaluating these methods for specific speech and audio applications.
Content:	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).
Assessment/type of examination:	oral exam (30 minutes) or homework or practical report
Literature:	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, 2017.; S. Vaseghi: Advanced Digital Signal Processing and Noise Reduction, Wiley, 2006.; S. Haykin: Adaptive Filter Theory, Prentice Hall, 2013, E. Vincent, T. Virtanen, S. Gannot: Audio source separation and speech Enhancement, Wiley, 2018.

5.2.3 Acoustics

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Module title:	Acoustics
Module code:	phy679
Course:	Acoustics
Term:	Winter
Person in charge:	Prof. Dr. Steven van de Par
Lecturer:	Prof. Dr. Steven van de Par
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Acoustics
Teaching Methods/ semester periods per week:	Lecture: 3hrs/week, Exercise: 1hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Introductory acoustics lecture
Aim/learning outcomes:	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.
Content:	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.
Assessment/type of examination:	written exam (max. 3 hours) or 30 minutes oral exam or presentation or homework or practical report
Literature:	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.

5.2.4 Psychoacoustics

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Module title:	Psychoacoustics
Module code:	phy960
Course:	Applied Psychophysics / Auditory Scene Analysis in Speech and Music
Term:	
Person in charge:	Steven van de Par
Lecturer:	Steven van de Par
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Acoustics
Teaching Methods/ semester periods per week:	Lecture: 3hrs/week, Exercise: 1hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Introductory acoustics lecture
Aim/learning outcomes:	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).
Content:	**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
Assessment/type of examination:	one or two examination, totaling to 180 min. written exam or 30 min. oral exam
Literature:	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.

5.2.5 Advanced Topics in Biomedical Physics and Acoustics

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Module title:	Advanced Topics in Biomedical Physics and Acoustics
Module code:	phy686
Course:	This module offers special as well as advanced engineering courses in Biomedical Physics and Acoustics. The list of eligible courses will be updated each academic year. Please refer to the courses listed for this module in Stud.IP.
Term:	winter or summer
Person in charge:	Prof. Dr. B. Poppe and Prof. Dr. ir. Doclo
Lecturer:	Depending on selected courses
Language:	Depending on selected courses
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Acoustics Master Engineering Physics (Master); Schwerpunkt: Biomedical Physics
Teaching Methods/ semester periods per week:	Depending on selected courses
Workload:	Overall workload of 180 h
Credit points:	3 + 3 or 6
Prerequisites acc. syllabus	
Recommended prerequisites:	Depending on selected courses
Aim/learning outcomes:	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 specialization skills. The students acquire advanced knowledge and skills related to the specialization areas biomedical physics and acoustics.
Content:	Depending on selected courses
Assessment/type of examination:	Depending on selected courses, one or two examinations
Literature:	Depending on selected courses

6 Laser and Optics

6.1 Engineering Sciences

6.1.1 Spectrophysics

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Module title:	Spectrophysics
Module code:	Phy632
Course:	Applied Photonics I / Spectrophysics (WS, 5.04.4661)
Term:	Winter
Person in charge:	Prof. Dr. Neu
Lecturer:	Prof. Dr. Walter Neu
Language:	German or English depending on demand
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master) ¿ Schwerpunkt: Laser and Optics
Teaching Methods/ semester periods per week:	Lecture: 3 hrs/week,Laboratory: 1 hrs/week
Workload:	Attendance: 28 hrs, Self study: 62 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Atomic and Molecular Physics, Optical systems
Aim/learning outcomes:	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.
Content:	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
Assessment/type of examination:	max. 2hr written examination or max 1h oral examination or experimental work and laboratory reports or presentation or homework

Literature:	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 topics

6.1.2 Photonics

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Module title:	Photonics
Module code:	phy600
Course:	Photonics (WS, 5.04.4668)
Term:	Winter
Person in charge:	Prof. Dr. U. Teubner
Lecturer:	Prof. Dr. U. Teubner
Language:	German or English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Advanced Physics
Teaching Methods/ semester periods per week:	Lecture: 4 hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Basic knowledge on optics, electrodynamics and atomic physics
Aim/learning outcomes:	Starting from basics, the module yields advanced knowledge of the physics of lasers, laser beams, different laser types, modulators and of interaction of optical radiation with matter The second part of the course is related to imaging sensors and sensor systems which is of major importance everywhere in science and engineering. This course provides substantial background of the relevant physics and engineering methods. In the extended laboratory part, using modern imaging systems such as scientific and professional cameras, students get experience.
Content:	Fundamentals of lasers (optical gain, optical resonator, laser beams), laser types, laser safety; modern image sensors (CCD,CMOS, scientific sensors such as backside illuminated ones, XUV-detectors, MCP, etc.) are treated in detail, dynamic range and noise, optical imaging systems, basics of image processing.
Assessment/type of examination:	2 hr written examination or 30 min oral examination or experimental work or homework or presentation
Literature:	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; U. Teubner, H.J. Bruckner: Optical Imaging and Photography (DeGruyter, Berlin); Further literature: Nakamura: Image Sensors and Signal Processing for Digital Still Camera (CRC Taylor and Francis) Original literature according indication during course

6.1.3 Medical Optics

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Module title:	Medical Optics
Module code:	phy608
Course:	Medical Optics (WS, 5.04.663)
Term:	Winter
Person in charge:	Prof. Dr. Neu
Lecturer:	Prof. Dr. Neu
Language:	German (English)
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Laser and Optics
Teaching Methods/ semester periods per week:	Lecture / 4 hrs/week
Workload:	Attendance:56 hours, Self study: 124 hours
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Medizin for Scientist , Optics, Laser Physics
Aim/learning outcomes:	To provide advanced knowledge in the field of medical optics and optical technologies in medicine as well as their theoretical background and experimental methods. Students will be scientifically competent positioned to critically follow current developments and initiate the design (development and design) of innovative optical applications in medicine.
Content:	Physiology and psychophysics of vision, theory of imaging systems, ophthalmic optics, lighting technology, photometry, vision in the workplace and in traffic, optical measurements on patients, diagnostic and therapeutic laser applications, radiation protection (infrared, UV, laser), microscopy, diffraction and subdiffraction limited methods, optical spectroscopy, fluorescence methods.
Assessment/type of examination:	max. 2hr written examination or max 1h oral examination or experimental work and laboratory reports or presentation or homework
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 Körper 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

6.1.4 Laser Material Processing

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Module title:	Laser Material Processing
Module code:	Phy638
Course:	Laser Material Processing (WS, 5.04.4669)
Term:	Winter
Person in charge:	Prof. Dr. Neu and Prof. Dr.-Ing. Schüning
Lecturer:	Dr.-Ing. Thomas Schüning
Language:	English
Location	Emden
Curriculum allocation:	Master Engineering Physics, Laser and Optics
Teaching Methods/ semester periods per week:	Lecture: 4 hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Knowledge in physics, optics, production engineering
Aim/learning outcomes:	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
Content:	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 favourable working parameters; The participants should be able to understand the procedures of the material processing with laser beams and evaluate the tasks of manufacturing
Assessment/type of examination:	Internship report between 15 and 30 pages or formal presentation between 10 and 20 pages report and between 15 and 30 minutes presentation or oral examination between 20 and 45 minutes
Literature:	Script;H. Hügel: Strahlwerkzeug Laser, Teubner Studienbücher; Materialbearbeitung mit dem Laserstrahl im Geräte- und Maschinenbau, VDI-Verlag; Hügel, Helmut: Laser in der Fertigung, Vieweg + Teubner Verlag

6.1.5 Advanced Engineering Topics in Laser and Optics

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Module title:	Advanced Engineering Topics in Laser and Optics
Module code:	phy682
Course:	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.
Term:	winter or summer
Person in charge:	Prof. Dr. W. Neu
Lecturer:	Related to selected course/s
Language:	Related to selected course/s
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Laser and Optics
Teaching Methods/ semester periods per week:	Related to selected course/s
Workload:	Overall workload of 180 h
Credit points:	3 + 3 or 6
Prerequisites acc. syllabus	
Recommended prerequisites:	Related to selected course/s
Aim/learning outcomes:	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.
Content:	Photonics, Optics, Metrology
Assessment/type of examination:	Related to selected course/s
Literature:	Related to selected course/s

6.2 Specialization

6.2.1 Laser Design and Beam Guiding

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Module title:	Laser Design and Beam Guiding
Module code:	Phy637
Course:	Laser Design and Beam Guiding (SS, 5.04.4664)
Term:	Summer
Person in charge:	Prof. Dr. W. Neu
Lecturer:	Prof. Dr. W. Neu
Language:	English
Location	Oldenburg / Emden
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Laser and Optics
Teaching Methods/ semester periods per week:	Lecture: 4 hrs/week , practical applications included in lecture
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	basic knowledge on optics and laser physics
Aim/learning outcomes:	students acquire advanced knowledge for the design of lasers and laser systems, they also understand the propagation of laser beams and their forming.
Content:	design of different laser types; physics of active and passive laser components; beams and resonators; lab work
Assessment/type of examination:	2 hr written examination or 30 min oral examination or presentation (20 minutes) or homework (20 pages)
Literature:	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, VDE-Verlag, Berlin; Additional literature given in the lecture

6.2.2 Biophotonics and Spectroscopy

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Module title:	Biophotonics and Spectroscopy
Module code:	phy634
Course:	Biophotonics and Spectroscopy (SS, 5.04.4667)
Term:	Winter or Summer
Person in charge:	Prof. Dr. W. Neu
Lecturer:	W. Neu, M. Schellenberg, S. Koch
Language:	German or English depending on demand
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Laser and Optics
Teaching Methods/ semester periods per week:	Lecture: 2 hrs/week, Seminar: 2hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Basics in optics and laser physics, in particular, fundamentals of optics and photonics; atomic and molecular physics; spectrophysics
Aim/learning outcomes:	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.
Content:	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 4. Demonstrate analytical application of these atomic and molecular absorption and emission techniques 5. Discriminate the analytical challenges that can be appropriately solved by these spectroscopic techniques
Assessment/type of examination:	max. 2hr written examination or max 1h oral examination or experimental work and laboratory reports or presentation or homework

Literature:	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

6.2.3 Engineering Scientific Instrumentaion

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Module title:	Engineering Scientific Instrumentaion
Module code:	phy965
Course:	
Term:	Winter
Person in charge:	Prof. Philipp Huke
Lecturer:	Prof. Philipp Huke
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Laser and Optics
Teaching Methods/ semester periods per week:	Lecture: 3 hrs/week first, 2 hrs/week second half of semester; Seminar: 1 hrs/week first 2 hrs/week second half of the semester
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	• Basic tools in physics and engineering • Knowledge about current research areas • Basics in optics and spectroscopy • Advanced Metrology
Aim/learning outcomes:	Understanding the evolution of a scientific experiment from scratch to conduction. Understanding the physics / capabilities of an instrument. Learning tools for the development of a scientific instrument with an engineering and science team.
Content:	Relevant scientific questions often require large scientific facilities like CERN or the ELT to conduct their experiment. The evolution of a scientific 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 specification from a scientific question b. Translate these specifications to engineering c. Develop first simulations of the experiment d. Develop the physical design of an instrument including d.1. Trade-off 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
Assessment/type of examination:	Internship report: Between 15 and 30 pages or Written examination: 120 minutes
Literature:	White/Blue books of Instruments

6.2.4 Intense Light Physics

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Module title:	Intense Light Physics
Module code:	Phy966
Course:	
Term:	Summer
Person in charge:	Prof. Dr. U. Teubner
Lecturer:	Prof. Dr. U. Teubner
Language:	English
Location	Emden
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Laser and Optics
Teaching Methods/ semester periods per week:	Lecture: 4 hrs/week , practical applications included in lecture
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Basics in optics and laser physics, in particular, Fundamentals of Optics and Photonics; Atomic Physics, Electrodynamics
Aim/learning outcomes:	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.
Content:	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-α -sources and keV and MeV electron and ion sources and their application to micro fabrication micro and nano analysis.; atto physics, strong field physics
Assessment/type of examination:	experimental work and laboratory reports or max. 2hr written examination or max 1h oral
Literature:	

6.2.5 Advanced Topics in Laser and Optics

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Module title:	Advanced Topics in Laser and Optics
Module code:	phy683
Course:	This module offers special as well as advanced 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.
Term:	winter or summer
Person in charge:	Prof. Dr. W. Neu
Lecturer:	Related to selected course/s
Language:	Related to selected course/s
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Laser and Optics
Teaching Methods/ semester periods per week:	Related to selected course/s
Workload:	Overall workload of 180 h
Credit points:	3 + 3 or 6
Prerequisites acc. syllabus	
Recommended prerequisites:	Related to selected course/s
Aim/learning outcomes:	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.
Content:	Photonics, Optics, Metrology,
Assessment/type of examination:	Related to selected course/s
Literature:	Related to selected course/s

7 Renewable Energies

7.1 Engineering Sciences

7.1.1 Energy Ressource and Systems

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Module title:	Energy Ressource and Systems
Module code:	phy641
Course:	Energy Meteorology (WS, 5.06.021) and Energy Systems (WS, 5.06.022)
Term:	Winter
Person in charge:	Dr. D. Heinemann
Lecturer:	Dr. D. Heinemann
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Renewable Energies Master European Master in Renewable Energy (Master); Mastermodule Master Sustainable Renewable Energy Technologies (SuRE) (Master); Mastermodule
Teaching Methods/ semester periods per week:	each Lecture: 2hrs/week
Workload:	Attendance: 56 hrs, Self-study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus	
Recommended prerequisites:	
Aim/learning outcomes:	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.

Content:	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
Assessment/type of examination:	Written examination: max 180 minutes

Literature:	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/)

7.1.2 Solar Energy

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Module title:	Solar Energy
Module code:	pre022
Course:	Photovoltaics (WS 5.06.035) and Fuel Cells and Energy Storage (WS, 5.06.036)
Term:	Winter
Person in charge:	H. Torio
Lecturer:	H. Torio, M. Knipper, C. Agert
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Renewable Energies Master Sustainable Renewable Energy Technologies (SuRE) (Master); Mastermodule
Teaching Methods/ semester periods per week:	each lecture: 2 hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	
Aim/learning outcomes:	After successful completion of the module students should be able to: critically evaluate and compare relevant Renewable Energy conversion processes and technologies: photovoltaics, fuel cells and storage critically appraise various electrochemical storage processes and the respective storage techniques analyse various system components and their interconnections within a complex Renewable Energy supply system.

Content:	This module will give an overview over a selection of the major renewable energy technologies and some possibilities of their storage. The focus is on the scientific principles of components and the technical description of the components. Further detailed system analysis will be presented in other modules. Physics of PV: - Basic and most important properties of solar radiation related to photovoltaics - PV cells basics: Fundamental physical processes in photovoltaic materials - Characterisation and basic modelling of solar cells Component Description: - PV generator - Charge controller - Inverter - Balance of system components System Description - Grid Connected System - Stand Alone System Solar Thermal Energy (Seminar and Exercises: 90 h workload) - Assessment of solar thermal ambient parameters: regional global, diffuse, reflected solar radiation on horizontal and on tilted plane, ambient temperature - Solar thermal system components: collectors; heat exchangers; thermal storage; thermally driven compression chillers - Solar cooling systems and components - Characterization of solar thermal systems, their operation and performance - F-Chart and Utilizability methods as main methods for assessing system performance
Assessment/type of examination:	Written exam, 2 times 1 hour related to the specific fields of renewable energy within the module

Literature:

Photovoltaics

- 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 and Richard Corkish (Edit.), 2007: Applied Photovoltaics, Earthscan Publications Ltd.,
- Twidell, John and Weir, Toni, 2005: Renewable Energy Resources Taylor and Francis.

Fuel Cells and Energy Storage

- Larminie/Dicks: Fuel Cells Systems Explained, 2000, (Wiley, 2000, ISBN 0-471-49026-1),
- EG and G Services, Parsons Inc.: Fuel Cell Handbook, (DE-AM26-99FT40575, 7th Edition, 2005; `www.fuelcells.org/fchandbook.pdf`),
- G. Hoogers (Ed.): Fuel Cell Technology Handbook, (CRC Press, Boca Raton/London, 2003, ISBN 0-8493-0877-1),
- C.-J. Winter/J. Nitsch: Hydrogen as an Energy Carrier (Springer-Verlag, Heidelberg/N.Y., 1985, ISBN 0-387-18896-7/3-540-18896-7),
- O'Hayre/Cha/Colella/Prinz: Fuel Cell Fundamentals, (Wiley, 2009, 2nd ed., IBSN 978-0-470-25843-9),
- C.H. Hamann, A. Hammett, W. Vielstich, Electrochemistry, 2nd Ed. Wiley, Weinheim 2007,
- D. Pletcher, A First Course in Electrode Processes. The Electrochemical Consultancy, 1991,
- A.J. Bard, L.R. Faulkner, Electrochemical Methods, Fundamentals and Applications. 2. Ed., Wiley, 2001,
- M. Winter, R.J. Brodd; What are Batteries, Fuel Cells and Supercapacitors? in Chem. Rev. 2004, Vol. 104, pp. 4245-4269,
- A.J. Bard, G. Inzelt, F. Scholz (Eds.) Electrochemical Dictionary. 2. Aufl. Springer, Berlin 2012 (Available as an eBook, very good explanation in English), Page 7 of 39,
- Fischer, W. (1996). Stationary lead-acid batteries - an introductory handbook. Brilon, Germany: Hoppecke.

7.1.3 Water and Biomass Energy

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Module title:	Water and Biomass Energy
Module code:	pre042
Course:	Biomass Energy (WS, 5.06.M313) and Solar Thermal (WS, 5.06.M311)
Term:	Winter
Person in charge:	H. Torio
Lecturer:	Prof. Dr. Michael Wark, Dr. Herena Torio
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Renewable Energies Master Sustainable Renewable Energy Technologies (SuRE) (Master); Mastermodule
Teaching Methods/ semester periods per week:	Lecture: 2 hrs/week and Seminar: 2 hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	
Aim/learning outcomes:	After successful completion of the module students should be able to: - critically evaluate and compare major Renewable Energy conversion processes and technologies in solar thermal energy and biomass energy, - analyze various system components and their interconnections within a complex Renewable Energy supply system, - evaluate the Renewable Energy supply systems' operational size and efficiency, - critically evaluate non-technical impact and side effects when implementing renewable energy supply systems.

Content:	Biomass Energy (Lecture – 90 h workload) - Energy mix overview; gas, heat, electricity, Pros and Cons of biomass, - Chemical composition of biomass: sugar, cellulose, starch, fats. Oils, proteins, lignin, - Natural photosynthesis in plants: chemical storage of solar energy; general mechanisms, - Chemistry and Biology (microorganism) of Biogas Technology, - Conversion processes of biomass: classification, main pathways, - Introduction to catalysis used in biomass conversion, - Chemical fuels (chemical energy storage) from biomass, routes to platform chemicals and separation processes, - Technology concepts for bioenergy usage, - Introduction into economical and legal constraints. Hydro and Marine Power (Lecture + Excursion - 90 h workload) – Revision of hydraulic basics and their application to hydro and marine power – Hydropower and marine power resources and their representation – Technological and economical state of the art - Description of such systems' components, their characteristics, their interaction in a system, their main features and their challenges
Assessment/type of examination:	1 formal presentation between 5 and 10 pages report and between 10 and 15 minutes presentation and one written exam of 1 hour. Assessments related to the specific fields of renewable energy within the module

Literature:

Biomass Energy

- R. Schlögl (Ed.), Chemical Energy Storage, De Gruyter, 2013, ISBN: 978-3-11-026407-4, Chapter 2, Pages 59-133,
- D.L. Klass. Biomass for renewable energy, fuels, and chemicals, Chapter 4 Virgin Biomass Production, p. 91ff,
- Food and Agriculture Organization of the UN (FAO) http://www.fao.org,
- IEA Energy Technology Essentials - Biomass for Power Generation and CHP. http://www.iea.org/techno/essentials3.pdf,
- R.A. Houghton, Forest Hall, and Scott J. Goetz. Importance of biomass in the global carbon cycle J. Geophys.Res., 114, 2009,
- Schlögl, Robert (2013). Chemical energy storage (Elektronische Ressource] ed.). Berlin [u.a.]: De Gruyter.,
- Twidell and Weir. Renewable Energy Resources, Chapter 10, http://www.4shared.com/document/HpYwRDPy/Renewable_Energy_Resources_2nd.html,
- Wheildon‘s 2013, http://www.wheildons.co.uk/wp-content/uploads/2013/07/carbon-neutral.jpg,
- Waste-to-Energy Research and Technology Council (WtERT), 2009, http://www.wtert.eu/default.asp?Menue=13&ShowDok=12#Hydrolysis,

Hydro and Marine Power

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

7.1.4 Wind Energy Physics, Data and Analysis

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Module title:	Wind Energy Physics, Data and Analysis
Module code:	phy644
Course:	Wind Energy Physics (WS,5.04.4061) and Wind Physics Measurements Project (SS, 5.04.4234)
Term:	Winter Winter and Summer
Person in charge:	Prof. Dr. M. Kühn
Lecturer:	Prof. Dr. Martin Kühn, Dr. Detlev Heinemann, Dr. Matthias Wächter, Dipl.-Phys., Prof. Dr. Joachim Peinke
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Renewable Energies
Teaching Methods/ semester periods per week:	attendance: 2*28 hrs, self-study: 124 hrs
Workload:	6
Credit points:	
Prerequisites acc. syllabus:	The module starts in the winter term: Wind Energy Phyics has to be taken before participating in Wind Physics Measurement Project
Recommended prerequisites:	
Aim/learning outcomes:	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
Content:	The winter term lecture 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, (pi-theorem), 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)

Assessment/type of examination:	Portfolio
Literature:	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

7.1.5 Computational Fluid Dynamics

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Module title:	Computational Fluid Dynamics
Module code:	phy616
Course:	Computational Fluid Dynamics I and II, (SS, 5.04.4072 and 5.04.4075)
Term:	Summer
Person in charge:	Prof. Dr. L. Lukassen,
Lecturer:	Prof. Dr. L. Lukassen, Prof. Dr. J. Peinke , Dr. B. Stoevesandt
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Renewable Energies Master Engineering Physics (Master); European Wind Energy Master Master Sustainable Renewable Energy Technologies (SuRE) (Master)
Teaching Methods/ semester periods per week:	Lecture: 2hrs/week, Excersise: 2hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	Fluid Dynamics I
Recommended prerequisites:	
Aim/learning outcomes:	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.
Content:	**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.
Assessment/type of examination:	Written examination: Between 90 and 180 minutes or Oral examination: Between 20 and 45 minutes or 1 Term paper: Between 15 and 30 pages

Literature:	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)

7.1.6 Advanced Computing

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Module title:	Advanced Computing
Module code:	phy964
Course:	???
Term:	Term:
Person in charge:	Prof. Dr. Martin Kühn, Prof. Dr. Simon Doclo
Lecturer:	
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Biomedical Physics Master Engineering Physics (Master); Schwerpunkt: Acoustics Master Engineering Physics (Master); Schwerpunkt: Renewable Energies
Teaching Methods/ semester periods per week:	Lecture: 2hrs/week; Exersise: 2hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Basic knowledge in computing, knowledge in undergraduate mathematics and physics
Aim/learning outcomes:	Learning of advanced programming concepts and their application in biomedical physics, acoustics, laser and optics, and renewable energies.
Content:	Advanced programming concepts for C, python and Matlab; Artificial Intelligence and Data Science; Visual Computing; Software Engineering
Assessment/type of examination:	written exam: max 180 minutes or oral exam: max 30 minutes
Literature:	

7.1.7 Advanced Engineering Topics in Renewable Energies

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Module title:	Advanced Engineering Topics in Renewable Energies
Module code:	phy687
Course:	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.
Term:	winter or summer
Person in charge:	Prof. Dr. Martin Kühn
Lecturer:	Related to selected course/s
Language:	Related to selected course/s
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Renewable Energies
Teaching Methods/ semester periods per week:	Related to selected course/s
Workload:	Overall workload of 180 h
Credit points:	3 + 3 or 6
Prerequisites acc. syllabus	
Recommended prerequisites:	Related to selected course/s
Aim/learning outcomes:	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.
Content:	E.g. metrology, data logging, measurement methodology, construction, monitoring, control engineering, remote sensing.
Assessment/type of examination:	Related to selected course/s
Literature:	Related to selected course/s

7.2 Specialization

7.2.1 Photovoltaic Physics

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Module title:	Photovoltaic Physics
Module code:	phy609
Course:	Photovoltaic Physics (SS, 5.04.4063)
Term:	Summer
Person in charge:	Prof. Dr. M. Kühn
Lecturer:	Dr. Michael Richter, Dr. Levent Gütay
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Renewable Energies Master Sustainable Renewable Energy Technologies (SuRE) (Master); Mastermodule
Teaching Methods/ semester periods per week:	Lecture: 4 hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	Solid-state-Pysics, semi-conductor Physics, Module Renewable Energy Technologies I
Aim/learning outcomes:	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
Content:	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
Assessment/type of examination:	written exam between 90 and 180 minutes or presentation between 20 and 45 minutes or oral exam between 20 and 45 minutes or homework between 15 and 30 pages or internship report between 15 and 30 pages

Literature:	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

7.2.2 Wind Physics Student's Lab

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Module title:	Wind Physics Student's Lab
Module code:	phy646
Course:	Wind Physics Student's Lab; Currently two different seminars: • Dynamics and control of grid-connected wind turbines (WS, 5.04.4238) • Wind turbine rotor in turbulent inflow (WS, 5.04.4239)
Term:	Winter and Summer
Person in charge:	Prof. Dr. Kühn
Lecturer:	Andreas Schmidt
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Renewable Energies
Teaching Methods/ semester periods per week:	Seminar with laboratory experiments for research-based learning / Seminar mit Blockpraktikum zum forschungsbasierten Lernen: 4 hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	Wind Energy Utilization (BA) or equivalent course, Design of Wind Energy Systems: in SAME SEMESTER or before
Recommended 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. Prerequisites for "Dynamics and control of grid-connected wind turbines": Function of lift-driven wind energy converters; description of rotor behavior by means of dimensionless parameters, basics of electrotechnics. Prerequisites for "Wind turbine rotor in turbulent inflow": Basics of stochastics.
Aim/learning outcomes:	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 different versions. These versions represent the work of different research groups at ForWind – University Oldenburg. The seminars will be offered in subsequent semesters or in parallel.

Content:

The seminar “Dynamics and control of grid-connected wind turbines“ is related to the work of the research group Wind Energy Systems (WESys). It intends to give a deeper insight into two fields of wind engineering: One is the grid connection and interaction of wind turbines and the other is their operational control as special case in the field of control engineering. The seminar uses an experimental system which allows to investigate control tasks and interaction mechanisms of the functional chain of wind field, rotor, drive train, generator, transformer and electric grid. The seminar consists of three main phases:

1st phase: Preparational learning

• building up basic competences
• identification of the technical tasks
• introduction to current research
• introduction to the experiment
• investigating standard situations, physical effects and functional principles by means of the experimental system

2nd phase: Research-based learning

• defining own research questions
• defining an experimental strategy
• planning the experiment
• 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 to measure wind flows in high resolutions and how turbulence can be described, investigated and evaluated for different purposes. The students gain a deep understanding of the phenomenon of turbulence. They perform own experiments in a wind tunnel with an active turbulence grid. They learn to establish their own research questions and are encouraged to develop own methods.

The seminar consists of three main phases:

1st phase: Preparational learning

• building up basic competences
• introduction to current research
• practical measurements of flows with different sensors in the wind tunnel
• evaluation methods of data of turbulent wind flows

2nd phase: Research-based learning

• defining own research questions
• defining an experimental strategy
• planning the experiment
• set-up, execution, data acquisition and decommissioning of experiments

3rd phase: Evaluation and documentation

Assessment/type of examination:	Portfolio
Literature:	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. 6th Ed., 2016, Springer-Verlag; ISBN: 978-3-662-53154-9

7.2.3 Future Power Supply Systems

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Module title:	Future Power Supply Systems
Module code:	phy647
Course:	Future Power Supply Systems (SS, 5.06.306)
Term:	Summer
Person in charge:	Prof. Dr. Carsten Aggert
Lecturer:	Prof. Dr. Carsten Aggert
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Renewable Energies Master Sustainable Renewable Energy Technologies (SuRE) (Master); Mastermodule
Teaching Methods/ semester periods per week:	Lecture and Seminar: 4 hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	Renewable Energy Technologies I
Recommended prerequisites:	Knowledge from module RE technology I, Mathematics
Aim/learning outcomes:	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 micro-grids - 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

Content:	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-to-gas (e.g. methane) and power-to-liquids (e.g.methanol)
Assessment/type of examination:	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.
Literature:	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

7.2.4 Wind Resources and its Applications

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Module title:	Wind Resources and its Applications
Module code:	phy648
Course:	Wind Resources and its Applications (SS, Advanced Wind Energy Meteorology, 5.04.4063 and SS, Wind Energy Application, 5.06.205)
Term:	Summer
Person in charge:	Prof. Dr. M. Kühn
Lecturer:	Dr. Igor Waldl, Dr. Gerald Steinfeld
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Renewable Energies Master Sustainable Renewable Energy Technologies (SuRE) (Master); Mastermodule
Teaching Methods/ semester periods per week:	Lecture: 4 hrs/week
Workload:	Attendance: 72 hrs, Self study: 108 hrs
Credit points:	6
Prerequisites acc. syllabus:	Energy Meteorology
Recommended prerequisites:	Knowledge in Basics Wind Energy, Fluid Dynamics I, Matlab,
Aim/learning outcomes:	assess different aspects of wind energy farms by modelling, comparison, explanation of wind energy potential, wind energy farm's output, power curves, wind energy project development, assess in detail influences of meteorological/ climatological aspects on the performance of wind power systems, 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.

Content:	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 Risø Models Spacing and efficiency 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
Assessment/type of examination:	1 Written examination: 120 minutes or Oral examination: Between 30 and 45 minutes or Internship report: Between 15 and 20 pages in one lecture and regular active participation in the other lecture

Literature: 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

7.2.5 Design of Wind Energy Systems

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Module title:	Design of Wind Energy Systems
Module code:	phy649
Course:	Design of Wind Energy Systems (SS, 5.04.4235)
Term:	Winter
Person in charge:	Prof. Dr. M. Kühn
Lecturer:	Prof. Dr. Martin Kühn, Dr. Vlaho Petrovic
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Renewable Energies Master Sustainable Renewable Energy Technologies (SuRE) (Master); Mastermodule
Teaching Methods/ semester periods per week:	Lecture and seminar: 2 and 2 hrs/week
Workload:	Attendance: 56 hrs, Self study: 108 hrs
Credit points:	6
Prerequisites acc. syllabus:	Wind Energy Utilization (Bachelor) or Wind Energy Physics (Master) or Basics of Wind Energy (Master SURE)
Recommended prerequisites:	Basics in Wind Energy Utilisation
Aim/learning outcomes:	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 specific design situations for wind turbines, - estimate the influence of dynamics of a wind turbine, especially in the context of fatigue loads, - transfer their knowledge to more complex topics such as simulation and measurements of dynamic loads, - calculate the economic aspects of wind turbine

Content:	This lecture and seminar on wind turbine design spans from the wind to the wind turbine and its components as well as from the physics, to engineering and techno-economical as well as organisational aspects. Lecture content: - introduction to wind turbine design, - introduction to aeroelastic simulations, - blade element momentum theory (BEM), - rotor design, - wind turbine control, - dynamic loading and structural dynamics, - measurements of performance and dynamic loads, - wind field modelling, - wake effects in wind turbine design, - offshore environmental conditions, - design load cases and certification, - fatigue loads, - component design, - offshore loads In the seminar part each student group performs analytical assignments and aero-elastic calculations on their own wind turbine design.
Assessment/type of examination:	Internship report: Between 15 and 30 pages
Literature:	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

7.2.6 Smart Grid Management

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Module title:	Smart Grid Management
Module code:	inf511
Course:	Smart Grid Management (SS, 2.01.511)
Term:	Summer
Person in charge:	Prof. Dr. Sebastian Lehnhoff
Lecturer:	Prof. Dr. Sebastian Lehnhoff
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Renewable Energies Master Informatik (Master); Angewandte Informatik Master Sustainable Renewable Energy Technologies (SuRE) (Master); Mastermodule Master Umweltmodellierung (Master); Mastermodule Master Wirtschaftsinformatik (Master); Akzentsetzungsmodule der Informatik
Teaching Methods/ semester periods per week:	Lecture / excercise: 3 and 1 hrs/week
Workload:	Attendance: 72 hrs,Self study: 108 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	physics, digital information processing

Aim/learning outcomes:	After successful completion of the course the students should be able to understand the existing structures and technical basis of energy systems to produce, transfer and distribute electricity and their interaction and dependency on each other. They should have developed an understanding for necessary IT- and process control technology components, methods and processes to control and operate electrical energy systems. The students are able to estimate and evaluate the requirements and challenges of ICT and computer science which are caused by the development and integration of unforeseeable fluctuations of decentralised plants. The students will be able to estimate the influence of distributed control concepts and algorithms for decentralised plants and consumers in the so called Smart Grid energy systems. Regarding the requirements the students will be able to analyse the safety, reliability, realtime capability and flexibility of Smart Grid energy systems. **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 mathematical methods of network calculation **Social competencies** The students: • create solutions in small teams • discuss their solutions **Self-competence** The students: • reflect their own use of electricity as a limited resource

Content:	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)
Assessment/type of examination:	Written examination: Between 90 and 180 minutes or Oral examination: Between 20 and 45 minutes
Literature:	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

7.2.7 Solar Energy Meteorology

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Module title:	Solar Energy Meteorology
Module code:	Pre114
Course:	5.04.4064 and 5.06.M211
Term:	
Person in charge:	Torio, Herena Holtorf, Hans-Gerhard
Lecturer:	Torio, Herena Holtorf, Hans-Gerhard Schmidt, Thomas
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Renewable Energies Master Sustainable Renewable Energy Technologies (SuRE) (Master); Mastermodule
Teaching Methods/ semester periods per week:	Lecture: 2hrs/week Seminar: 2hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	3 and 3
Prerequisites acc. syllabus:	
Recommended prerequisites:	Successful participation in "Energy Meteorology 5.06.M117"
Aim/learning outcomes:	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)

Content:	This specialization module covers more in-depth topics concerning solar energy meteorology. Based on students' knowledge about the solar resource, solar thermal and photovoltaic technology, students deepen their knowledge on the resource for such systems. I. Adv. Solar Energy Meteorology (Lecture - 90 h workload) - Physics of radiative processes in the atmosphere - Physical modelling of atmospheric radiative transfer (incl. computing tools) - Solar irradiance modelling for solar energy applications - Solar spectral irradiance: Theory and relevance for solar energy systems - Satellite-based estimation of solar irradiance - Solar irradiance (and solar power) forecasting - Solar radiation measurements: Basics and setup of high quality measurement system II. Solar Energy Meteorology Applications (Lecture and Seminar – 90h workload) - sources of solar data and discussion of their quality - solar resource assessment: o basic models, o measurements, o satellite models o data sets - validation and application of solar resource data sets - forecasting of solar radiation: sky-camera forecasts, satellite-based forecasts, numerical weather predictions, statistical methods - forecast validation - selected applications - irradiance and PV power forecasting - application of solar resource data for yield assessment
Assessment/type of examination:	1 Written examination: 90 to 180 minutes and regular active participation
Media:	
Literature:	- S. Hegedus, A. Luque, Handbook of Photovoltaic Science and Engineering, published John Wiley and Sons (2nd Edition 2011) - MSG Cloud Physical Properties (CPP) by KNMI `http://msgcpp.knmi.nl/mediawiki/index.php/MSG_Cloud_Physical_Properties_(CPP)` - 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/`

7.2.8 Photovoltaic Systems

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Module title:	Photovoltaic Systems
Module code:	Pre113
Course:	5.06.M207 and 5.06.M209
Term:	Winter
Person in charge:	Torio, Herena Holtorf, Hans-Gerhard
Lecturer:	Torio, Herena Holtorf, Hans-Gerhard Knipper, Martin
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Renewable Energies Master Sustainable Renewable Energy Technologies (SuRE) (Master); Mastermodule
Teaching Methods/ semester periods per week:	Lecture: 2hrs/week Seminar: 2hrs/week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	3 and 3
Recommended prerequisites:	
Aim/learning outcomes:	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)

Content:	This specialization module covers more in-depth topics concerning photovoltaics systems. The module consists of: Photovoltaic Systems Lecture (90h workload) Description and operation of PV System's balance of system components o inverter, o charge controllers o cabling o generator stand o storage battery with a focus on housing (ventilation) Quality indicators for PV Systems and their regional differences o PV on-grid, o PV off-grid / stand alone, o PV-pumping, o PV-hybrid Sizing of PV systems – back of the envelope approach as well as by a simulation software Photovoltaic Systems Seminar (90h workload) Within the seminar groups of up to five students select a PV system related research question, work on the solution and present their findings. In addition, external PV experts are invited to present from their work experience. An excursion to a PV power plant concludes the lessons learned in the field.
Assessment/type of examination:	; Presentation: Between 20 and 45 minutes and regular active participation
Media:	
Literature:	- 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

7.2.9 Control of Wind Turbines and Wind Farms

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Module title:	Specialization
Module code:	phy987
Course:	Control of Wind Turbines and Wind Farms
Term:	Summer
Person in charge:	Prof. Dr. M. Kühn
Lecturer:	Dr. Vlaho Petrović
Language:	English
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Renewable Energies Master Sustainable Renewable Energy Technologies (SuRE) (Master); Mastermodule
Teaching Methods/ semester periods per week:	Lectures and exercises: 4 hours per week and home assignments
Workload:	Attendance: 72 hrs, Self study: 108 hrs
Credit points:	6
Prerequisites acc. syllabus:	Wind Energy Utilization (Bachelor) or Wind Energy Physics (Master) or Basics of Wind Energy (Master SURE) and Design of Wind Energy Systems (can be attended in parallel)
Recommended prerequisites:	Basic knowledge in linear algebra and mathematical analysis is required. A good grasp of the Matlab/Simulink environment is required for exercises.
Aim/learning outcomes:	After successful completion of the course, students • 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 • 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 have understood relevant physical phenomena in a wind farm • 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

Content:	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 The content of the courses 'Control of Wind Turbines and Wind Farms' and ‚Design of Wind Energy Systems' have been alined in such a manner that they can be attended in parallel.
Assessment/type of examination:	Written examination: Between 90 and 180 minutes or Oral examination: Between 20 and 45 minutes or Internship report: Between 15 and 30 pages
Media:	Beamer, PCs with Matlab/Simulink for exercises
Literature:	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.

7.2.10 Advanced Laboratories in Renewable Energies

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Module title:	Advanced Laboratories in Renewable Energies
Module code:	Phy967
Course:	Advanced Laboratories in Renewable Energies
Term:	Summer
Person in charge:	Prof. Dr. Martin Kühn
Lecturer:	Prof. Dr. Martin Kühn, Martin Kraft
Language:	English / German
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Renewable Energies
Teaching Methods/ semester periods per week:	Laboratory work 3 hours per week and seminar 1 hour per week
Workload:	Attendance: 56 hrs, Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus:	
Recommended prerequisites:	
Aim/learning outcomes:	Students acquire the competence to plan, execute, analyze, document and present complex and advanced physical experiments. They deepen their experience in working with state-of the-art measurement and analyzing equipment within the field of Experimental Physics applied in the field of renewable Energy. The Adv. Labs are research oriented.
Content:	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.
Assessment/type of examination:	3 labs with 3 protocols plus Homework tasks
Media:	data projector presentation, Blackboard
Literature:	Script

7.2.11 Advanced Topics in Renewable Energies

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Module title:	Advanced Topics in Renewable Energies
Module code:	phy689
Course:	This module offers special as well as advanced courses in Renweable Energies. The list of eligible courses will be updated each academic year. Please refer to the courses listed for this module in Stud.IP.
Term:	winter or summer
Person in charge:	Prof. Dr.M. Kühn
Lecturer:	Related to selected course/s
Language:	Related to selected course/s
Location	Oldenburg
Curriculum allocation:	Master Engineering Physics (Master); Schwerpunkt: Renewable Energies
Teaching Methods/ semester periods per week:	Related to selected course/s
Workload:	Overall workload of 180 h
Credit points:	3 + 3 or 6
Prerequisites acc. syllabus	
Recommended prerequisites:	Related to selected course/s
Aim/learning outcomes:	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.
Content:	E.g. Fluid dynamics, metrology, data logging, measurement methodology, construction, monitoring, control engineering, remote sensing.
Assessment/type of examination:	Related to selected course/s
Literature:	Related to selected course/s