Carl v. Ossietzky Universität Oldenburg
Hochschule Emden/Leer

Version vom 01.10.2017

Modulhandbuch
Master of Science

Engineering Physics

Master of Science in Engineering Physics (M.Sc.)

Study starting in the winter semester:

	CP ->	**3**	**6**	**9**	**12**	**15**	**18**	**21**	**24**	**27**	**30**	**Summe**
Semester ->	**4**	**Thesis**										
	CP	30										**30**
	3	**Theoretical Methods** phy611		**Seminar Advanced Topics in EP** phy640	Specialization IV phy665		**Advanced Research Project** (Preparation Master Thesis) phy691					
	CP	**6**		**3**	6		15					**30**
	2	**Advanced Physics II** phy613		Engineering Sciences III phy655		Specialization II phy664		Specialization III phy662		**Tools and Skills in Engineering Sciences** phy681		
	CP	**6**		6		6		6		6		**30**
	1	**Advanced Physics I** (z. B. Quantenmechanik) phy612		**Advanced Metrology** phy631		Engineering Sciences I phy653		Engineering Sciences II phy654		Specialization I phy663		
	CP	**6**		**6**		6		6		6		**30**

Physik/ Mathematik	Ingenieurwissenschaften	Spezialisierung	Labor	Management	**Pflicht**	*Wahlpflicht*

The field of specialization consists of Biomedical Physics & Acoustics, Laser & Optics, Renewable Energies.
It is possible to study the program with a specialization focus or without.

Attention: Only the specialization Laser & Optics is offered completely in English for the other specializations German is also needed!

Content

Additional lectures may be selected; prior coordination with study program coordinator is required.

Specializations requirements

A specialization in Biomedical Physics with certification as Medical Physician, i.e. the Fachanerkennung DGMP (Deutsche Gesellschaft für Medizinische Physik e.V.) requires the following:

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

1. Die Absolvent/innen haben die konsekutiven Bachelor/Masterstudiengänge „Physik“ oder „Engineering Physics“ erfolgreich abgeschlossen und die Veranstaltungen
    - 5.04.341 „Kern- und Teilchenphysik“
    - 5.04.4642 „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 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 Veranstaltungen 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:
        - 05.04.4486 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 23.6.2017 bis zum 30.09.2022 bzw. bis zu einer Änderung des Cirriculums. Für eine Rezertifizierung ist rechtzeitig ein erneuter Zertifizierungsantrag zu stellen.

Die Absolvent/innen des Studienganges müssen sich bei Beginn der klinischen Tätigkeit zur Weiterbildung anmelden (Anträge unter http://www.dgmp.de).

Die Kandidat/innen haben während der i.d.R. dreijährigen berufspraktischen, klinischen Weiterbildungsphase nach Abschluss des Studiums pro Jahr noch 50 Weiterbildungspunkte (gleich Stunden) durch den Besuch anerkannter Weiterbildungsveranstaltungen im Spezialgebiet - das auch das Arbeitsgebiet sein muss - nachzuweisen.

Für das Spezialgebiet N6 ist die Fachkunde im Strahlenschutz 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.

Modules

Advanced Physics I (phy612) lectures:

Module title:	Advanced Physics I
Module code:	phy612
Course:	**Photonics (WS, 5.04.4668)**
Term:	Winter
Person in charge:	Prof. Dr. B. Poppe, Prof. Dr. B. Struve
Lecturer:	Prof. Dr. H. Brückner, Prof. Dr. B. Struve
Language:	German or English
Location:	Emden or Oldenburg
Curriculum allocation:	Master Engineering Physics 1st semester
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, electrodynamics and atomic physics
Aim/learning outcomes:	Starting from basics, the module yields advanced knowledge of the physics of lasers, of interaction of optical radiation with matter, optoelectronic principles and components as, e.g. laser beams, different laser types, light emitters, detectors, modulators. The students acquire skills in working with lasers and optoelectronic components.
Content:	Fundamentals of lasers (optical gain, optical resonator, laser beams), laser types, laser safety; electronic bandstructures in matter, semiconductor junctions, radiation laws, light emitting diodes, photodetectors, solar cells
Assessment/type of examination:	2 hr written examination or 30 min oral examination or experimental work or homework or presentation
Media:	Script, blackboard, transparencies, computer presentation, practical laboratory work
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 & Sons • Ebeling: Integrierte Optoelektronik, Springer Verlag • Original literature according indication during course

Module title:	Advanced Physics I
Module code:	phy612
Course:	**Allgemeine Relativitätstheorie (WS, 5.04.4261)**
Term:	Winter
Person in charge:	Prof. Dr. B. Poppe, NN
Lecturer:	Prof. D. A. Engel
Language:	German
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 2nd semester
Teaching Methods/semester periods per week:	Lecture / 3 Exercise / 1
Workload:	Attendance: 56 hours Self study: 124 hours
Credit points:	6
Prerequisitesacc. syllabus	
Recommended prerequisites:	
Aim/learning outcomes:	
Content:	Äquivalenzprinzip, Bewegung im Gravitationsfeld, Metrik, Tensoren, Kovariante Ableitung, Riemannscher Krümmungstensor, Einsteinsche Feldgleichungen, Erhaltungsgrößen, Schwarzschild Lösung, Schwarze Löcher, Gravitationsstrahlung, Experimentelle Tests, Kosmologie, Friedmann-Gleichungen
Assessment/type of examination:	1 Klausur oder 1 Referat oder 1 mündliche Prüfung oder 1 Hausarbeit
Media:	Board, beamer
Literature:	• C. W. Misner, K. S. Thorne, J. A. Wheeler: Gravitation. Freeman, New York, 2002 • S. Weinberg: Gravitation and cosmology: principles and applications of the general theory of relativity. John Wiley, New York, 1972 • R. d’ Inverno: Introducing Einstein’s relativity. Clarendon Press, Oxford, 1992 • J. B. Hartle: Gravity: an introduction to Einstein’s general relativity. Addison-Wesley, San Francisco (CA), 2003

Advanced Physics II (phy613) lectures:

Module title:	Advanced Physics II
Module code:	phy613
Course:	**Fluiddynamik (WS & SS, 5.04.4071)**
Term:	Winter and Summer
Person in charge:	Prof. Dr. B. Poppe, Prof. Dr. B. Struve
Lecturer:	Prof. Dr. Peinke
Language:	German or English depending on demand
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1nd semester
Teaching Methods/ semester periods per week:	Lecture / 4 Excersise / 2
Workload:	Attendance: 84 hours Self study: 96 hours
Credit points:	6
Prerequisites acc. syllabus	
Recommended prerequisites:	
Aim/learning outcomes:	
Content:	Fluiddynamik 1: Grundgleichungen: Navier-Stokes-Gleichung, Kontinuitätsgleichung, Bernoulli-Gleichung; Wirbel- und Energiegleichungen; Laminare Flüsse und Stabilitätsanalyse; exakte Lösungen, Anwendungen Fluiddynamik 2: Reynolds-Gleichung, Schließungsproblem und Schließungsansätze, Turbulenzmodelle: Kaskadenmodelle - Stochastische Modelle.
Assessment/type of examination:	1 Klausur oder 1 Referat oder 1 mündliche Prüfung oder 1 Hausarbeit (Prüfung im Sommersemester)
Media:	Script, board, beamer
Literature:	• D. J. Tritton: Physical fluid dynamics. Clarendon Press, Oxford, 2003 • G. K. Batchelor: An introduction to fluid dynamics. Cam-bridge 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

Module title:	Advanced Physics II
Module code:	phy613
Course:	**Theoretische Physik III: Quantenmechanik (M.Ed.) (SS, 5.04.741)**
Term:	Summer
Person in charge:	Prof. Dr. B. Poppe, NN
Lecturer:	Dr. Petrovic
Language:	German
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 2nd semester
Teaching Methods/semester periods per week:	Lecture / 3 Exercise / 1
Workload:	Attendance: 84 hours Self study: 156 hours
Credit points:	6
Prerequisitesacc. syllabus	
Recommended prerequisites:	
Aim/learning outcomes:	Die Studierenden erwerben die Kompetenzen, die Anwendungssituationen der Quantenmechanik zu erkennen und Standardprobleme lösen sowie den Stoff (unter anderem an der Schule) geeignet vermitteln zu können.
Content:	Grundlegende Konzepte und Strukturen der nicht-relativistischen Quantenmechanik (Superpositions-prinzip, Wellenfunktion, Operatoren, Eigenwertproblem, Wahrscheinlichkeitsinterpretation, Schrödinger-Gleichung, Hilbert-Raum sowie aktuelle Themen wie Wechselwirkungsfreie Quantenmessung, Bellsche Ungleichung, Dekohärenz), Deutungs- und Interpretationsprobleme sowie Fragen der Vermittlung von Quantenmechanik, unter anderem an der Schule.
Assessment/type of examination:	1 Klausur oder 1 Referat oder 1 mündliche Prüfung oder 1 Hausarbeit
Media:	Beamer
Literature:	• C. Cohen-Tannoudji, et al.: Quantenmechanik, de Gruyter; • W. Nolting: Grundkurs Theoretische Physik, 5 Quantenmechanik, Springer Verlag; • J. Pade: Quantenmechanik zu Fuß, Springer (auch englisch: Quantum Mechanics for Pedestrians 1 & 2, Springer); • B.H. Bransden, C.J., Joachain: Quantum Mechanics, Prentice Hall; • J. Audretsch: Verschränkte Welt, Wiley; • F. Selleri: Die Debatte um die Quantentheorie, Vieweg Verlag.

Module title:	Advanced Physics II
Module code:	phy613
Course:	**Theoretische Physik II: Quantenmechanik (B.Sc.) (WS, 5.04.221)**
Term:	Summer
Person in charge:	Prof. Dr. B. Poppe, NN
Lecturer:	Prof. D. J. Kunz-Drolshagen
Language:	German
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 2nd semester
Teaching Methods/ semester periods per week:	Lecture / 4 Exercise / 2
Workload:	Attendance: 84 hours Self study: 186 hours
Credit points:	9
Prerequisites acc. syllabus	
Recommended prerequisites:	Einführung in die Theoretische Physik, Klassische Teilchen und Felder I
Aim/learning outcomes:	Die Studierenden erwerben Kenntnisse über die grundlegenden Konzepte und Methoden der nichtrelativistischen Quantenmechanik. Sie erlangen Fertigkeiten zur Anwendung dieser Kenntnisse auf fundamentale Beispiele wie Zustände in Potentialtöpfen, den harmonischen Oszillator, Zentralfeldprobleme und periodische Potentiale. Sie erwerben Kompetenzen zur selbstständigen Bearbeitung quantenmechanischer Probleme, zur Präsentation der Lösungswege, zum Erkennen von Zusammenhängen zwischen Mechanik und Quantenmechanik sowie zur Interpretation des abstrakten mathematischen Formalismus.
Content:	Schrödingergleichung, Unschärferelation, Messprozess, Darstellungstheorie, Drehimpulse, Spin, Wasserstoffatom, Systeme identischer Teilchen, Störungstheorie
Assessment/type of examination:	1 Klausur oder 1 Referat oder 1 mündliche Prüfung oder 1 Hausarbeit
Media:	Board, beamer
Literature:	• C. Cohen-Tannoudji, B. Diu, F. Laloë: Quantenmechanik. De Gruyter, Berlin • F. Schwabl: Quantenmechanik: eine Einführung. Springer, Berlin • B. H. Bransden, C. J. Joachain: Quantum mechanics. Prentice Hall, Harlow • D. J. Griffiths: Introduction to Quantum Mechanics Prentice Hall, New Jersey

Module title:	Advanced Physics II
Module code:	phy613
Course:	**Kosmologie (SS, 5.04.4539) & Akkretionsscheiben (SS, 5.04.1003)**
Term:	Summer
Person in charge:	Prof. Dr. B. Poppe
Lecturer:	Prof. D. J. Kunz-Drolshagen & Dr. Saskia Grunau
Language:	German, English on request
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 2nd semester
Teaching Methods/semester periods per week:	Lecture / 2
Workload:	Attendance: 56 hours Self study: 124 hours
Credit points:	3 & 3
Prerequisites acc. syllabus	
Recommended prerequisites:	Kenntnisse aus den Vorlesungen Teilchen und Felder, Quantenmechanik (Astrophysik, Allgemeine Relativitätstheo- rie, Quantenfeldtheorie)
Aim/learning outcomes:	Die Studierenden erhalten einen Überblick über die aktuellen Fragestellungen der Kosmologie. Sie lernen die Konzepte und Methoden der Relativitätstheorie, der Feldtheorie, der Astrophysik und der Teilchenphysik zusammenzuführen, um sie auf die relevanten Fragestellungen der Kosmologie anzuwenden, und mit Hilfe der Beobachtungsdaten ein konsis- tentes Modell der Evolution des Universums zu formulieren.
Content:	**Kosmologie:** Friedmann-Lemaitre Lösungen, Kosmische Hintergrund- strahlung, Nukleosynthese, Baryonenasymmetrie, Inflationä- res Universum, Dunkle Materie, Dunkle Energie **Akkretionsscheiben** enstehen wenn Materie, z.B in Form von Gas oder Staub, auf ein massives kompaktes Objekt, wie ein schwarzes Loch oder ein Neutronenstern, zufallen. Dabei sammelt sich die Materie als rotierende Scheibe um das Zentralobjekt. Eine Akkretionsscheibe kann aus Plasma, Gas oder Staub bestehen. Da sich die einfallende Materie stark aufheizt, entsteht Wärmestrahlung die zum Aufspüren schwarzer Löcher oder Neutronensterne genutzt werden kann.
Assessment/type of examination:	1 Klausur oder 1 Referat oder 1 mündliche Prüfung oder 1 Hausarbeit
Media:	Board, beamer
Literature:	• S. Weinberg: Cosmology, Oxford University Press 2008 • V. Mukhanov: Physical Foundations of Cosmology, Cambridge University Press 2005 • E. W. Kolb, M. S. Turner: The early universe. Addison-Wesley, Redwood City (CA), 1990 • H. Goenner: Einführung in die Kosmologie. Spektrum Akademischer Verlag, Heidelberg, 1994

Module title:	Advanced Physics II
Module code:	phy613
Course:	**Akustik (SS, 5.04.711)**
Term:	Summer
Person in charge:	Prof. Dr. S. van de Par
Lecturer:	Prof. S. van de Par, B. Kollmeier
Language:	German
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 2^{nd} semester
Teaching Methods/semester periods per week:	Lecture / 3 Exercise / 1
Workload:	Attendance: 56 hours Self study: 124 hours
Credit points:	6
Prerequisitesacc. syllabus	
Recommended prerequisites:	
Aim/learning outcomes:	
Content:	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, Stoßwellen, Photoakustischer Effekt; ausgesuchte Kapitel der Akustik, der Vibrationen und des Ultraschalls.
Assessment/type of examination:	1 Klausur oder 1 Referat oder 1 mündliche Prüfung oder 1 Hausarbeit
Media:	Board, beamer
Literature:	• Kollmeier, B.: Skriptum Physikalische, technische und medizini- sche Akustik, Universität Oldenburg, http://medi.uni-olden- burg.de/16750.html • o Heckl, Müller: Taschenbuch der technischen Akustik, Springer- Verlag • o F.G. Kollmann: Maschinenakustik, Springer-Verlag

Theoretical Methods (phy611) lectures:

Module title:	Theoretical Methods
Module code:	phy611
Course:	**Computerorientierte Physik, (WS & SS, 5.04.874)**
Term:	Winter
Person in charge:	Prof. Dr. Poppe, N.N
Lecturer:	Prof. Dr. Hartmann
Language:	German
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 3nd semester
Teaching Methods/ semester periods per week:	Lecture / 3 Excersise / 1
Workload:	Attendance: 56 hours Self study: 124 hours
Credit points:	6
Prerequisites acc. syllabus	
Recommended prerequisites:	Theoriemodule des Bachelor-Studiums, Kenntnisse einer höheren Programmiersprache (vorzugsweise C)
Aim/learning outcomes:	Erweiterung und Abrundung der Ausbildung in theoretischer Physik durch den Erwerb solider und vertiefter Kenntnisse fortgeschrittener Konzepte und Methoden der theoretischen Physik. Die Studieren- den erwerben je nach gewählter Veranstaltung Kenntnisse auf den Gebieten Vertiefung des Verständnisses der nicht-relativistischen Quantenmechanik, Grundlagen der relativistischen Quantenme- chanik, grundlegende numerische Methoden der theoretischen Physik, Algorithmen und Datenstrukturen im wissenschaftlichen Rechnen, Debugging, Grundlagen der allgemeinen Relativitätstheo- rie, Aspekte der Astrophysik und Kosmologie. Sie erlangen Fertig- keiten im sicheren Umgang mit modernen Methoden der theoreti- schen Physik wie Diagrammentwicklungen, Molekulardynamik- und Monte-Carlo-Simulationen und differentialgeometrischen Konzepten, in der quantitative Analyse von fortgeschrittenen Problemen der theoretischen Physik und in der Weiterentwicklung der physika- lischen Intuition. Sie erweitern ihre Kompetenzen zur erfolgreichen Bearbeitung anspruchsvoller Probleme der theoretischen Physik mit modernen analytischen und numerischen Methoden, zur eigen- ständigen Erarbeitung von Zugängen zu aktuellen Entwicklungen der theoretischen Physik und zum Verständnis übergreifender Kon- zepte und Methoden der theoretischen Physik und der Naturwissenschaften allgemein.
Content:	Debugging, Datenstrukturen, Algorithmen, Zufallszahlen, Daten- analyse, Perkolation, Monte-Carlo-Simulationen, Finite-Size Scaling, Quanten-Monte-Carlo, Molekulardynamik-Simulationen, ereignisgetriebene Simulationen, Graphen und Algorithmen, genetische Algorithmen, Optimierungsprobleme
Assessment/type of examination:	1 Klausur oder 1 Referat oder 1 mündliche Prüfung
Media:	Board, beamer
Literature:	• T. H. Cormen, S. Clifford, C.E. Leiserson, und R.L.

	Rivest: Intro- duction to Algorithms. MIT Press, 2001 • K. Hartmann: Practical guide to computer simulation. World- Scientific, 2009 • J. M. Thijssen: Computational Physics. Cambridge University Press, 2007 • M. Newman, G. T. Barkema: Monte Carlo Methods in Statistical Physics. Oxford University Press, 1999

Module title:	Theoretical Methods
Module code:	phy611
Course:	**Modelling and Simulation (WS, 5.04.4665)**
Term:	Winter
Person in charge:	B. Poppe, N.N.
Lecturer:	Prof. Dr.-Ing. Strybny, Prof. Dr. rer. nat. Garen
Language:	German or English depending on demand
Location:	Oldenburg
Curriculum allocation:	o Master Engineering Physics, 3st semester o Bachelor Maritime Technology and Shipping Management, 6th semester
Teaching Methods/ semester periods per week:	Lecture: 3 hrs/week Computational Lab: 1 hrs/week
Workload:	Attendance: 52 hrs Self study: 128 hrs
Credit points:	6
Prerequisites acc. syllabus	
Recommended prerequisites:	
Aim/learning outcomes:	The students attending successful the course acquire an advanced understanding of the conceptual design of models in the field of engineering sciences. Special emphasis is on identifying the significant physical processes and the choice of the most efficient modelling type. The interaction of numerical simulations with field measurements and laboratory measurements including the theory of similarity will be discussed. To meet the needs of renewable energy, laser technology, environmental sciences and marine sciences the practical focus is on the modelling and simulation of fluid dynamics in small scales and close to structures.
Content:	• Understanding of advanced fluid dynamics including three-dimensional, transient and compressible processes • Identifying the significant physical processes, defining the dimensionality and relevant scales in time and space • Theory of similarity, range of dimensionless numbers • Potential Theory • Numerical Algorithms and possibilities of independent coding of simplest mathematical models • Limitations of numerical models, risk of empirical approaches included in numerical models • Introduction of a complete chain of Open-Source-CFD-Tools, considering preprocessing, processing and postprocessing tools • Need and availability of appropriate measurement techniques for the steering, calibration and verification of models • Contactless high-resolving measuring techniques in the fluid dynamics • Limits of accuracy of different modelling and simulation concepts
Assessment/type of	2 hrs written exam

examination:	
Media:	beamer presentations, blackboard, script, exercises using the PC
Literature:	• Versteeg, K.H. & Malalasekera, W.: An Introduction to Computational Fluid Dynamics. Prentice Hall, 2nd rev. Ed., 2007.

Module title:	Theoretical Methods
Module code:	phy611
Course:	**Personalized Medicine (WS, 5.04.4666)**
Term:	Summer
Person in charge:	B. Poppe, N.N.
Lecturer:	Prof. Dr. Thorsten Schmidt
Language:	English
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 3st semester
Teaching Methods/ semester periods per week:	Lecture: 4 hrs/week
Workload:	Attendance: 72 hrs Self study: 108 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.
Media:	Transparencies, blackboard, computer presentation
Literature:	• Genomic and Personalized Medicine: V1-2 Huntington F. Willard & Geoffrey S. Ginsburg; Academic Press; 2. Edition. (30. Oktober 2012); Language: English; ISBN-10: 0123822270 • Cancer Genomics: From Bench to Personalized Medicine; Graham Dellaire & Jason Berman; Academic Press; 1. Edition (17. January 2014); Language: English; ISBN-10: 0123969670 • Systems Biology: A Textbook; Eda Klipp et al (2009); Wiley-VCH Verlag GmbH & Co. KGaA; Auflage: 1. Edition; Language: Englisch; ISBN-10: 3527318747

Advanced Metrology (phy631):

Module title:	**Advanced Metrology**
Module code:	phy631
Course:	Advanced Metrology (WS, 5.04.4660)
Term:	Winter
Person in charge:	W. Neu, B. Poppe
Lecturer:	W. Neu, B. Poppe, S. Doclo, M. Kühn
Language:	German or English depending on demand
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st semester
Teaching Methods/semester periods per week:	Lecture: 2 hrs/week
Workload	Attendance: 28 hours Self study: 62 hours
Credit points	3
Prerequisites acc. syllabus	Lecture series 5.04.4660 (2 SWS) plus ONE additional seminar • 5.04.4849 Blockpraktikum Psychophysik, Neurosensorik und auditorische Signalverarbeitung (Biomed. Physics and Acoustics) • 5.04.4221 Grundkurs im Strahlenschutz mit Praktikum (Biomed. Physics and Acoustics) • 5.04.6610 Modern Methods in Optical Microscopy (Laser & Optics) • 5.04.6611 Advanced optical spectroscopy (Laser & Optics)
Recommended prerequisites:	
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 within the context of Laser&optics, Biomedical physics & acoustics, and renewable energies. Demonstrate systematic knowledge across appropriate advanced metrology technologies, management and environmental issues to provide solutions for international industries and/or research organisations
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:	1 Klausur oder 1 Referat oder 1 mündliche Prüfung oder 1 Hausarbeit
Media:	Lecture script, transparencies, blackboard, electronic media, presentation, lecture practical demonstrations, practical work in laboratory
Literature:	• T. Yoshizawa (Ed.): Handbook of Optical Metrology: Principles and Applications, 2nd rev. ed., Crc Pr Inc., 2015 • Recent publications on specific topics

Engineering Science I (phy653) lectures:

Module title:	Engineering Science I
Module code:	phy653
Course:	**Energy Resource & Systems (WS, 5.06.021 & 5.06.022)** Lectures: • Energy Meteorology (5.06.021) • Energy Systems (5.06.022)
Term:	Winter
Person in charge:	B. Poppe, N.N.
Lecturer:	Dr. Heinemann
Language:	English
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st semester
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:	After successful completion of the module students should be able to: - characterise the global energy system and analyse 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 & 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 Exam
Media:	
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 - Peixoto, J.P. & 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 & 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 & 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/)

Module title:	Engineering Sciences I
Module code:	Phy653
Course:	**Applied Photonics I / Spectrophysics (WS, 5.04.4661)**
Term:	Winter
Person in charge:	Prof. Dr. Teubner, Prof. Dr. Kühn, Prof. Dr. ir. Doclo
Lecturer:	Prof. Dr. Walter Neu
Location:	Oldenburg
Language:	German or English depending on demand
Curriculum allocation:	Master Engineering Physics, 1st semester
Teaching Methods/semester periods per week:	Lecture: 3 hrs/week Laboratory: 1 hrs/week
Workload:	Attendance: 56 hrs Self study: 124 hrs
Credit points:	6
Prerequisitesacc. 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
Media:	Lecture script, transparencies, blackboard, electronic media, presentation, lecture practical demonstrations, practical work in laboratory
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. 1&2, Springer, 5nd ed. 2014 & 4th ed., 2008 • Saleh & Teich, Fundamentals of Photonics (Wiley)

	• Recent publications on specific topics

Module title:	Engineering Sciences I
Module code:	Phy653
Course:	**Psychophysik und Audiologie (PPAA) (WS, 5.04.4021)**
Term:	Winter
Person in charge:	Prof. Dr. Teubner, Prof. Dr. Kühn, Prof. Dr. ir. Doclo
Lecturer:	Prof. Dr. Dr. B. Kollmeier, Prof. Dr. S. van de Par, Dr. T. Brand, Dr. S. Uppenkamp, Dr. R. Weber
Language:	Deutsch
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st – 3rd Semester
Teaching Methods/ semester periods per week:	VL: 3 SWS Ü / SE / PR: 1 SWS
Workload:	Attendance: 56 hours Self study: 124 hours
Credit points:	6
Prerequisites acc. syllabus	
Recommended prerequisites:	Einführende Module sowie möglichst ein vertiefendes Modul in Akustik und Signalverarbeitung
Aim/learning outcomes:	
Content:	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 Schallempfindungsstörungen, Tinnitus, Otoakustische Emissionen (Diagnostisch), Stapediusreflexaudiometrie, 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
Assessment/type of examination:	Exam or presentation or oral exam or homework or practical report
Media:	Beamer, wiss. Texte
Literature:	• Skript: Kollmeier, B.: Psychologische, physiologische und audiologische Akustik (Audiologie), Download von: http://medi.uni-oldenburg.de/16750.html • WA Yost, Fundamentals of Hearing, Academic Press, 2000. • Blauert, Jens, Räumliches Hören, S. Hirzel Verlag, 1997. • A Bregman, Auditory Scene Analysis, MIT Press, 1990. • M Cooke, Modelling Auditory Processing and Organisation, Cambridge University Press, 1993. • P Dallos and AN Popper and RR Fay, The Cochlea, Springer Handbook in Auditory Research, 1996.

	• Kießling, J., Kollmeier, B., Diller, G., Versorgung und Rehabilitation mit Hörgeräten, Thieme, Stuttgart • Moore, Brian C. J., Hearing, Academic Press, 1995. • Moore, Brian C. J., An introduction to the psychology of hearing, Academic Press, 1997. • JO Pickles, An Intoduction to the Physiology of Hearing, Academic Press, 1988. • W Yost and A Popper and R Fay, Human Psychophysics, Springer Handbook in Auditory Research 3, Springer Verlag, 1993. • Zwicker, E. and Fastl, H., Psychoacoustics : Facts and Models, Springer, 1999.

Module title:	Engineering Sciences I
Module code:	Phy653
Course:	**Physiologie der Tiere und Menschen (WS, 5.02.271)**
Term:	Wintersemester
Person in charge:	Prof. Dr. Brückner, Prof. Dr. Kühn, Prof. Dr. ir. Doclo
Lecturer:	Apl. Prof. Dr. Karin Dedek
Language:	Deutsch
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st – 3rd Semester
Teaching Methods/semester periods per week:	SE: 3 SWS
Workload	Attendance: 42 hours Self study: 138 hours
Credit points	6
Prerequisites acc. syllabus	
Recommended prerequisites:	
Aim/learning outcomes:	Grundlegende Kenntnisse und Zusammenhänge der Physiologie mit Schwerpunkt Humanphysiologie.
Content:	Der Vorlesungsstoff 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.
Assessment/type of examination:	Written exam
Media:	Tafel, Beamer
Literature:	Klinke, Pape, Kurtz, Silbernagl: Physiologie, Aufl. 6, 2010

Engineering Science II (phy654) lectures:

Module title:	Engineering Science II
Module code:	phy654
Course:	**Renewable Energy Technology I (WS, 5.06.035 & 5.06.036)** Lectures: • Photovoltaics (5.06.035) • Fuel Cells & Energy Storage (5.06.036)
Term:	Winter
Person in charge:	B. Poppe, N.N.
Lecturer:	Dr. Robin Knecht, Hans Holtorf (PhD), Dr. Robert Steinberger
Language:	English
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st semester
Teaching Methods/ semester periods per week:	Lecture: 4 hrs/week , special time slots (blocked periods)
Workload:	attendance: 56 hrs self-study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus	
Recommended prerequisites:	Extended basic physics, mathematics and engineering knowledge
Aim/learning outcomes:	Related to selected courses - critically evaluate Renewable Energy conversion processes and technologies - 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. - 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:	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 (Course offer within Master studies). Photovoltaics (Lecture – 90 h workload) Physics of PV: - Basic and most important properties of solar radiation related to photovoltaics - PV cells basics: Fundamental physical processes in photovoltaic materials - 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 Fuel Cells & Energy Storage (Lecture – 90 h workload) - Fundamentals of electrochemistry and thermodynamics, energy and environmental balances - Basics of hydrogen production - starting materials, processes, efficiencies, environmental impacts - Basics of fuel cells function, materials, construction, systems, applications - Fundamental setup of most common battery types - Fundamental chemical reactions in these batteries Operational characteristics, weir processes and service lives of these batteries.
Assessment/type of examination:	Written Exam
Media:	Script, transparencies, blackboard, computer presentation
Literature:	Solar Energy PV - Green, Martin A., 1981: Solar cells : operating principles, technology and system applications, Prentice Hall. - Green, M.A., 2007: Third Generation Photovoltaics, Advanced Solar Energy Conversion, Springer Series in Photonics - Markvart, Tom and Castaner, Luis, 2003: Practical Handbook of Photovoltaics, Fundamentals and Applications, Elsevier Science - Nelson, Jenny, 2003: The Physics of Solar Cells (Properties of Semiconductor Materials), Imperial College Press. - Stuart R. Wenham, Martin A. Green, Muriel E. Watt& Richard Corkish (Edit.), 2007: Applied Photovoltaics, Earthscan Publications Ltd.; - Twidell, John & Weir, Toni, 2005: Renewable Energy Resources Taylor & Francis. Fuel Cells & Energy Storage - Larminie/Dicks: Fuel Cells Systems Explained, 2000, (Wiley, 2000, ISBN 0-471-49026-1) - EG&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) - Fischer, W. (1996). Stationary lead-acid batteries - an introductory handbook. Brilon, Germany: Hoppecke.

Module title:	Engineering Science II
Module code:	phy654
Course:	**Wind Energy Physics (WS 5.04.4061 & SS 5.04.4234)** Lectures: • Wind Energy Physics (5.04.406) • Wind Physics Measruement Project (5.04.4234)
Term:	Winter
Person in charge:	B. Poppe, N.N.
Lecturer:	Dr. Robin Knecht, Hans Holtorf (PhD), Dr. Robert Steinberger
Language:	English
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1^{st} semester
Teaching Methods/ semester periods per week:	Lecture: 2 hrs/week each term
Workload:	attendance: 2*28 hrs self-study: 124 hrs
Credit points:	6
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 (Light detection and ranging): • analyses and conversion of data from LIDAR measurements
Assessment/type of examination:	
Media:	
Literature:	

Module title:	Engineering Sciences II
Module code:	Phy654
Course:	**Applied Photonics II - Fundamentals of Optics (WS, 5.04.657)**
Term:	Winter
Person in charge:	Prof. Dr. Teubner, Prof. Dr. Kühn, Prof. Dr. ir. Doclo
Lecturer:	Prof. Dr. Ulrich Teubner
Language:	German or English depending on demand
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st semester
Teaching Methods/semester periods per week:	Lecture: 3 hrs/week Laboratory: 1 hrs/week
Workload:	Attendance: 56 hrs Self study: 124 hrs
Credit points:	6
Prerequisitesacc. 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. 2hr written examination or max 1h oral examination or experimental work and laboratory reports or presentation or homework
Media:	blackboard, transparencies, lecture practical demonstrations, practical work in laboratory
Literature:	• Born & Wolf: Principles of Optics (Cambridg Press) • E. Hecht: Optics (Addison-Wesley) • Pedrotti & Pedrotti: Introduction to Optics (Prentice-Hall) • Saleh & Teich, Fundamentals of Photonics (Wiley) • all those books are also available in German

Module title:	Engineering Sciences II
Module code:	Phy654
Course:	**Machine Learning – Probabilistic Unsupervised Learning (WS, 5.04.4213)**
Term:	Wintersemester
Person in charge:	Prof. Dr. Brückner, Prof. Dr. Kühn, Prof. Dr. ir. Doclo
Lecturer:	Prof. Dr. Jörg Lücke
Language:	English
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st – 3rd Semester
Teaching Methods/semester periods per week:	VL: 2 SWS; Ü: 2 SWS; (incl. prog. laboratory)
Workload	Attendance: 56 hours Self study: 124 hours
Credit points	6
Prerequisites acc. syllabus	
Recommended prerequisites:	Basic knowledge in higher Mathematics as taught as part of first degrees in Physics, Mathematics, Statistics, Engineering or Computer Science (basic linear algebra and analysis). Basic programming skills (course supports matlab & python). Many relations to statistical physics, statistics, probability theory, stochastic but the course's content will be developed independently of detailed prior knowledge in these fields.
Aim/learning outcomes:	The students will acquire advanced knowledge about mathe-matical models of data and sensory signals, and they will learn how such models can be used to derive algorithms for data and signal processing. They will learn the typical scien-tific challenges associated with algorithms for unsupervised knowledge extraction including, clustering, dimensionality reduction, compression and signal enhancements. Typical examples will include applications to computer vision and computer hearing. Furthermore, the students will learn modern interpretations of neural learning and neural percep-tion based on probabilistic data models.
Content:	The field of Machine Learning develops and provides methods for the analysis of data and signals. Typical applica-tion domains are computer hearing, computer vision, general pattern recognition and large-scale data analysis (recently often termed "Big Data"). Furthermore, Machine Learning methods serve as models for information processing and learning in humans and animals, and are often considered as part of artificial intelligence approaches. This course gives an introduction to unsupervised learning methods, i.e., methods that extract knowledge from data without the requirement of explicit knowledge about individual data points. We will introduce a common probabilistic frame-work for learning and a methodology to derive learning algo-rithms for different types of tasks. Examples that are derived are algorithms for clustering, classification, component extraction, feature learning, blind source separation and dimensionality reduction. Relations to neural network models and learning in biological

	systems will be discussed were appropriate.
Assessment/type of examination:	Exam or presentation or oral exam or homework or practical report
Media:	Black board, electronic slides, animations, programming
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)

Module title:	Engineering Sciences II
Module code:	Phy654
Course:	**Spezialkurs Strahlenschutzseminar (WS, 5.04.4222)**
Term:	Wintersemester
Person in charge:	Prof. Dr. Brückner, Prof. Dr. Kühn, Prof. Dr. ir. Doclo
Lecturer:	Prof. Dr. B. Poppe, Dr. A. Rühmann, H. von Boetticher, K. Dörner
Language:	Deutsch
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st – 3rd Semester
Teaching Methods/semester periods per week:	VL / SE: 4 SWS
Workload	Attendance: 56 hours Self study: 124 hours
Credit points	6
Prerequisites acc. syllabus	
Recommended prerequisites:	Experimentalphysik I-V, Kern- und Elementarteilchenphysik, Medizinsche Strahlentherapie, Grundkurs im Strahlenschutz
Aim/learning outcomes:	Der Kurs vertieft sämtliche im Grundkurs im Strahlenschutz erlernten Kenntnisse, Fähigkeiten und Kompetenzen. Insbesondere wird Wert auf die Kompetenz gelegt Situationen und Fragen des Strahlenschutzes fundiert bewerten zu können.
Content:	Inhalte entsprechend der Stoffzusammenstellung der Richtlinie Strahlenschutz in der Medizin und der Fachkunderichtlinie zur Röntgenverordnung: Strahlenschutzrelevante Aspekte in der Strahlentherapie, Nuklearmedizin und Radiologie. Dieser Kurs erfüllt zusammen mit dem Grundkurs die theoretischen Anforderungen zur Erlangung der Fachkunde im Strahlenschutz.
Assessment/type of examination:	Exam or presentation or oral exam or homework or practical report
Media:	PowerPoint
Literature:	Skript zum Kurs wird während des Kurses zur Verfügung gestellt

Engineering Science III (phy655) lectures:

Module title:	Engineering Science III
Module code:	phy655
Course:	**Renewable Energy Technology II (WS 5.06.031 & WS 5.06.032)** Lectures: • Biomass Energy (5.06.031) • Solar Thermal (5.06.032)
Term:	Winter
Person in charge:	B. Poppe, N.N.
Lecturer:	Dr. HerenaTorio, Prof. Michael Wark, Hans Holtorf PhD
Language:	English
Location:	Oldenburg
Curriculum allocation:	Bachelor Engineering Physics, 5th semester
Teaching Methods/ semester periods per week:	Seminar plus Exercises: 2 hrs/week, lecture 2 hrs/week; special time slots (blocked periods)
Workload:	attendance: 56 hrs self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus	
Recommended prerequisites:	Extended basic physics, mathematics and engineering knowledge
Aim/learning outcomes:	Related to selected courses critically evaluate Renewable Energy conversion processes and technologies analyse various system components and their interconnections within a complex Renewable Energy supply system. evaluate the Renewable Energy supply systems' operational size and efficiency. critically evaluate non-technical impact and side effects when implementing renewable energy supply systems
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 (Course offer within Master studies). **Solar Thermal Energy (Seminar & Exercises – 90 h workload)** - Assessment of solar thermal ambient parameters: regional global, diffuse, reflected solar radiation on horizontal and on tilted plane, ambient temperature - Solar thermal collectors - Solar thermal heat exchangers - Solar thermal storages - Solar thermal systems and their operation - Characterization of solar thermal systems

	Biomass Energy (Lecture – 90 h workload) - Energy mix overview; gas, heat, electricity, Pros & 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 & 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
Assessment/type of examination:	Compulsory attendance during the sessions of group work and tutorials
Media:	Script, transparencies, blackboard, computer presentation
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 & 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 Solar Thermal - DGS, (2010) Planning and installing solar thermal systems, a guide for installers, architects and engineers, 2nd ed. - Duffie JA, Beckman WA (2013) Solar engineering of thermal processes: Wiley. - Kasper, B., & Antony, F. (2004). Solarthermische Anlagen.

Module title:	Engineering Science III
Module code:	phy655
Course:	**Computational Fluid Dynamics (CFD I & II), (SS, 5.04.4072 & 5.04.4075)**
Term:	Summer
Person in charge:	Prof. Dr. Poppe, N.N
Lecturer:	Prof. Dr. J. Peinke , Dr. S. Albensoeder, Dr. B. Stoevesandt
Language:	German or English depending on demand
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 3nd semester
Teaching Methods/ semester periods per week:	Lecture / 2 Excersise / 2
Workload:	Attendance: 56 hours Self study: 124 hours
Credit points:	6
Prerequisites acc. syllabus	
Recommended prerequisites:	Fluid Dynamics I
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:	1 Klausur oder 1 Referat oder 1 mündliche Prüfung
Media:	Board, beamer
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 edi- tion, Butterworth-Heinemann, Amsterdam, • P. Sagaut, Large Eddy Simulation for Incompressible Flows, Springer, Berlin, 1998 • J. Fröhlich, Large Eddy Simulationen turbulenter Strömun- gen, Teubner, Wiesbaden, 2006 (in German)

Module title:	Engineering Science III
Module code:	phy655
Course:	**Fuzzy-Regelung uns künstliche neuronale Netze in Robotik und Automation (SS, 2.01.303)**
Term:	Summer
Person in charge:	B. Poppe, N.N.
Lecturer:	Prof. Dr. Sergej Fatikow
Language:	Deutsch
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st – 3rd Semester
Teaching Methods/ semester periods per week:	VL: 3 SWS, Ü: 1 SWS
Workload:	Attendance: 56 hours Self study: 124 hours
Credit points:	6
Prerequisites acc. syllabus	
Recommended prerequisites:	
Aim/learning outcomes:	Studierende sollen als Spezialisten verschiedener Disziplinen ihre anwendungsspezifischen Steuerungs- und Informationsverarbeitungsprobleme durch den Einsatz von Fuzzy-Logik und neuronaler Netze lösen können.
Content:	Steuerungsprobleme in Robotik und Automation, Einführung in Fuzzy- und Neuro-Systeme, Grundlagen der Fuzzy-Logik, Fuzzy-Logik regelbasierter Systeme, Modelle neuronaler Netze, Lernalgorithmen für neuronale Netze, Mehrschichtige Netze und Backpropagation, Assoziativspeicher und stochastische Netze, Selbstorganisierende Netze, Entwurf klassischer Regler, Entwurf von Fuzzy-Regelungssystemen, Praktische Anwendungen der Fuzzy-Logik, Entwurf von Neuro-Regelungssystemen, Praktische Anwendungen neuronaler Netze, Fuzzy + Neuro: Grundlagen und Anwendungen
Assessment/type of examination:	Exam or presentation or oral exam or homework or practical report
Media:	Skript im Internet, Tafel, Beamerpräsentationen.
Literature:	• Essentiell: * Vorlesungsskript in Buchform (erhältlich zum Selbstkostenpreis von € 10,- im Sekretariat, A1-3-303) Empfohlen: * Bothe, H.-H.: Neuro-Fuzzy-Methoden, Springer, 1998 * Braun, Feulner, Malaka: Praktikum Neuronale Netze, Springer, 1997 * Kahlert, J.: Fuzzy Control für Ingenieure, Vieweg, Braunschweig Wiesbaden, 1995 * Nauck, D., Klawonn, F. und Kruse, R.: Neuronale Netze und Fuzzy-Systeme, Vieweg, 1994 * Zell, A.: Simulation Neuronaler Netze, Addison-Wesley / Oldenbourg Verlag, Bonn, 1996 Gute Sekundärliteratur:

	* Altrock, M. O. R.: Fuzzy Logic, R. Oldenbourg Verlag, 1993 * Bekey, A. and Goldberg, K.Y. (Eds.): Neural Networks in Robotics, Kluwer Academic, 1996 * Berns, K. und Kolb, T.: Neuronale Netze für technische Anwendungen, Springer, 1994 * Bothe, H.-H.: Fuzzy Logic, Springer, 1993 * Bunke, H., Kandel, A. (eds.): Neuro-Fuzzy Pattern Recognition, World Scientific Publ., 2000 * Kahlert, J. und Hubert, F.: Fuzzy-Logik und Fuzzy-Control, Vieweg, 1993 * Kim, Y.H. and Lewis, F.L.: High-Level Feedback Control with Neural Networks, World Scientific, 1998 * Kratzer, K.P.: Neuronale Netze, Carl Hanser, 1993 * Lämmel, U. und Cleve, J.: Künstliche Intelligenz (neuronale Netze), Fachbuchverlag Leipzig, 2001 * Lawrence, J.: Neuronale Netze, Systhema Verlag, München, 1992 * Omidvar, O. and van der Smagt, P. (eds.): Neural Networks for Robotics, Academic Press, 1997 * Patterson, D.W.: Künstliche neuronale Netze, Prentice Hall, 1996 * Pham, D.T. and Liu, X.: Neural Networks for Identification, Prediction and Control, Springer, 1997 * Rigoll, G.: Neuronale Netze, Expert Verlag, Renningen-Malmsheim, 1994 * Ritter, H., Martinetz, Th. und Schulten, K.: Neuronale Netze, Addison-Wesley, 1991 * Schulte, U.: Einführung in Fuzzy-Logik, Franzis-Verlag, München, 1993 * Tizhoosh, H.R.: Fuzzy-Bildverarbeitung, Springer, 1998 * von Altrock, C.: Fuzzy Logic: Technologie, Oldenbourg, 1993 * White, D. and Sofge, D. (Eds.): Handbook of Intelligent Control, Van Nostrand Reinhold, New York, 1992 * Zakharian, S. Ladewig-Riebler, P. und Thoer, St.: Neuronale Netze für Ingenieure, Vieweg, Wiesbaden, 1998 * Zalzala, A. and Morris, A. (Eds.): Neural Networks for Robotic Control, Ellis Horwood, London, 1996 * Zimmermann H.-J. (Hrsg.): Datenanalyse, VDI-Verlag, 1995 * Zimmermann, H.-J. (Hrsg.): Neuro + Fuzzy: Technologien und Anwendungen, VDI-Verlag, 1995 * Zimmermann, H.-J. und von Altrock, C. (Hrsg.): Fuzzy Logic: Anwendungen, Oldenbourg, 1994

Module title:	Engineering Science III
Module code:	phy655
Course:	**Digital Signal Processing (SS, 5.04.4586)**
Term:	Summer
Person in charge:	B. Poppe, N.N.
Lecturer:	Prof. Dr. Doclo
Language:	German or English depending on demand
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st – 3rd Semester
Teaching Methods/ semester periods per week:	Lecture / 2 Exercise / 2
Workload:	Attendance: 56 hours Self study: 124 hours
Credit points:	6
Prerequisites acc. syllabus	
Recommended prerequisites:	
Aim/learning outcomes:	Vermittlung der theoretischen Methoden der digitalen Signal- und Systemdarstellung bis hin zu modernen Verfahren und Optimalsystemen zur Verarbeitung stochastischer Prozesse. Vertiefung des Vorlesungsstoffes in analytischen, numerischen und Programmierübungen. Nach Abschluss des Moduls beherrschen die Studierende moderne Signalverarbeitungsmethoden und können die gelernten Methoden zur Analyse akustischer Systeme und zur Erklärung der Funktionsweise signalverarbeitender Systeme einsetzen.
Content:	Grundlagen der diskreten und integralen Signalrepräsentation (Eigenfunktionen), Abtastung, Signaltransformationen (Fourier-Transformation, Diskrete Fourier-Transformation, FFT, z-Transformation), Systemeigenschaften (Linearität, Zeitinvarianz, Stabilität, Kausalität), Methoden zur Beschreibung und Analyse von digitalen Systemen im Zeit- und Frequenzbereich (Impulsantwort, Übertragungsfunktion), stochastische Prozesse und lineare Systeme, digitale Filter, Optimalfilter, Adaptive Filter im Zeit- und Frequenzbereich.
Assessment/type of examination:	Exam
Media:	Tafel, Folien, Beamer, Computerübungen
Literature:	• B. Girod, R. Rabenstein, A. Stenger, Signals and Systems, Wiley, 2001. • J. G. Proakis, D. G. Manolakis, Digital Signal Processing – Principles, Algorithms and Applications, Prentice Hall, 2007. • A. V. Oppenheim, R. W. Schafer, Discrete-Time Signal Processing, Prentice Hall, 2009. • S. Haykin, Adaptive Filter Theory, Prentice Hall, 2001.

Module title:	Specialization IV
Module code:	phy665
Course:	**Biophotonics and Spectroscopy (SS, 5.04.4667)**
Term:	Winter or Summer
Person in charge:	Prof. Dr. Brückner, Prof. Dr. Kühn, Prof. Dr. ir. Doclo
Lecturer:	W. Neu, M. Schellenberg, S. Koch
Language:	German or English depending on demand
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st – 3rd Semester
Teaching Methods/semester periods per week:	Lecture / 2 hrs/week Seminar / 2hrs/week
Workload	Attendance: 56 hours Self study: 124 hours
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 3. Demonstrate analytical application of these atomic and molecular absorption and emission techniques 4. Discriminate the analytical challenges that can be appropriately solved by these spectroscopic techniques
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, practical work in laboratory
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&2, Springer, 5nd ed. 2014 & 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

Advanced Topics in Engineering Physics (phy640):

Module title:	**Advanced Topics in Engineering Physics**
Module code:	phy640
Course:	Advanced Topics in Engineering Physics
Term:	Winter and Summer
Person in charge:	Prof. Dr. Neu
Lecturer:	Prof. Dr. Neu, Dr. S. Koch
Language:	German or English depending on demand
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1^{st} - 4^{th} semester
Teaching Methods/ semester periods per week:	Seminar / 2 hrs/week
Workload:	Attendance: 28 hours Self study: 62 hours
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:	max 1h oral presentation and written report or oral exam (1 hour and regular active and documented participation in the seminar spread over the first three semesters.
Media:	Script, transparencies, blackboard, electronic media, presentation, practical demonstrations
Literature:	• M. Alley: The Craft of Scientific Presentations, Springer, 2nd ed., 2013 • Publications according to seminar topics

Specialization I (phy663) lectures:

Module title:	Specialization I
Module code:	phy663
Course:	**Physical Basics of Photovoltaics (WS, 5.04.4063)**
Term:	Winter
Person in charge:	B. Poppe, N.N.
Lecturer:	Dr. Michael Richter, Dr. Levent Güntay
Language:	English
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st semester
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:	
Media:	
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

Module title:	Specialization I
Module code:	phy663
Course:	**Energieinformationssysteme (WS, 2.01.510)**
Term:	Winter
Person in charge:	B. Poppe, N.N.
Lecturer:	Dr. Jörg Bremer, Prof. Dr. Sebastian Lehnhoff, Astrid Niesse
Language:	Deutsch
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st semester
Teaching Methods/ semester periods per week:	Lecture / seminar: 2 & 2 hrs/week
Workload:	Attendance: 72 hrs Self study: 108 hrs
Credit points:	6
Prerequisites acc. syllabus	
Recommended prerequisites:	
Aim/learning outcomes:	Die Studierenden besitzen Kenntnisse über verschiedene Ansätze zur Integration dezentraler Anlagen, den regulatorischen Rahmen, die dazu relevanten Normen und Architekturkonzepte und können dieses Wissen in konkreten Anwendungsfällen zielgerichtet anwenden. Fachkompetenzen Die Studierenden: - entwerfen und bewerten IT-Architekturen für das Energiemanagement - modellieren die Objekte der Domäne - modellieren Energieinformationssysteme - erkennen und differenzieren weitergehende Fragestellungen im Rahmen des dezentralen Energiemanagements Methodenkompetenzen Die Studierenden: - benennen Probleme aus dem Bereich der Energiemanagement und analysieren diese methodisch und schlagen Lösungen vor - wenden verschiedene Ansätze zur Simulation dezentraler Erzeuger und Verbraucher an Sozialkompetenzen Die Studierenden: - diskutieren gemeinsam Lösungen aus dem Bereich des Energiemanagements - erstellen Use-Cases in Kleingruppen - präsentieren ihre Lösungen Selbstkompetenzen Die Studierenden: - reflektieren ihr Handeln durch geeignete Strukturierung und Zerlegung von Systemen - reflektieren den eigenen Umgang mit der begrenzten Ressource Energie
Content:	Die Veranstaltung behandelt die Informatikgrundlagen zum Energiemanagement: Vermittlung von Kenntnissen zu den Anforderungen an Informationssysteme der Energieversorgung mit besonderer Berücksichtigung der

	technischen Komponenten und Anforderungen dezentraler und regenerativer Energieerzeugung.
Assessment/type of examination:	Referat oder Hausarbeit
Media:	
Literature:	

Module title:	Specialization I
Module code:	phy663
Course:	**Design of Wind Energy Systems (& Aeroelastic Simualtion of Wind Turbines) (SS, 5.04.4235, SS 5.04.4236)**
Term:	Winter
Person in charge:	B. Poppe, N.N.
Lecturer:	Prof. Martin Kühn, Andreas Schmidt
Language:	English
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st semester
Teaching Methods/ semester periods per week:	Lecture / seminar: 2 & 2 hrs/week
Workload:	Attendance: 72 hrs Self study: 108 hrs
Credit points:	6
Prerequisites acc. syllabus	Wind Energy Utilization (Bachelor) or Wind Energy (Master), Design of Wind Energy Systems (parallel)
Recommended prerequisites:	*Basics in Wind Energy Utilisation*
Aim/learning outcomes:	**Design of Wind Energy Systems** The students attending the course will have the possibility to expand and sharpen of their knowledge about wind turbine design from the basic courses. The lectures include topics covering the whole spectrum from early design phase to the operation of a wind turbine. Students will learn in exercises how to calculate and evaluate design aspects of wind energy converters. At the end of the lecture, they should be able to: + estimate the site specific energy yield, + calculate the aerodynamics of wind turbines using the blade element momentum theory, + model wind fields to obtain 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 **Aeroelastic Simulation of Wind turbines:** student who has met the objectives of the course will be able to: o understand the basic concept of an aero-servo-elastic computer code to determine the unsteady aerodynamic loads, o derive and validate the required parameters to model the aero-hydro-elastic response of a wind turbine, o identify and interpret the required empirical parameters to correct the blade element momentum (BEM) method with respect to dynamic inflow, unsteady airfoil aerodynamics (dynamic stall), yawed flow, dynamic wake modeling,

	o explain the effects of the different models on the resulting time series and validate the code, o interpret design standards for on- and offshore wind turbines, select the required load cases according to site-specific environmental data, o identify the dimensioning load cases and calculate design loads for different main components of a wind turbine.
Content:	**Design of Wind Energy Systems** ntroduction to industrial wind turbine design, + rotor aerodynamics and Blade Element Momentum (BEM) theory, + dynamic loading and system dynamics, + wind field modelling for fatigue and extreme event loading, + design loads and design aspects of onshore wind turbines, + simulation and measurements of dynamic loads, + design of offshore wind turbines, + power quality and grid integration on wind turbines. **Aeroelastic Simulation of Wind turbines:** The course focuses on the practical implications and hands-on experience of the aero-hydro-servo -elastic modelling and simulation of wind turbines. The subjects are similar but the treatment is complementary to the parallel course ‘Design of Wind Energy Systems’, which deals with the underlying theoretical background: O advanced wind field modelling for fatigue and extreme event loading, O modelling of wind farm flow and wake effects, O rotor aerodynamics (e.g. stationary or dynamic effects, comparison of Blade Element Momentum theory and more advanced methods like free vortex methods or CFD), O structural dynamics and dynamic modelling of wind turbine structures (modelling by ordinary or partial differential equations, stochastics, multi body system modelling), O advanced control of wind turbines, O design standards, design loads and design aspects of offshore and onshore wind turbines. The students analyse in pairs a model of an entire wind turbine with the aid of a typical wind turbine design tool like GH Bladed, Flex5 or Aerodyn/FAST.
Assessment/type of examination:	Exam or presentation or oral exam or homework or practical report
Media:	Blackboard, transparencies, beamer presentations,

	exercises using the PC
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 •

Module title:	Specialization I
Module code:	phy663
Course:	**Fiber Technology and Integrated Optics (WS, 5.04.664)** (lecture and experimental work in laboratory)
Term:	Winter
Person in charge:	Prof. Dr. Brückner, Prof. Dr. Kühn, Prof. Dr. ir. Doclo
Lecturer:	Prof. Dr. Brückner
Language:	English
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, specialization Laser & Optics
Teaching Methods/ semester periods per week:	Lecture: 4 hrs/week during first half of the semester Experimental work: 4 hrs/week during 2nd half of semester
Workload:	Attendance: 56 hrs Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus	
Recommended prerequisites:	basic knowledge on laser physics, optoelectronics or optical communication
Aim/learning outcomes:	students acquire basic knowledge for applications and handling of optical fibers and components and for assembling fiber systems
Content:	properties and preparation of optical fibers, fiber connections, optical fiber components, active optical fibers, photonic crystal fibers, polarization management, fiber optical amplifiers and lasers, Raman fiber amplifier and laser, fiber optical sensors, optical metrology
Assessment/type of examination:	Experimental work or 1 hr written examination or 30 min oral examination
Media:	Script, blackboard, computer presentation
Literature:	• Excerpts from lecture script, • Voges, Petermann: Optische Kommunikationstechnik, Springer Verlag, 2002 • John M. Senior: Optical Fiber Communication, Prentice Hall 1992

Module title:	Specialization I
Module code:	Phy663
Course:	**Advanced Topics Speech and Audio Processing (WS, 5.04.4586)**
Term:	Winter
Person in charge:	Prof. Dr. Brückner, Prof. Dr. Kühn, Prof. Dr. ir. Doclo
Lecturer:	Prof. Dr. S. Doclo, Prof. Dr.-Ing. T. Gerkmann
Language:	Englisch
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st Semester
Teaching Methods/semester periods per week:	VL: 2 SWS, PR: 2 SWS
Workload	Attendance: 56 hours Self study: 124 hours
Credit points	6
Prerequisites acc. syllabus	
Recommended prerequisites:	Basic principles of signal processing (preferably successfully completed the course Signal- und Systemtheorie and/or Blockpraktikum Digitale Signalverarbeitung)
Aim/learning outcomes:	The students will gain in-depth knowledge on the subjects' speech and audio processing. The practical part of the course mediates insight about important properties of the methods treated in a self-study approach, while the application and transfer of theoretical concepts to practical applications is gained by implementing algorithms on a computer.
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:	Exam or presentation or oral exam or homework or practical report
Media:	Blackboard, Powerpoint slides, acoustical demonstrations, computer simulations.
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, 2007. • S. Vaseghi: Advanced Digital Signal Processing and Noise Reduction, Wiley, 2006. S. Haykin: Adaptive Filter Theory, Prentice Hall, 2013.

Specialization II (phy664) lectures:

Module title:	Specialization II
Module code:	phy664
Course:	**Photovoltaic Systems & Advanced Solar Energy Meteorology (X.XX.XXX & SS 5.04.4064)**
Term:	Summer
Person in charge:	B. Poppe, N.N.
Lecturer:	Hans Holtorf, Phd , Dr. Detelv Heinemann
Language:	English
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 2nd semester
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:	RE Technologies I
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 - categorize and feature different PV systems (PV on-grid, PV off-grid, PV pumping, PV-hybrid) - explain concepts behind PV system design - explain the operation principl7es of PV systems
Content:	This specialization module covers more in-depth topics concerning photovoltaics systems and solar energy meteorology. Based on their knowledge about the solar resource and photovoltaic behaviour students learn to design a photovoltaic system for various environmental conditions and predict its performance. 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 & relevance for solar energy systems - Satellite-based estimation of solar irradiance - Solar irradiance (& solar power) forecasting - Solar radiation measurements: Basics & setup of high-quality measurement system Photovoltaic Systems (Lecture – 90 h workload) - Detailed description of involved balance of system components (e.g. inverter, charge controllers)

	- System Operation - Detailed System Design – from meteorological input across component rating to energy service output
Assessment/type of examination:	Passing of the written exam in Solar Energy Meteorology (120 min). Active participation in Photovoltaic Systems. The specific conditions of the active participation will be communicated in the beginning of the semester.
Media:	
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 • 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 & Sons, First Edition, Chichester, 2012.(ISBN-13: 978-1119992851) • lecture notes for the respective courses

Module title:	Specialization II
Module code:	phy664
Course:	**Wind Physics Student's Lab (WS & SS, 5.04.4238)**
Term:	Winter or Summer
Person in charge:	B. Poppe, N.N.
Lecturer:	Prof. Martin Kühn, Andreas Schmidt
Language:	English
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 2nd semester
Teaching Methods/ semester periods per week:	Seminar with laboratory experiments for research oriented learning / Seminar mit Blockpraktikum zum forschungsbasierten Lernen: 4 hrs/week
Workload:	Attendance: 72 hrs Self study: 108 hrs
Credit points:	6
Prerequisites acc. syllabus	• Wind Energy Utilisation (BA) or equivalent course • Design of Wind Energy Systems: in SAME SEMESTER or before
Recommended prerequisites:	
Aim/learning outcomes:	The "Wind Physics Student's Lab" aims to foster the learning processes in courses and seminars by own research activities of the students in wind physics. The course is offered in the scope of the initiative FLiF+ (German: "Forschendes Lernen im Focus") at the University Oldenburg (see https://www.uni-oldenburg.de/flif/) and is organised as seminar with integrated work in the laboratory. Groups of two students each will investigate an individual, self-formulated research question and will be guided by the supervisors through the research-based learning process. The seminar "Dynamcis 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 understanding of the control of wind turbines 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.
Content:	The seminar consists of three main phases with different learning steps: 1st phase: Class-room seminar • building up basic competences • identification of the technical tasks • introduction to current research • introduction to the learning platform • investigating standard situations and functional interaction by means of the experimental system • defining an own research question • defining an experimental strategy • planning the experiment 2nd phase: Laboratory work (1 week) • set-up, execution, data acquisition and decommissioning of the experiment

	3rd phase: Evaluation and documentation • evaluating the experiment • documentation with a short report (paper) • presentation
Assessment/type of examination:	Portfolio
Media:	
Literature:	

Module title:	Specialization II
Module code:	phy664
Course:	**Physics with Ultrashort Pulses and Intense Light (SS, 5.04.4663)**
Term:	Summer
Person in charge:	Prof. Dr. Brückner, Prof. Dr. Kühn, Prof. Dr. ir. Doclo
Lecturer:	Prof. Dr. Ulrich Teubner
Language:	German or English depending on demand
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 2nd semester
Teaching Methods/semester periods per week:	Lecture: 2 hrs/week Laboratory: 2 hrs/week
Workload:	Attendance: 56 hrs Self study: 128 hrs
Credit points:	6
Prerequisitesacc. 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 examination or presentation or homework
Media:	blackboard, transparencies, practical work in laboratory
Literature:	• E.Gamaly; Femtosecond Laser-Matter Interactions(Pan Stanford); P.Gibbon: Short pulse laser interactions with matter (Imperial College Press); D.Bäuerle: Laser Processing and Chemistry (Springer); Further literature according indication during course

Module title:	Specialization II
Module code:	Phy664
Course:	**Akustik (SS,5.04.711)**
Term:	Sommer
Person in charge:	Prof. Dr. Brückner, Prof. Dr. Kühn, Prof. Dr. ir. Doclo
Lecturer:	Prof. Dr. Steven van de Par, Prof. Dr. Dr. Birger Kollmeier
Language:	Deutsch
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 2nd Semester
Teaching Methods/semester periods per week:	VL: 3 SWS, Ü / SE / PR: 1 SWS
Workload	Attendance: 56 hours Self study: 124 hours
Credit points	6
Prerequisites acc. syllabus	
Recommended prerequisites:	
Aim/learning outcomes:	Die Studierenden erwerben fortgeschrittene der Akustik. Sie erlangen Fertigkeiten zum sicheren und selbstständigen Umgang mit modernen Konzepten und Methoden der Angewandten Physik. Sie erweitern ihre Kompetenzen hinsichtlich der Fähigkeiten zur erfolgreichen Bearbeitung anspruchsvoller Probleme der Angewandten Physik mit modernen experimentellen und numerischen Methoden, zur eigenständigen Erarbeitung von Zugängen zu aktuellen Entwicklungen der Angewandten Physik sowie zum Verständnis übergreifender Konzepte und Methoden der Angewandten Physik.
Content:	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, Stoßwellen, Photoakustischer Effekt; ausgesuchte Kapitel der Akustik, der Vibrationen und des Ultraschalls.
Assessment/type of examination:	Exam or presentation or oral exam or homework or practical report
Media:	Tafel, Folien, Beamer, Computerprogramme
Literature:	• Kollmeier, B.: Skriptum Physikalische, technische und medizinische Akustik, Universität Oldenburg, http://medi.uni-oldenburg.de/16750.html • Kuttfuff, H., Akustik Eine Einführung, Springer-Verlag • Heckl, Müller: Taschenbuch der technischen Akustik, Springer-Verlag • F.G. Kollmann: Maschinenakustik, Springer-Verlag

Module title:	Specialization II
Module code:	Phy664
Course:	**Biomedizinische Physik und Neurophysik (SS, 5.04.317)**
Term:	Summer
Person in charge:	Prof. Dr. Brückner, Prof. Dr. Kühn, Prof. Dr. ir. Doclo
Lecturer:	Prof. Kollmeier, Prof. Poppe, Prof. Verhey, Dr. Uppenkamp
Language:	German
Location:	Oldenburg
Curriculum allocation:	Bachelor in Physik, 6. Semester; Bachelor Engineering Physics, 4th or 5th semester Master Engineering Physics, 1st – 3rd Semester
Teaching Methods/ semester periods per week:	Lecture: 2 hrs/week Exercises: 2 hrs/week
Workload:	Attendance: 56 hrs Self study: 124 hrs
Credit points:	6
Prerequisites acc. syllabus	
Recommended prerequisites:	Inorganic and organic chemistry, biology (in each case Abitur level), physics (Bachelor level); additionally, recommended: Practical course attempts from the progressing and/or block practical course from the areas acoustics and/or medical physics and/or signal processing
Aim/learning outcomes:	Students are expected to gain an overview of bio-medical physics. They shall understand the activities of physicists in medicine and be able to analyse current research topics of medical physics.
Content:	Medical bases: Anatomy and physiology of humans, sense and neuro physiology, Psychophysics, pathophysiology of select organ systems, pathology of select diseases, physics in the biomedicine: Methods of biophysics and neuro physics, Roentgen diagnostics, radiotherapy, nuclear medicine, tomography, the medical acoustics/ultrasonic, medical optics and laser applications, Audiology
Assessment/type of examination:	Successful attendance of the weekly exercises, 30 min. oral exam and presentation. Here, you will find information about the consideration of bonus points for module marks.
Media:	Script, transparencies, blackboard, Beamer presentation, experiments.
Literature:	Silbernagl, S., Lang, F.: Taschenatlas der Pathophysiologie, Thieme, 2007 Silbernagel, Despopulos: Taschenatlas der Physiologie, Thieme 2007 Klinke/Silbernagl: Lehrbuch der Physiologie, Thieme, 2005 J.Richter: Strahlenphysik für die Radioonkologie, Thieme. 1998

Specialization III (phy662) lectures:

Module title:	Specialization III
Module code:	phy662
Course:	**Future Power Supply Systems (SS, X.XX.XXX)**
Term:	Winter
Person in charge:	B. Poppe, N.N.
Lecturer:	Prof. Dr. Carsten Aggert
Language:	English
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st semester
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:	
Aim/learning outcomes:	
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:	
Media:	

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

Module title:	Specialization III
Module code:	phy662
Course:	**Wind Resources and its Applications (SS, 5.04.4063 & SS, 5.06.205)** Lectures: • Advanced Wind Energy Meteorology (5.04.4063) • Wind Energy Appcation (5.06.205)
Term:	Summer
Person in charge:	B. Poppe, N.N.
Lecturer:	Dr. Igor Waldl, Dr. Detlev Heinemann
Language:	English
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 2nd semester
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 & LES models - Wind farm modelling - Offshore-Specific Conditions - Resource Assessment & Wind Power Forecasting - Wind Measurements & 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 Page **2** of **2** - 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:	
Media:	
Literature:	Advanced Wind Energy Meteorology - Holton, J.R. & 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 & E. Bossanyi, 2011: Wind Energy Handbook, Second Edition, John Wiley. - Gasch, R. & 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

Module title:	Specialization III
Module code:	phy662
Course:	**Laser Design and Beam Guiding (SS, 5.04.4664)**
Term:	Summer
Person in charge:	Prof. Dr. Brückner, Prof. Dr. Doclo, Prof. Dr. Kühn
Lecturer:	Prof. Dr. B. Struve
Language:	English / German
Location:	Oldenburg / Emden
Curriculum allocation:	Master Engineering Physics 2nd semester, specialization Laser & 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 experimental work or homework presentation
Media:	Script, blackboard, computer presentation, laboratory work
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

Module title:	Specialization III
Module code:	Phy662
Course:	**Informationsverarbeitung und Kommunikation (SS, 5.04.4012)**
Term:	Sommersemester
Person in charge:	Prof. Dr. Brückner, Prof. Dr. Kühn, Prof. Dr. ir. Doclo
Lecturer:	Dr. J. Anemüller
Language:	German or English depending on demand
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1^{st} – 3^{rd} Semester
Teaching Methods/semester periods per week:	VL: 2 SWS, Ü: 2 SWS
Workload	Attendance: 56 hours Self study: 124 hours
Credit points	6
Prerequisites acc. syllabus	
Recommended prerequisites:	Kenntnisse der Inhalte aus den Veranstaltungen Lineare Algebra, Mathematische Methoden der Physik, Messtechnik und Block-Praktikum Digitale Signalverarbeitung (FPR-B)
Aim/learning outcomes:	Die Studierenden erlernen, wie statistische Eigenschaften von Signalen zur Lösung von Problemen der Angewandten Physik, insbesondere der Klassifikation, parametrischen Modellierung und Übertragung von Signalen genutzt werden können. Theoretische Lernziele beinhalten damit eine Wiederholung und Festigung statistischer Grundlagen und eine Verständnis von deren Nutzung für Algorithmen unterschiedlicher Zielsetzung und Komplexität. Im praktischen Teil werden Eigenschaften der behandelten Methoden selbständig erarbeitet sowie Algorithmen auf dem Rechner implementiert und auf reale Daten angewendet, so daß der Umgang mit theoretischen Konzepten und ihre praktische Umsetzung erlernt werden.
Content:	Grundfragen der Informationsverarbeitung (Klassifikation, Regression, Clustering), Lösungsmethoden basierend auf Dichteschätzung und diskriminativen Ansätzen (z.B. Bayes Schätzung, k-nearest neighbour, Hauptkomponentenanalyse, support-vector-machines, Hidden-Markov- Modelle), Grundlagen der Informationstheorie, Methoden der analogen und digitalen Nachrichtenübertragung, Prinzipien der Kanalcodierung und Kompression
Assessment/type of examination:	Exam or presentation or oral exam or homework or practical report
Media:	Tafel, Folien, Beamerpräsentation der Beispielprogramme, Ausgabe von Referenz-Programmen für die Übungen
Literature:	T. M. Cover, J. A. Thomas: Elements of information theory. John Wiley, 1991 K. Sayood: Introduction to data compression. Kaufmann, 2003 Bishop: Pattern Recognition and Machine Learning, Springer, 2006 MacKay: Information Theory, Inference and Learning Algorithms, Cambridge University Press, 2003

Specialization IV (phy665) lectures:

Module title:	Specialization IV
Module code:	phy665
Course:	**Smart Grids (SS, 2.01.511)**
Term:	Winter
Person in charge:	B. Poppe, N.N.
Lecturer:	Prof. Dr. Sebastian Lehnhoff,Astrid Niesse, Dr. Jörg Bremer
Language:	English
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 2nd semester
Teaching Methods/ semester periods per week:	Lecture + Exercise : 4 hrs/week
Workload:	Attendance: 56 hrs Self study: 124hrs
Credit points:	6
Prerequisites acc. syllabus	
Recommended prerequisites:	
Aim/learning outcomes:	Revised to English taught course in Summer term 2018: Nach erfolgreichem Abschluss der Lehrveranstaltung sollen die Studierenden die bestehenden Strukturen und technischen Grundlagen von Energiesystemen zur Erzeugung, Übertragung und Verteilung elektrischer Energie und deren Zusammenspiel und Abhängigkeiten untereinander verstehen. Sie sollen ein Verständnis für die notwendigen informations- und leittechnischen Komponenten, Verfahren und Prozesse zur Führung und zum Betrieb elektrischer Energiesysteme entwickeln und An- und Herausforderungen insbesondere an die Informations- und Kommunikationstechnik (IKT) und für die Informatik abschätzen und bewerten können, die sich durch den Ausbau und die Integration unvorhersehbar fluktuierender dezentraler Erzeuger in das bestehende System ergeben. Die Studierenden sollen in die Lage versetzt werden, den Einfluss von verteilten Regelkonzepten und Algorithmen für dezentrale Erzeuger und Verbraucher in sogenannten Smart Grids auf den Betrieb elektrischer Energiesysteme einzuschätzen und hinsichtlich der Anforderungen an Betriebssicherheit, Zuverlässigkeit, Echtzeitfähigkeit und Flexibilität zur analysieren. Fachkompetenzen Die Studierenden: • benennen und erkennen die bestehenden Strukturen und technischen Grundlagen von Energiesystemen zur Erzeugung, Übertragung und Verteilung elektrischer Energie und deren Zusammenspiel und Abhängigkeiten untereinander

	-benennen notwendigen informations- und leittechnischen Komponenten, Verfahren und Prozesse zur Führung und zum Betrieb elektrischer Energiesysteme • bewerten An- und Herausforderungen die sich durch den Ausbau und die Integration unvorhersehbar fluktuierender dezentraler Erzeuger in das bestehende System ergeben schätzen den Einfluss von verteilten Regelkonzepten und Algorithmen für dezentrale Erzeuger und Verbraucher in sogenannten Smart Grids auf den Betrieb elektrischer Energiesysteme einMethodenkompetenzen Die Studierenden: -analysieren Anforderungen an Betriebssicherheit, Zuverlässigkeit, Echtzeitfähigkeit und Flexibilität in sogenannten Smart Grids auf den Betrieb elektrischen Energiesystemen • verwenden weiterführende mathematische Methoden der Netzberechnung Sozialkompetenzen Die Studierenden: • erarbeiten in Kleingruppen Lösungen zu gegebenen Problemen • diskutiert die eigenen Lösungen mit anderen Selbstkompetenzen Die Studierenden: • reflektieren den eigenen Umgang mit der begrenzten Ressource Energie
Content:	Revised to English taught course in Summer term 2018: Bei der Vorlesung „Intelligentes Netzmanagement" werden die wesentlichen elektrotechnischen Grundlagen vermittelt, um Smart Grids (als Wechselstromsysteme) zu modellieren und Eingriffe durch aktives Last- und Erzeugungsmanagement auf ihre Netzverträglichkeit hin zu analysieren. Besonderer Wert wird dabei auf die Untersuchung der Berechnungs- und Speicherkomplexität von Verfahren zur (stationären) Netzszustandsbestimmung und Lastflussrechnung gelegt, deren iterative Natur und fehlende Echtzeitfähigkeit effizientere Mechanismen und häufig heuristische Näherungsverfahren erforderlich machen, um vorgegebene harte Zeitschranken einzuhalten. Die wesentlichen Inhalte sind: • Organisation des europäischen Energiemarkts (Regulatorischer Rahmen, Verantwortlichkeiten im liberalisierten elektrischen Energiesystem) • Aufbau und Betrieb elektrischer Energieversorgungsnetze (Netztopologien, Versorgungsaufgabe, Netznutzungsentgelte, Versorgungsqualität/Systemdienstleistungen, Störfälle und Schutzsysteme) • Netzberechnung (Komplexe Zeigerdarstellung, Wirk- /Blindleistung, mathematische

	Leitungsmodelle/Netzmodelle, Abbildungen: Knotenleistungen zu Knotenspannungen/-strömen, Berechnung von Leitungsströmen, Leistungsflussrechnung, Fixpunktiterationsverfahren, Newton-Raphson-Methode, Spannungsabfälle entlang Leitungen und Kabel) • Intelligentes Netzmanagement (Smart Grids, Aggregationsformen, Ansätze des maschinellen Lernens) Nach Abschluss der Veranstaltung sollen Studierende in die Lage versetzt werden, wichtige Fragestellungen und Optimierungsaufgaben in zukünftigen Smart Grids bearbeiten zu können: • Wie \"leistungsfähig\" muss ein elektrisches Energieversorgungsnetz sein? • Ist eine gegebene Versorgungssituation stabil? • Falls nicht: Wie stabilisiere ich meine Versorgungssituation eingriffsminimal? • Wieviel Messtechnik benötige ich, um spezifische Engpässe zu erkennen? • Wie reagiere ich angemessen auf Fehlersituationen?
Assessment/type of examination:	
Media:	
Literature:	

Module title:	Specialization IV
Module code:	phy665
Course:	**Processing and analysis of biomedical data (WS, 5.04.4207)**
Term:	Winter
Person in charge:	Prof. Dr. Brückner, Prof. Dr. Kühn, Prof. Dr. ir. Doclo
Lecturer:	S. Uppenkamp, S. Ewert, V. Hohmann
Language:	English
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 1st – 3rd Semester
Teaching Methods/ semester periods per week:	VL: 2 SWS, Ü: 2 SWS
Workload:	Attendance: 56 hours Self study: 124 hours
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:	Exam or presentation or oral exam or homework or practical report
Media:	Slides, Computer Exercises
Literature:	• Kirkwood B.R. and Sterne A.C., Essential Medical Statistics: 2nd editition. Blackwell Science. Oxford, 2003 • o Cho, Z.H. and Singh J. P. J.M.: Foundations of Medical Imaging. John Wiley, New York, 1993 • o Kutz, J.N. Data-Driven Modeling and Scientific Computation: Methods for complex systems and Big Data. Oxford University Press, Oxford, 2013

Module title:	Engineering Science III
Module code:	phy655
Course:	**Lasermaterialbearbeitung unter besonderen werkstoffwissenschaftlichen Aspekten (WS, 5.04.4669)**
Term:	Winter
Person in charge:	Prof. Dr. Brückner, Prof. Dr. Kühn, Prof. Dr. ir. Doclo
Lecturer:	Dr.-Ing. Thomas Schüning
Language:	German
Location:	Emden
Curriculum allocation:	Photonik (BA) Master Engineering Physics, 1st – 3rd Semester
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:	Overview of the procedures of the material processing with laser beams: Procedure, allocation of the procedures in relation to production engineering the laser beam as tool. Deepening treatment of the manufacturing processes with laser beams in relation of quality, speed and costs. The manufacturing processes are: Cutting procedure, joining process, surface processing, material property changing, generative process. Examples from the industrial manufacturing.
Assessment/type of examination:	2 hr written final examination
Media:	Blackboard, transparencies, beamer presentation
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

Advanced Research Project (phy691):

Module title:	**Advanced Research Project**
Module code:	phy691
Course:	Advanced Research Project
Term:	Winter or Summer
Person in charge:	Prof. Dr. Doclo, Prof. Dr. Kühn, Prof. Dr. Neu
Lecturer:	Acc.
Language:	English or German
Location:	Acc. selected course
Curriculum allocation:	Master Engineering Physics, 3th Semester
Teaching Methods/ semester periods per week:	Project work / 20 hours/week
Workload:	Attendance: 280 hours Self study: 170 hours
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:	Reports or presentation
Media:	Practical course, written report on the results, presentation, electronic media, practical demonstrations
Literature:	• Acc. Research field • Recent publications on specific topics

Tools and Skills in Engineering Sciences (phy681) lectures:

Module title:	Tools and Skills in Engineering Sciences
Module code:	phy681
Course:	**Tools in advanced photonics (SS, 5.04.4665)**
Term:	Summer
Person in charge:	Prof. Dr. Doclo, Prof. Dr. Neu
Lecturer:	Brückner, Neu, Struve, Teubner, Schellenberg, Koch
Language:	German or English
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 2nd semester
Teaching Methods/semester periods per week:	Lab course / 4 hrs/week
Workload	Attendance: 56 hours Self study: 124 hours
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:	Teaching and learning in this component will be through "hands on" demonstration. This form of teaching and learning is important in acquiring competence and skills and advancing understanding by practical experience. The students learn to consider specific key instrument types in current usage in the field of photonics, laser and optics. This will be delivered in a lab course study format with each instrument being evaluated in terms of operating principle, design, and signal processing.
Content:	Laser design and concepts in photonics, solid state lasers, tunable laser systems, gas lasers, industrial laser systems, ultrashort laser systems, diode lasers, optical fiber technology, photonics instrumentation.
Assessment/type of examination:	max 1h oral examination or experimental work and laboratory reports or presentation or homework
Media:	Practical course, written report on the results, presentation, electronic media, practical demonstrations
Literature:	• T. Yoshizawa (Ed.): Handbook of Optical Metrology: Principles and Applications, 2nd rev. ed., Crc Pr Inc., 2015 • Saleh & Teich, Fundamentals of Photonics (Wiley) • W. Demtröder, Laser Spectroscopy Vol. 1&2, Springer, 5nd ed. 2014 & 4th ed., 2008 • Frank Träger (Ed.): Springer Handbook of Lasers and Optics. Springer, 2nd ed., 2012. • Recent publications on specific topics •

Module title:	Tools and Skills in Engineering Sciences
Module code:	phy681
Course:	**Workshop Management (SS, 5.04.4666)**
Term:	Summer
Person in charge:	Prof. Dr. Doclo, Prof. Dr. Neu
Lecturer:	Dr. S. Koch , M. Reck
Language:	German or English depending on demand
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 2nd semester
Teaching Methods/semester periods per week:	Seminar / 2 h/Woche
Workload	Attendance: 28 hours Self study: 152 hours
Credit points	6
Prerequisites acc. syllabus	
Recommended prerequisites:	
Aim/learning outcomes:	Students are able to organize summer schools, workshops, etc..
Content:	Students should develop ideas for summer schools or workshops within the field of physics or public-spirited to enhance the community of the study course Engineering Physics. Events will be planned, arranged and carried out by the participants. The seminar includes - ideas for summer schools, workshops, conferences, etc. - planning financial aspects - funding - time tables - human resources - arranging locations.
Assessment/type of examination:	1 presentation or 1 oral examination or 1 homework or 1 practical exercise
Media:	
Literature:	

Module title:	Tools and Skills in Engineering Sciences
Module code:	phy681
Course:	**International Sustainability Management (WS, 2.12.021 & 2.12.022)**
Term:	Winter
Person in charge:	Prof. Dr. Doclo, Prof. Dr. Neu
Lecturer:	Prof. Dr. Bernd Siebenhüner
Language:	English
Location:	Oldenburg
Curriculum allocation:	Master Engineering Physics, 2nd semester
Teaching Methods/semester periods per week:	V (2 SWS) S (2 SWS)
Workload	Attendance: 56 hours Self study: 124 hours
Credit points	6
Prerequisites acc. syllabus	
Recommended prerequisites:	
Aim/learning outcomes:	- Knowledge on the basic concepts and strategies of sustainability management related to corporate practice: * Sustainability: Basic concepts, strategies, * Domestic and international challenges for business, * Business case for sustainable development, * Integrative concepts of sustainable corporations, * Sustainable strategies, * Management instruments - Discussing topics of international sustainability management with students from different scientific disciplines. - Ability to present and evaluate different concepts and instruments of international sustainability management
Content:	This module consists of a one lecture and one seminar (2 weekly contact hours per lecture/seminar) dealing with basic concepts and strategies of sustainability management within corporations. Both, lecture and seminar give an overview of current sustainability strategies for companies and present a variety of instruments to integrate and initiate sustainable development within corporations. While the lecture focuses more on theoretical approaches and introduces basic concepts of corporate sustainability management, the seminar provides a variety of case studies and business cases to demonstrate different concepts and instruments of sustainability management. The seminar provides the possibilities for inter- and transdisciplinary exchange and discussions.
Assessment/type of examination:	Presentation and written summary
Media:	
Literature:	• BMU/BDI (Eds.) 2002: Sustainability Management in Business Enterprises. CSM, University of Lueneburg (Schaltegger, Herzig, Kleiber, Müller), http://www2.leuphana.de/umanagement/csm/content/nama/downloads/pdf-dateien/nmu_fs_engl_final.pdf • Charter, Martin/Tischner, Ursula (Eds.) (2001): Sustainable Solutions, Developing Products and Services for the Future, Sheffield: Greenleaf; • Board on Sustainable Development of the National Research Council, 1999 Our Common Journey: A Transition Toward Sustainability.

	Washington D.C.: National Academy Press; • Dyllick, Thomas, and Kay Hockerts, 2002 "Beyond the Business Case for Corporate Sustainability." Business Strategy and the Environment, 2002: 130-141; • Gladwin, T., et al., 1995 "Shifting paradigms for sustainable development: Implications for management theory and research." Academy of Management Review, 20: 874 - 907; • Hart, Stuart, 1997 "Strategies for a sustainable world." Harvard Business Review, January-February 1997: 67-76; • Holliday, Charles O., et al., 2002 Walking the Talk. The Business Case for Sustainable Development. Sheffield: Greenleaf; • Hutchinson, Andrew, and Frances Hutchinson, 1997 Environmental Business Management: Sustainable Development in the New Millennium. London u.a.: McGraw-Hill. • Shrivastava, Paul, and Stuart L. Hart, 1995 "Creating sustainable corporations." Business Strategyandthe Environment 1995: 154 165.

Master Thesis:

Module title:	**Master Thesis**
Module code:	MAM
Course:	Master Thesis
Term:	Winter or Summer
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:	Die erlernten Kenntnisse und Methoden sind auf ein konkretes wissenschaftliches Problem anzuwenden und mit den erworbenen Schlüsselqualifikationen wie Teamarbeit, Projektmanagement und Präsentationstechniken zu kombinieren.
Content:	Die Masterarbeit bildet den Abschluss des Masterstudiums. In ihrem Rahmen bearbeiten die Studierenden selbständig ein aktuelles Thema aus den Forschungsgebieten der Arbeitsgruppen. Begleitet wird die Arbeit durch ein Seminar zur Darstellung und Überprüfung der Zwischenergebnisse und des Fortgangs der Arbeit. Die Ergebnisse werden in einem Abschlusskolloquium verteidigt und sollen in der Regel zu einer wissenschaftlichen Publikation beitragen.
Assessment/type of examination:	Master Thesis and colloquium
Media:	As required
Literature:	As required