Module Advanced Nonlinear Optics

Modul: Advanced Nonlinear Optics

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	4	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	4	60 min	benotet

Workload	120 h
Attendance study period	56 h
Self-study time	64 h
Module coordinator	Prof. Dr. Andrea Trabattoni
Lecturer	Prof. Dr. Andrea Trabattoni
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Advanced Nonlinear Optics - Vorlesung	4	Muendliche Pruefung

Requirements for participation:	Recommended for participation:
none	Basic knowledge of optics, laser physics, atomic physics. “Nonlinear optics” course.

Qualification goals

The students will acquire knowledge on advanced light-matter interactions, from the mathematical and physical point of view. They will learn about the nonperturbative physics of ultraintense and strong laser fields, and important concepts around light-driven dynamics in atoms, molecules and materials. The lecture will be accompanied by numerical exercises and practical examples to guide the students through cutting-edge topics of light-matter interactions.

Contents

- Overview of light-atom interactions.
- The photoelectric effect and beyond.
- Overview of perturbative nonlinear optics.
- The breakdown of the perturbative picture.
- Above-threshold ionisation.
- Multi-photon absorption vs. electron tunnelling.
- Atoms interacting with high-energy photons.
- Light-driven electronics in matter.
- Photo-driven electron-nucleus interactions in nuclear transitions.

Special features

Literature

Boyd, Nonlinear Optics, Academic Press. J.C. Diels, W. Rudolph: Ultrashort Laser Pulse Phenomena, 2 Ed. (Elsevier, 2006). Thomas Brabec, "Strong Field Laser Physics”, Springer Series in optical sciences (2008). Published research papers will be suggested during the course.

Applicability in other degree programs

LbS/SprintING M.Ed.; Optische Technologien B.Sc.;

Module Advanced Thermodynamics / ThermoLab

Modul: Advanced Thermodynamics / ThermoLab

Type of module	Area of competence
Pflicht	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	. Semester	**Admission SoSe:**	. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
SL	Studienleistung	1	2 Laborversuche	unbenotet
PL	Klausur / Muendliche Pruefung	4	90 min/20 min	benotet

Workload	150 h
Attendance study period	70 h
Self-study time	80 h
Module coordinator	Prof. Dr.-Ing. habil. Stephan Kabelac
Lecturer	Prof. Dr.-Ing. habil. Stephan Kabelac
Institute	Institut für Thermodynamik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Advanced Thermodynamics / ThermoLab - Vorlesung	2	Studienleistung
Advanced Thermodynamics / ThermoLab - Übung	2	Klausur / Muendliche Pruefung
Advanced Thermodynamics / ThermoLab - Labor	1	

Requirements for participation:	Recommended for participation:
keine	Basics of Thermodynamics (Thermodynamics I)

Qualification goals

After successful completion of this module the student will be able to describe different pathways in energy conversion on transferring primary energy into technical useful energy.

Contents

This module competes the basic foundation of technical thermodynamics by applying the laws of thermodynamics to a variety of energy conversion processes. They learn to design different types of energy conversion devices such as furnaces, fuel cells, gas turbines and Rankine cycles on a quantitative basis. Also describing the environmental impact on behalf of CO2-emissions by burning fossile fuels is part of the learned methods. Furthermore they will assess different energy conversion capabilities using the exergy concept. By the lab the students will gain practical experience in running energy conversion devices on a laboratory scale and social competence through teamwork. Table of Content: - Short repetition of the first and second law of thermodynamics - Combustion and fuel cell basics - Rankine cycle, stirling engine and joule cycle as a heat conversion machines - Modern steam power plant, carbon capture and storage - Energy conversion in nozzle, diffusor, turbine and compressor - Heat pump, refrigerator and humid air

Special features

2 laboratories are part of this module. This course is taught in English language and has the same content as the course "Thermodynamics II / ThermoLab" held in German language. It can substitute the German version.

Literature

Moran, M. J.; Shapiro, H. M.; Boettner D. D. und Bailey, B. B.: Fundamentals of Engineering Thermodynamics, 8th ed. Hoboken: Wiley, 2014 Kondepudi, D.: Modern Thermodynamics, 2nd ed.; Hoboken: Wiley, 2014 Van Wylen, G. J.; Sonntag, R. E.; Borgnakke, C.: Fundamentals of classical thermodynamics, 4th ed.; New York: Wiley, 1994

Applicability in other degree programs

Wirtschaftsingenieur B.Sc.;

Module Analysis of deformation measurments

Modul: Analysis of deformation measurments

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	4	15 min	benotet
SL	Studienleistung	1	Übung	unbenotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Dr.-Ing. Mohammad Omidalizarandi
Lecturer	Dr.-Ing. Mohammad Omidalizarandi
Institute	Geodätisches Institut Hannover
Faculty	Fakultät für Bauingenieurwesen und Geodäsie

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Analysis of deformation measurments - Vorlesung	2	Muendliche Pruefung
Analysis of deformation measurments - Hörsaalübung	2	Studienleistung

Requirements for participation:	Recommended for participation:
none	Knowledge in adjustment computations is necessary, programming skills are helpful (i.e. MATLAB).

Qualification goals

The module provides in-depth knowledge in the detection, analysis and determination of deformations (change detection) from engineering measurement processes. Upon successful completion of the module, the students can analyse, evaluate and interpret synthetic and real data in different model approaches.

Contents

Deformation measurements (Terrestrial laser scanner, Image-assisted total stations, Inertial measurement units, Laser tracker, etc.)

- Deformation processes
- Point / line / surface-based deformation monitoring
- Descriptive deformation models (congruence models, block movements, strain, kinematic model)
- Sensitivity analysis
- Causal deformation models (static model, dynamic model)
- models (static model, dynamic model)
- Evaluation and analysis strategies
- Practical examples in civil structures (bridges, tunnels, dams, etc.)

Special features

Practical excercises for deepening the knowledge with the aid of practical examples. Veranstaltung wird in Englisch gegeben.

Literature

Most of the analysis techniques are introduced based on actual publications and datasheets. The individual references are given in the lecture notes. One basic reference is: Ghilani, C. D. und Wolf, P. R.: Adjustment computations. Spatial data analysis. 5. Aufl. Hoboken, NJ: John Wiley & Sons, Inc., 2010

Applicability in other degree programs

Module Application-Specific Instruction-Set Processors

Modul: Application-Specific Instruction-Set Processors

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	5	20 min	benotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof. Dr.-Ing. Holger Blume
Lecturer	Prof. Dr.-Ing. Holger Blume
Institute	Institut für Mikroelektronische Systeme
Faculty	Fakultät für Elektrotechnik und Informatik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Application-Specific Instruction-Set Processors - Vorlesung	2	Muendliche Pruefung
Application-Specific Instruction-Set Processors - Hörsaalübung	2	

Requirements for participation:	Recommended for participation:
keine	empfohlen: - Digitalschaltungen der Elektronik (für ET-Studierende) - Grundlagen digitaler Systeme (für Informatiker)

Qualification goals

Die Studierenden kennen die erweiterte Prozessorarchitektur (Instruction-, Data-, und Task-Level- Parallelism). Sie sind fähig zur Umsetzung von anwendungsspezifischen Instruktionssatz-Prozessoren (ASIPs). Sie können Arithmetik-orientierten Hardware-Erweiterungen implementieren. Sie kennen neuartige Entwick- lungstendenzen von Prozessoren, wie z.B. hochparallele Prozessoren und rekonfigurierbare Prozessoren.

Contents

1. Introduction to Embedded Computer Architectures. — 2. Fundamentals of Processor Design. — 3. Application-Specific Instruction-Set Processor (ASIP). Customizable processors. — 4. Computer Arithmetics. Hardware acceleration of complex arithmetic functions. — 5. Reconfigurable Processor Architectures. — 6. Approximate and Stochastic Processor Architectures. — 7. Fault-Tolerant Processor Architectures. — 8. Cryp- tographic Processor Architectures. — 9. Neuromorphic Processor Architectures. AI Processor Architectures..

Special features

Diese Vorlesung wird auf Englisch unterrichtet.

Literature

- Gries, M.; Keutzer, K.; ”Building ASIPS: The Mescal Methodology”, Springer, 2010 -Leibson, S.: ”Designing SOCs with Configured Cores. Unleashing the Tensilica Xtensa and Diamond Cores”, Morgan Kaufmann, 2006 -Henkel, J.; Parameswaran, S.:”Designing Embedded Processors”, Springer, 2007 -Nurmi, J.: ”Processor Design. System-On-Chip Computing for ASICs and FPGAs”, Springer, 2007 -Flynn, M. J.; Luk, W.: ”Computer System Design. System-on-Chip”, Wiley, 2011 -González, A.; Latorre, F.; Magklis, G.: ”Processor Microarchitecture: An Implementation Perspective”, Morgan&Claypool Publishers, 2010 -Fisher, J.; Faraboschi, P.; Young, C.: ”Embedded Computing: A VLIW Approach to Architecture, Compilers, and Tools”, Morgan Kaufmann, 2005. -Hennessy, J.L.; Patterson, D. A.; ”Computer Architecture: A Quantitative Approach”, Morgan Kaufmann, 2011

Applicability in other degree programs

Module Applied Machine Learning in Genomic Data Scienece

Modul: Applied Machine Learning in Genomic Data Science

Type of module	Area of competence
Wahlpflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	5	20 min	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Dr.-Ing. Jan Voges
Lecturer	Dr.-Ing. Jan Voges
Institute	Institut für Informationsverarbeitung
Faculty	Fakultät für Elektrotechnik und Informatik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Applied Machine Learning in Genomic Data Science - Vorlesung	2	Muendliche Pruefung
Applied Machine Learning in Genomic Data Science - Hörsaalübung	1	

Requirements for participation:	Recommended for participation:
none	Hands-on programming experience (preferably in Python) is required.

Qualification goals

Students will learn how to preprocess and prepare genomic data for machine learning tasks, choose appropriate features, train, and evaluate models, and interpret the results. By the end of the course, students will have a solid understanding of how machine learning can be applied to genomics and related areas, enabling them to explore further research and career opportunities in this exciting and rapidly evolving field. The course consists of a standard lecture, exercise sessions and project work. During the lecture the important concepts are introduced. In the exercise sessions, students will be guided in practical programming exercises. In the project work, the students work in small groups on programming projects during the semester. The successful participation in the project work is a pre-requisite to take part in the final exam.

Contents

The combined field of machine learning, genomics, and data science has witnessed a remarkable rise in recent years, transforming the landscape of biomedical research and healthcare, and revolutionizing our understanding of disease mechanisms and drug development, paving the way for precision medicine. In this course, students will enhance their understanding of how machine learning techniques can be applied to analyze and interpret biological data, specifically in the context of genomics. This course will provide students with a solid foundation in basic concepts and techniques used in genomic data science. Students will learn about various machine learning algorithms. They will gain an understanding of how these algorithms work and when to apply them to different types
of data.

Special features

Participation limit: 30 (limited by room size). The project work must be completed during the semester; the successful participation in the project work is a pre-requisite to take part in the final exam. Lecture, exercise sessions and project work are only offered in the winter semester.

Literature

Durbin et al., Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids

Applicability in other degree programs

Module Applied Wave Optics

Modul: Applied Wave Optics

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe/SoSe	1 Semester	Englisch	4	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
SL	Muendliche Pruefung	0	30 min	unbenotet
PL	Klausur / Muendliche Pruefung	4	90 min/ 30 min	benotet

Workload	120 h
Attendance study period	28 h
Self-study time	92 h
Module coordinator	Dr.-Ing. Reinhard Caspary
Lecturer	Dr.-Ing. Reinhard Caspary
Institute	Cluster of Excellence PhoenixD
Faculty	

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Applied Wave Optics - Vorlesung	2	Muendliche Pruefung Klausur / Muendliche Pruefung

Requirements for participation:	Recommended for participation:
none	Electromagnetism, Maxwell’s equations, geometrical optics.

Qualification goals

The students describe the physical principles of dielectric waveguides. They derive the behaviour of electromagnetic fields and waves at interfaces from Maxwell's equations. Based on this, they describe the prerequisites and properties of total reflection. From the conditions for total reflection and constructive interference, they develop the characteristic equation of wave guidance. They solve the wave equation graphically for simple film waveguides and develop the transverse modes in more complicated waveguiding structures based on this. They use the concept of mode expansion to describe non-ideal waveguides as well as coupling structures in practice.

The students explain the significance of stable or unstable laser resonators and derive stability criteria for simple resonators using the transfer matrix method. They explain the concept of coherence of optical radiation and describe experiments for measuring the coherence length. They derive the basic terms of the rate equation for lasers and name important consequences from the rate equation in the steady state. They derive laser threshold and laser modes from the transmission of the Fabry-Perot resonator.

The students describe the recording and reproduction of transmission holograms and derive important boundary conditions. They compare holography with photography and tomography. They identify the holographic recording as an interferogram and derive its diffraction properties mathematically. They name the two basic concepts of digital holography and explain digital holographic microscopy as an application example.

Contents

- Maxwells equations, wave equation
- Plane waves, Poyntings theorem
- EM fields at interfaces
- TE/TM waves, Fresnel equations
- Wave guiding, transversal modes
- Mode expansion, mode coupling
- Coupling structures

Module Applied Wave Optics

Modul: Applied Wave Optics

- Laser resonator, resonator stability - Optical coherence - Rate equations, gain equations - Transmission holograms - Digital holography, computer generated holograms
Special features
Literature
A. Ghatak: Optics; F. A. Jenkins, H. E. White: Fundamentals of Optics; K. J. Ebeling: Integrated Optoelectronics; F. K. Kneubühl, M. W. Sigrist: Laser; J. W. Goodman: Introduction to Fourier Optics
Applicability in other degree programs
LbS/SprintING M.Ed.; Optische Technologien B.Sc.;

Module Artificial intelligence in propulsion system develpment for sustainable mobility

Modul: Künstliche Intelligenz in der Antriebssystementwicklung für nachhaltige Mobilität

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Deutsch/Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	5	20 min	benotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Dr.-Ing. Reza Rezaei
Lecturer	Dr.-Ing. Reza Rezaei
Institute	Institut für Technische Verbrennung
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Künstliche Intelligenz in der Antriebssystementwicklung für nachhaltige Mobilität - Vorlesung	2	Muendliche Pruefung
Künstliche Intelligenz in der Antriebssystementwicklung für nachhaltige Mobilität - Praktikum	1	
Künstliche Intelligenz in der Antriebssystementwicklung für nachhaltige Mobilität - Exkursion	1	

Requirements for participation:	Recommended for participation:
keine	Verbrennungsmotoren I Mechatronische Grundkenntnisse zur Antriebstechnik

Qualification goals

Das Modul vermittelt praxisorientiert die Grundlagen der virtuellen Entwicklung alternativer Antriebe sowie die Nutzung intelligenter Methoden in der Automobilindustrie für eine nachhaltige Mobilität. Nach erfolgreicher Absolvierung des Moduls sind die Studierenden in der Lage:
- Aktuelle Trends in der Automobilindustrie einzuordnen
- Nachhaltige CO2-neutrale Antriebskonzepte zu beschreiben und zu unterscheiden
- Die Charakteristik alternativer Antriebe sowohl auf Komponenten- als auch auf Gesamtsystemebene wiederzugeben
- Den virtuellen Entwicklungsprozess in der Automobilindustrie von der Hardwareauslegung bis zur Felderprobung zu erläutern
- Gängige Simulationstools und neuartige modellbasierte Ansätze zur Auslegung und Bewertung von Antriebskonzepten zu nutzen
- Mithilfe von KI bzw. maschinellem Lernen eine Optimierung von Antriebssystemen vorzunehmen
- Weitere Anwendungen wie Data Science, zustandsorientierte Instandhaltung (CBM) und autonomes Fahren anhand realer Industrieprojekte einzuordnen

Contents

Es wird ein Überblick zu aktuellen Trends in Automobilindustrie gegeben. Die CO2 neutralen Antriebskonzepte von H2-Verbrennung bis zur Elektrifizierung werden kurz vorgestellt. Der Fokus dabei liegt auf der Nutzung neuartiger modellbasierter Ansätze inkl. maschinelles Lernen zur Auslegung und Bewertung der neuen Antriebskonzepte anhand von realen Beispielen. Dabei zielt die Methodik darauf ab, das Systemverhalten zu verstehen und mit neuartigen Methoden zu modellieren, um mit KI bzw. maschinellen Lernmethoden zu optimieren und im Anschluss das Antriebskonzept virtuell zu erproben. Weitere Anwendungen wie Data Science, zustandsorientierte Instandhaltung (CBM), autonomes Fahren, etc. werden anhand der realen Industriebeispielen vorgestellt. Hierzu, gibt es Gastvorträge aus der „University of Alberta (Canada) Energy Mechatronics Lab.“ Modulinhalte: 1) Vorstellung des modellbasierten Entwicklungsprozesses vom Konzept bis zur Serie inkl. Funktionsentwicklung und Control 2) Vorstellung aktueller Simulationskette mit Fokus 0D/1D

Module Artificial intelligence in propulsion system develpment for sustainable mobility

Modul: Künstliche Intelligenz in der Antriebssystementwicklung für nachhaltige Mobilität

Simulation, insbesondere GT-Suite inkl. Künstliche Intelligenz 3) Zwei Workshops (Übungen) zur Umgang mit der Simulationstoolkette. In der Vorlesungszeit werden Lizenzen wie GT-Suite, Simulink, etc. bereitgestellt 6) Praktische Beispiele aus realen Industrieprojekten zur Nutzung der modellbasierten Entwicklung und KI für die Antriebsystementwicklung 5) Theoretische Hintergründe der Modellierung, Auslegungsmethode, KI, etc. 6) Bearbeitung einer Projektarbeit zur eigenständigen Nutzung der Modellierungstoolkette für eine praxisrelevante Fragestellung
Special features
Die Teilnahme an einer Exkursion zur IAV am Standort Gifhorn (Zeitrahmen: 1 Tag) ist erforderlich. Die Exkursion beinhaltet den Besuch von Prüfständen der IAV, Fachvorträge, Einblick in verschiedene Produkte etc. inklusive Nachbereitung
Literature
Applicability in other degree programs
Maschinenbau M.Sc.; Mechatronik und Robotik M.Sc.; Optische Technologien M.Sc.;

Module Aspects of Process Design in Forming Technology

Modul: Aspects of Process Design in Forming Technology

Type of module		Area of competence					
Wahl							
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Klausur	5	90 min	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr.-Ing. Bernd-Arno Behrens
Lecturer	Prof. Dr.-Ing. Bernd-Arno Behrens Dr.-Ing. Richard Krimm
Institute	Institut für Umformtechnik und Umformmaschinen
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Aspects of Process Design in Forming Technology - Vorlesung	2	Klausur
Aspects of Process Design in Forming Technology - Hörsaalübung	1	

Requirements for participation:	Recommended for participation:
keine	keine

Qualification goals

• Understanding of the basic principles for material characterisation and numerical simulation used for the analysis of forming processes • Ability to apply digital design tools to solve problems related to forming technology. • Knowledge about restrictions based on pressshop facilities

Contents

This module provides an insight into the process of metal forming. After an introduction into the fundamentals of forming technology, the development of forming processes, the computer aided design process and the finite element analysis will be addressed. Experimentally determined parameters build the input for these analyses. The forming process takes place by use of various forming machines and peripheral devices. Subsequently, process-integrated quality assurance methods will be presented.

Special features

Vorlesungssprache: Englisch / Language of lectures: English

Literature

Handbook of Metal Forming, Lange, K.; McGraw-Hill, New York, 1985. R.H. Wagoner, J.L. Chenot: Fundamentals of Metal Forming, John Wiley and Sons, Inc. 1997 T. Altan, G. Ngaile, and G. Shen: Cold and Hot Forging, Fundamentals and Applications, ASM International, 2005 Bei vielen Titeln des Springer-Verlages gibt es im W-Lan der LUH unter www.springer.com eine Gratis Online-Version.

Applicability in other degree programs

Computational Methods in Engineering M.Sc.;

Module Atomic Optics

Modul: Atomoptik

Type of module				Area of competence			
Wahl							
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
SoSe	1 Semester	Englisch	4	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Klausur	3	90 min	benotet
SL	Studienleistung	1	Übungszettel >50%	unbenotet

Workload	120 h
Attendance study period	42 h
Self-study time	78 h
Module coordinator	Prof. Dr. Silke Ospelkaus-Schwarzer
Lecturer	Prof. Dr. Silke Ospelkaus-Schwarzer
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Atomoptik - Vorlesung	2	Klausur
Atomoptik - Übung	1	Studienleistung

Requirements for participation:	Recommended for participation:
keine	Atom and Molecular Physics, Quantumoptics recommended

Qualification goals

Students will gain insight in recent developments in the field of atomic physics.

Contents

Recent experimental procedures to investigate the physics of ultracold gases, lasermanipulation of single atoms and quantum engineering are discussed experimentally and theoretically.

- Matter-light interaction
- Radiation pressure
- Atom- and ion traps
- Cooling by evaporation
- Bose-Einstein condensation
- Ultracold Fermi gases
- Experiments based on ultracold and degenerated gases
- Atoms in periodic optical gratings
- ATOMICS and modern atomic physics experiments

Special features

The courses name on Stud.IP is "Atomoptik"

Literature

B. Bransden, C. Joachain, „Physics of Atoms and Molecules”, Longman 1983 R. Loudon, “The Quantum Theory of Light”, OUP 1973 Van der Straaten

Applicability in other degree programs

LbS/SprintING M.Ed.; Optische Technologien B.Sc.;

Module Audio and Speech Signal Processing

Modul: Audio and Speech Signal Processing

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	4	60 min	benotet
SL	Studienleistung	1	Laborübung	unbenotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Dr. -Ing. Waldo Nogueira Vazquez
Lecturer	
Institute	Institut für Informationsverarbeitung
Faculty	Fakultät für Elektrotechnik und Informatik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Audio and Speech Signal Processing - Vorlesung	2	Klausur
Audio and Speech Signal Processing - Hörsaalübung	1	Studienleistung
Audio and Speech Signal Processing - Labor	1	

Requirements for participation:	Recommended for participation:
keine	Grundlagen der digitalen Signalverarbeitung,Grundlagen von Matlab Digitale Signalverarbeitung,Informationstheorie, Quellencodierung,

Qualification goals

Sie haben die theoretischen und praktischen Kompetenzen erworben in Bezug auf: Grundlagen der Akustik, Physiologie und xnehmung von Schall, Grundlagen der digitalen Signalverarbeitung von Audiosignalen, Methoden zur Modellierung und Verarbeitung von Audio- und Sprachsignalen.

Contents

Das Modul setzt sich aus drei Teilen zusammen. Eine Vorlesung (2 SWS), eine Übung (1 SWS) und einer Laborübung (1 SWS). Das Modul vermittelt die Grundlagen der Sprachakustik. Nach erfolgreicher Absolvierung des Modulssind die Studierenden in der Lage, eine Methodik zur Analyse von Code, Erkennung und Synthese von Audiosignalen mithilfe von Signalverarbeitungstechniken zu entwickeln. Die Modulinhalte sind Mechanismen der Sprachproduktion, Klangklassifikation, Klangrepräsentation. Sowie Grundlagen der xnehmung: Tonhöhe, Intensität und Klangfarbe, Spektralanalyse von Audio- und Sprachsignalen und Sprachmodelle: Physikalische Sprachmodelle, Grundlagen der Sprachxnehmung sowie Spektrale Transformation von Audio- und Sprachsignalen.

Special features

Englischsprachige Lehrveranstaltung. Eine Studienleistung muss in der Form eines Kurztestat erbracht werden.

Literature

Basic Literature: - Quatieri, T.F. 2001. Discrete-Time Speech Signal Processing: Principles and Practice. Prentice Hall - Rabiner, L.R. and R.W. Schafer.2007. Introduction to Digital Speech Processing. Foundations and Trends in Signal Processing, Vol.1, Nos. 1-2, 2007 Additional Literature: - Rabiner, L.R. and R.W. Schafer. 1978. Digital Signal Processing of Speech Signals. Prentice Hall - OShaughnessay, D. 1999. Speech communications: human and machine. Wiley, John & Sons - Rabiner, L.R. and B.H.Juang. 1993. Fundamentals of Speech Recognition. Prentice Hall - Park, Sung-won. Linear Predictive Speech Processing - Spanias, Andreas. 1994."Speech Coding: A Tutorial Review". Proceedings of the IEEE - Pan, Davis. 1995. "A Tutorial on MPEG/Audio Compression". IEEE Multimedia Journal - Rabiner, Lawrence. 1989. "A Tutorial on Hidden Markov Models and Selected Applications in Speech Recognition". Proceedings of the IEEE

Module Audio and Speech Signal Processing

Modul: Audio and Speech Signal Processing

Applicability in other degree programs
Computational Methods in Engineering B.Sc.; Mechatronik und Robotik M.Sc.;

Module Basics of Simulation and Data Science

Modul: Grundlagen der Simulation und Data Science

Type of module				Area of competence			
Wahlpflicht							
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	5. Semester	**Admission SoSe:**	5. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Ausarbeitung	5	Ausarbeitung und Präsentation	benotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof. Dr.-Ing. Philipp Geyer
Lecturer	Prof. Dr.-Ing. Philipp Geyer
Institute	Institut für Entwerfen und Konstruieren, Nachhaltige Gebäude Systeme
Faculty	Fakultät für Architektur und Landschaft

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Grundlagen der Simulation und Data Science - Seminar	4	Ausarbeitung

Requirements for participation:	Recommended for participation:
keine	keine

Qualification goals

The students are able to: Collect and prepare data about performance of buildings or other engineering artefacts of by use of sensors Analyze data and conclude on reasons of good or bad performance Prepare data-driven models and use the for prediction and decision making

Contents

Welcome to a fascinating intersection of architecture and technology – a place where the future of designing buildings is unfolding right in front of you. With the rise of the Internet of Things (IoT), you're about to jump into a journey that shows you how data is changing the way we think about buildings.

Think about solving real-world puzzles about data quality. How do we make sense of data from those nifty IoT devices? In this course, it's like a fun playground – you'll get your hands on these devices and see how they're shaking up the world of architecture.

Have you ever wondered how IoT can change the way we track how buildings use heat and energy? Get ready to dive into how these devices can help us understand how buildings stay warm or cool. But that's just the start. You'll also learn about data – like how to handle missing bits of data, noisy information, and find hidden patterns.

As someone studying to be an architect, you're not just drawing buildings – you're creating experiences. And guess what? Data is like your secret tool. Discover the thrill of working with data and turning it into smart ideas. Then, watch as your ideas turn into pictures that help you make decisions to make even better buildings.

Imagine standing in front of a famous building like ArchLand, armed with data. It's not just a building anymore; it's like a canvas for your creativity. You can dive into its temperature patterns, make it more comfortable, and save energy using the data you've collected.

But there's more – get ready to explore the world of machine learning, where you'll create models that can predict and come up with new ideas. This isn't just a regular architecture class; it's like a ticket to shaping the architecture of the future.

Ready to jump in and learn how to use IoT and data skills to design amazing buildings? Come on board and be part of the exciting changes happening in architecture!

Module Basics of Simulation and Data Science

Modul: Grundlagen der Simulation und Data Science

Special features
Keine
Literature
Keine
Applicability in other degree programs

Module Best Practices for the Scientist Programmer

Modul: Best Practices für den programmierenden Wissenschaftler

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Deutsch/Englisch	3	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Projektorientierte Prüfungsform	3	Vortrag + Diskussion (60 min.)	benotet

Workload	90 h
Attendance study period	28 h
Self-study time	62 h
Module coordinator	apl. Prof. Dr. Ayhan Demircan
Lecturer	apl. Prof. Dr. Ayhan Demircan
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Best Practices für den programmierenden Wissenschaftler - Seminar	2	Projektorientierte Prüfungsform

Requirements for participation:	Recommended for participation:
keine	Ability to perform simple programming tasks in a language of choice (preferably Python)

Qualification goals

Besides their technical competence, the students develop their methods in literature research, implementation of technical and scientific knowledge, as well as their presentation techniques together with their ability to lead scientific discussions.

Contents

The students can choose among several topics, ranging over various fields in physics that have a high focus on computation. Topics include but are not limited to: - Quantum mechanics: Time-independent Schrödinger equation, Time-dependent Schrödinger equation, Quantum Monte Carlo simulations, Transfer-matrix methods - Statistical physics: Exact enumeration methods, Monte Carlo simulation methods, Molecular dynamics simulations, Spin dynamics simulations - Nonlinear Optics: The nonlinear Schrödinger equation (Solitons), The Lugiato Lefever equation (Cavity solitons), The Korteweg-De Vries equation, Laser rate equations For the seminar work, a student can put emphasis on one out of many possible "best practices", as, e.g., data visualization, data animation, testing, and the choice of adequate programming paradigms (e.g. recursive, divide-and-conquer, or object-oriented techniques). To complete the seminar, the student has to present the topic of his/her choice in terms of a semiar talk with a subsequent discussion.

Special features

keine

Literature

We provide specific literature for the individual topics, as well as concise Python scripts that solve the task at hand in a simple way.

Applicability in other degree programs

LbS/SprintING M.Ed.;

Module Biointerface Engineering

Modul: Biointerface Engineering

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Deutsch/Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	5	ca. 30 min	benotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Dr.-Ing. Marc Müller
Lecturer	Dr.-Ing. Marc Müller
Institute	Institut für Mehrphasenprozesse
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Biointerface Engineering - Vorlesung	2	Muendliche Pruefung
Biointerface Engineering - Übung	2	

Requirements for participation:	Recommended for participation:
keine	Biokompatible Werkstoffe, Biokompatible Polymere, Medizinische Verfahrenstechnik

Qualification goals

Das Modul vermittelt spezifische Kenntnisse zur anwendungsorientierten Charakterisierung und Modifikation von Biomaterialien und Medizinprodukten zur Optimierung der Biointerkation. Nach erfolgreicher Absolvierung des Moduls sind die Studierenden in der Lage:

• Aufgrund der Kenntnisse von grundlegenden physikalischen und mechanischen Eigenschaften der unterschiedlichen Biomaterialien eine anwendungsbezogene Auswahl zu treffen.

• Unterschiedliche Verfahren zur Modifikation und Charakterisierung von Biomaterialoberflächen und Grenzflächen (Biointerfaces) zu erläutern.

• Spezifische Biointeraktionen zwischen Biomaterialien und biologischem Milieu zu erläutern und bewerten.

• Eigene experimentelle Daten aus der Untersuchungen von Biomaterialien auszuwerten, zu interpretieren und durch ein wissenschaftliches Poster zu präsentieren

Contents

• Oberflächeneigenschaften ausgewählter Biomaterialien
• Verfahren zur Charakterisierung von Biomaterialoberflächen (physialisch, chemisch, optisch)
• Verfahren zur Beurteilung der Biointeraktion von Biomaterialien (Bio-/Hämokompatibilität)
• Verfahren zur Modifikation von Biomaterialien (physikalisch, chemisch)
• Angepasste und nicht-angepasste Biointerfaces
• Praktische Untersuchungen zur Herstellung und Charakterisierung von Biointerfaces
• Qualitätskriterien wissenschaftlicher Präsentationen

Special features

In der Übung werden experimentelle Untersuchungen zur Herstellung und Charakterisierung von Biomaterialien durchgeführt. Hierzu werden die Studierenden in Kleingruppen eingeteilt. Hierdurch werden die im Rahmen der Vorlesung vorgestellten Methoden praktisch erlernt und vertieft. Die experimentellen Daten werden in Form eines wissenschaftlichen Posters präsentiert. Die Anleitung zur Erstellung der Poster erfolgt ebenfalls im Rahmen der Übung. Vorlesung und Übung können nach Bedarf in englischer Sprache gehalten werden.

Literature

Biomimetic Medical Materials Advances in Experimental Medicine and Biology. I. Noh (ed.)(2018). Springer, Singapore.

Module Biointerface Engineering

Modul: Biointerface Engineering

https://doi.org/10.1007/978-981-13-0445-3 Biomaterials Science. An Introduction to Materials in Medicine. B.D. Ratner, A.S. Hoffman, F.J. Schoen, J.E. Lemons (eds)(2004). Elsevier Academic Press, San Diego. https://doi.org/10.1016/C2009-0-02433-7 Biomaterials, Medical Devices and Tissue Engineering: An Integrated Approach. F.H. Silver (ed.)(1994). Springer, Dordrecht. https://doi.org/10.1007/978-94-011-0735-8

Applicability in other degree programs

Computational Methods in Engineering B.Sc.;

Module Biomedical Engineering for Engineers II

Modul: Biomedizinische Technik für Ingenieure II

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Deutsch/Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	5	ca. 30 min	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Prof. h.c. Dr.-Ing. M.Sc. Birgit Glasmacher
Lecturer	Prof. Prof. h.c. Dr.-Ing. M.Sc. Birgit Glasmacher
Institute	Institut für Mehrphasenprozesse
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Biomedizinische Technik für Ingenieure II - Vorlesung	2	Muendliche Pruefung
Biomedizinische Technik für Ingenieure II - Übung	1	

Requirements for participation:	Recommended for participation:
keine	Biomedizinische Technik für Ingenieure I, Biokompatible Werkstoffe, Biokompatible Polymere

Qualification goals

Das Modul vermittelt spezifische Kenntnisse über medizintechnische Geräte und Systeme zur Diagnose und Therapie von Krankheitsbildern. Nach erfolgreicher Absolvierung des Moduls sind alle Studierenden in der Lage:

- Die Funktionsprinzipien von Diagnose- und Therapiesystemen zu erläutern.
- Eine anwendungsbezogene Auswahl der geeigneten Verfahren zu Diagnose und Therapie zu treffen.
- Optimierungspotential aktueller Diagnose- und Therapiesysteme zu erkennen.
- Konzepte für neuartige Systeme zu erarbeiten.

Contents

- Geschichtliche Entwicklung der Biomedizinischen Technik
- Funktionsweisen bildgebender diagnostischer Geräte wie EKG, EEG, EMG, Ultraschall, CT und Röntgen
- Therapieverfahren, wie Herzunterstützungssysteme
- Herstellungsverfahren, wie Stent-Herstellungsverfahren
- Aktuelle Entwicklungen und Innovationen, wie Cochlea-Implantat-Chirurgie

Special features

Die Veranstaltung beinhaltet Vorlesungen von anerkennen externen Dozenten und Dozentinnen aus der Industrie und Wissenschaft.

Literature

Vorlesungs-Handouts Lehrbuchreihe Biomedizinische Technik: Morgenstern U., Kraft M.: Band 1 - Biomedizinische Technik - Faszination, Einführung, Überblick. Berlin, Boston: De Gruyter, 2014. ISBN 978-3-11-025218-7 Werner J.: Band 9 - Biomedizinische Technik - automatisierte Therapiesysteme. Berlin, Boston: De Gruyter, 2014. ISBN 978-3-11-025213-2

Module Biomedical Engineering for Engineers II

Modul: Biomedizinische Technik für Ingenieure II

Applicability in other degree programs
Computational Methods in Engineering B.Sc.; Elektro- und Informationstechnik M.Sc.; LbS/Metalltechnik M.Ed.; Mechatronik und Robotik M.Sc.; Optische Technologien M.Sc.;

Module Biophotonics - Imaging Physics and Manipulation of Biological Cells

Modul: Biophotonik - Bildgebung und Manipulation von biologischen Zellen

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Deutsch/Englisch	4	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	4	90 min	benotet

Workload	120 h
Attendance study period	28 h
Self-study time	92 h
Module coordinator	Prof. Dr. Alexander Heisterkamp
Lecturer	Prof. Dr. Alexander Heisterkamp
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Biophotonik - Bildgebung und Manipulation von biologischen Zellen - Vorlesung	2	Klausur

Requirements for participation:	Recommended for participation:
keine	Basic knowledge in coherent optics, Possibly Fundamentals of Lasers in Medicine and Biomedical Optics (WS), Laserphysics

Qualification goals

The students gain special knowledge in nonlinear and integrated optics, and they can apply the corresponding mathematical methods. A special topic of photonics can be selected and deepened independently by the student. The topic shall be presented in the frame of a seminar with a subsequent discussion. Besides their technical competence, the students develop their methods in literature research, implementation of technical and scientific knowledge, as well as their presentation techniques together with their ability to lead scientific discussions

Contents

Within the lecture “Biophotonics” laser technologies and optical methods will be introduced, which are applied within modern cell biology, regenerative medicine and the field of tissue engineering. Especially laser-based imaging technologies, applied at the cellular level, will be covered, as well as tissue characterization and 3D volumetric imaging. This includes: - the fundamentals of microscopical imaging - different contrast mechanisms and optical clearing - optical coherence tomography - laser scanning microscopy and super resolution approaches - application within biotechnology, such as biochips - cell sorting and cell surgery and interaction with nanoparticles and nanostructures will be discussed.

Special features

keine

Literature

Prasad, Paras N.: Introduction to Biophotonics. John Wiley & Sons 2003. Jürgen Popp: Handbook of Biophotonics, Volume 1: Basics and Techniques, Jürgen Popp (Editor), Valery V. Tuchin (Editor), Arthur Chiou (Editor), Stefan H. Heinemann (Editor), ISBN: 978-3-527-41047-7 (TIB-Signatur: T 12 B 5852) Min Gu: Femtosecond Biophotonics: Core Technology and Applications. Cambridge University Press, 2010. ISBN: 0521882400 (TIB-Signatur: T 10 B 5962) Adam Wax: Biomedical Applications of Light Scattering, New York, NY [u.a.] : McGraw-Hill, 2010, ISBN: 978-0-07-159880-4 (TIB-Signatur: T 09 B 8078)

Applicability in other degree programs

Computational Methods in Engineering B.Sc.; LbS/Metalltechnik M.Ed.; LbS/SprintING M.Ed.; Optische Technologien B.Sc.;

Module Chemical analysis of plastics

Modul: Chemische Analyse von Kunststoffen

Type of module	Area of competence
Wahlpflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe/SoSe	1 Semester	Deutsch/Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
SL	Studienleistung	1	3 Laborberichte (ca. 5 Seiten)	unbenotet
PL	Klausur	4	90 min	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Dr. Madina Shamsuyeva
Lecturer	Dr. Madina Shamsuyeva
Institute	Institut für Kunststoff- und Kreislauftechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Chemische Analyse von Kunststoffen - Vorlesung	1	Studienleistung
Chemische Analyse von Kunststoffen - Labor	2	Klausur

Requirements for participation:	Recommended for participation:
keine	Polymerwerkstoffe empfohlen

Qualification goals

Das Modul vermittelt Kenntnisse über verschiedene chemische Methoden zur Charakterisierung von Polymerstrukturen und über den molekularen Aufbau, Alterungsprozesse und -mechanismen von Kunststoffen sowie über typische Kunststoffadditive. Nach erfolgreichem Abschluss des Moduls sind die Studierenden in der Lage, • chemische Methoden zur Analyse von Kunststoffen zu benennen und die richtigen Methoden für die jeweiligen Fragestellungen auszuwählen • Prinzipien, Vor- und Nachteile der gängigen polymer-chemischen Methoden zu verstehen

Contents

- Polymere / Polymerstruktur
- Spektralphotometrie (zzgl. Labor)
- IR- / Raman-Spektroskopie (zzgl. Labor)
- UV-Spektroskopie
- Fluoreszenzspektroskopie
- Röntgenphotoelektronenspektroskopie
- Auger-Elektronen-Spektroskopie
- Kernspinresonanzspektroskopie
- Pyrolyse-Gaschromatographie-Massenspektrometrie (zzgl. Labor)
- Größenausschlusschromatographie

Special features

Max. TN-Zahl: 15 / Zusatzinformationen: Das Modul enthält Praktikumstermine zu denen Laborberichte anzufertigen sind. Zudem gibt es eine schriftliche Klausur. Die Vorlesungsunterlagen sind in Englisch.

Literature

Instrumentelle Analytik. Theorie und Praxis (ISBN: 978-3-8085-7216-0) Analytical Chemistry: A Modern Approach to Analytical Science, 2nd Edition (ISBN: 978-3-527-30590-2)

Applicability in other degree programs

Computational Methods in Engineering B.Sc.; LbS/Metalltechnik M.Ed.;

Module Computational Biomechanics

Modul: Computational Biomechanics

Type of module	Area of competence
Wahlpflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	5. Semester	**Admission SoSe:**	5. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Klausur	5	90 min	benotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Dr.-Ing. Meisam Soleimani
Lecturer	Dr.-Ing. Dustin Roman Jantos
Institute	Institut für Kontinuumsmechanik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Computational Biomechanics - Vorlesung	2	Klausur
Computational Biomechanics - Hörsaalübung	2	

Requirements for participation:	Recommended for participation:
keine	Technische Mechanik II, Finite Elemente I Kontinuumsmechanik I

Qualification goals

This course is aimed at providing basic and solid concepts in biomechanics with focus on various physiological systems, including the musculoskeletal system (growth and remodeling in muscle, bone), the cardiovascular system (arteries, aneurysms, Atherosclerosis, Dissection, blood circulation) and computational methods used for the simulation of biomechanical phenomena. The ultimate objective of this course is to prepare the students with hands-on skills using computational packages and software to solve biomechanical problems. This course is generally suitable for MS, and PhD students in mechanical engineering department whose major is computational biomechanics. Hence, it is suitable for those who are interested in practicing a carrier or research (probably PhD programs) in computational mechanics with a biomedical application. The students are strongly recommended that they would consider prerequisites of this course prior to registering for that.

Contents

The topics below are covered in the course:
1. A recap on continuum solid mechanics as the mathematical framework in this course
2. A brief review of anatomy and physiology of the musculoskeletal system, a range of modelling and experimental methods applied to them.
3. Biomechanical constitutive models for soft tissues in the context of isotropic as well as anisotropic hyper-elasticity
4. Application of non-elastis constitutive models such as growth, viscoelasticity, and damage in biological tissues
5. An overview of the state-of-the-art mathematical model for pathological condition in soft tissues (As an example the focus will be on Atherosclerosis, Dissection and Aneurism in arteries)
6. Thoughts and considerations regarding the numerical simulation of biological processes in a FEM framework

Special features

keine

Literature

1. An Introduction to Biomechanics: Solids and Fluids, Analysis and Design, J.D. Humphrey and SL O'Rourke. Springer

Module Computational Biomechanics

Modul: Computational Biomechanics

(2015). 2. Biomechanics of Soft Tissue in Cardiovascular Systems, Gerhard A. Holzapfel & Ray W. Ogden, Springer (2003). 3. The Mathematics and Mechanics of Biological Growth, Alain Goriely, Springer (2016).
Applicability in other degree programs

Module Computational Photonics

Modul: Computational Photonics

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	6	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	4	90 min	benotet
SL	Studienleistung	2	Course work	unbenotet

Workload	180 h
Attendance study period	56 h
Self-study time	124 h
Module coordinator	apl. Prof. Dr. Ayhan Demircan
Lecturer	apl. Prof. Dr. Ayhan Demircan
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Computational Photonics - Vorlesung	2	Klausur
Computational Photonics - Hörsaalübung	2	Studienleistung

Requirements for participation:	Recommended for participation:
none	Nonlinear Optics

Qualification goals

The lecture explains various main numerical methods and techniques to solve scientific problems in linear and nonlinear optics. The studends deepen the knowledge in photonics by performing computer experiments. After successful completion of the module, the students are able to elaborate strategies to solve complex problems in optics using a computer.

Contents

The lecture is organized in two parallel-running tracks: Photonics Fundamentals, and Numerical Methods.

The course has a practical exercise component providing the student with basic computer simulation experience.
Topics:

•Light-matter interaction (Chromatic and geometric dispersion, secondand third-order susceptibility, Raman scattering, supercontinuum generation, multiphoton und tunneling ionization, low-order harmonic radiation)
•Light transport in turbid media
•Photoacoustics
•Matrix optics
•Pulse propagation equations
•Atoms in strong optical fields (Schrödinger equation for atoms, Higher-Harmonic generation, Brunel/THz radiation, attosecond optics)
•Computer modeling methods in electromagnetics (Time-domain solvers, frequency domain methods, finite element methods)
•Monte Carlo method •Spectral and Pseudospectral methods
•Runge-Kutta and operator splitting approach
•Parallel computing (openMP, openMPI)

Module Computational Photonics

Modul: Computational Photonics

Special features
In order to pass the module, the course work must be successfully completed in addition to the examination work.
Literature
Obayya: Computational Photonics; Joachain/Kylstra/Potvliege: Atoms in Intense Laser fields; Lux/Koblinger: Monte Carlo Particle Transport Methods: Neutron and Photon Calculations
Applicability in other degree programs
LbS/SprintING M.Ed.; Optische Technologien B.Sc.; Technische Informatik B.Sc.;

Module Cryoengineering and Cryobiology

Modul: Kryo- und Biokältetechnik

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Deutsch/Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	4	ca. 30 min	benotet
SL	Studienleistung	1	30 h	unbenotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Prof. h.c. Dr.-Ing. M.Sc. Birgit Glasmacher
Lecturer	Prof. Prof. h.c. Dr.-Ing. M.Sc. Birgit Glasmacher Prof. Dr.-Ing. habil. Stephan Kabelac
Institute	Institut für Mehrphasenprozesse
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Kryo- und Biokältetechnik - Vorlesung	2	Muendliche Pruefung
Kryo- und Biokältetechnik - Labor	1	Studienleistung

Requirements for participation:	Recommended for participation:
keine	Thermodynamik I und II, Wärmeübertragung, Medizinische Verfahrenstechnik

Qualification goals

Das Modul vermittelt grundlegende Kenntnisse über Kryotechnik und Kryobiologie sowie Prozesse zur Bereitstellung von tiefkalten Räumen und Konservierungsmethoden für lebende Zellen und Gewebe. Nach erfolgreichem Abschluss des Moduls sind die Studierenden in der Lage:

- Die physikalischen und thermodynamischen Grundlagen der Kältechnik und ihrer Kreisprozesse zu erläutern.
- Grundlegende Vorgänge während der Kryokonservierung suspendierter Zellen und Gewebe zu erläutern.
- Protokolle zum gezielten Einfrieren von Stammzellen und roten Blutkörperchen zu erarbeiten und zu beurteilen.
- Verfahren wie Kryochirurgie, Kryotherapie und Kryokonservierung zu erläutern.
- Prozesskennwerte und Qualitätskriterien zu berechnen und zu deuten.
- Praktische Experimente durchzuführen.

Contents

- Grundlagen der Kältetechnik, Kreisprozesse in der Kältetechnik, Methoden in der Kältetechnik, Kryotechnik
- Grundlagen der Biokältetechnik, Physikalische Grundlagen und Messtechniken
- Zellbiologische Grundlagen, Zellbiologische Messmethoden
- Technische Kryoverfahren, Kryokonservierung von Zellsuspensionen wie z.B. Blut und Geweben/Organen
- Kryobanking für Reproduktions-und regenerative Medizin, Kryochirurgie
- Laborversuch zur Kryokonservierung von roten Blutkörperchen

Special features

- Vorlesung und Übung auf Englisch möglich.
- Zur erfolgreichen Absolvierung des Moduls ist die erfolgreiche Teilnahme am Masterlabor "Kryo-und Biokältetechnik" notwendig. Dieses wird im Rahmen der Vorlesung angeboten.

Literature

Vorlesungsskript Fuller, B. (Ed.), Lane, N. (Ed.), Benson, E. (Ed.). (2004). Life in the Frozen State. Boca Raton: CRC Press, https://doi.org/10.1201/9780203647073 Baust, J. (Ed.), Baust, J. (Ed.). (2007). Advances in Biopreservation. Boca Raton: CRC Press, https://doi.org/10.1201/9781420004229

Module Cryoengineering and Cryobiology

Modul: Kryo- und Biokältetechnik

Applicability in other degree programs
Computational Methods in Engineering B.Sc.; Optische Technologien M.Sc.;

Module Data- and AI-driven Methods in Engineering

Modul: Data- and AI-driven Methods in Engineering

Type of module	Area of competence
Wahlpflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe/SoSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	5	60 min	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr.-Ing. Thomas Seel
Lecturer	Prof. Dr.-Ing. Thomas Seel
Institute	Institut für Mechatronische Systeme
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Data- and AI-driven Methods in Engineering - Vorlesung	2	Klausur
Data- and AI-driven Methods in Engineering - Übung	1	

Requirements for participation:	Recommended for participation:
keine	Basics of Machine Learning

Qualification goals

Upon completion of the module, students will be able to understand and tap the potential of data- and AI-driven methods in engineering applications and to apply them in relevant use cases. The students will be competent in choosing the right method for a given problem and in making application-specific adjustments while taking reliability, explainability and other relevant qualities into account. They will understand the roles of prior knowledge and data, and they will be able to leverage that understanding to obtain well-performing data- and AI-driven solutions.

Contents

The module teaches how to tap the potential of data- and AI-driven methods for problem solving in engineering applications and focuses in particular on how these methods can be used to design, analyze and optimize sustainable engineering systems and processes. Examples include intelligent energy management, predictive maintenance or sustainable process design, which can be achieved, for example, by the use of machine learning methods in optimization problems or complex data analysis or by using cognitive decision making and planning algorithms.

Specifically, the following concepts and methods are taught and discussed in the context of engineering applications:
- Overview and Classification of Problems and Methods
  - Summary of Fundamental Machine Learning and AI Methods and Concepts
  - Overview of Sustainable Engineering Applications and Use Cases
- Important Overarching Concepts
  - Sim-to-real-Gap, Transfer Learning, Domain Adaptation
  - Hybrid Methods and Physics-informed Machine Learning
  - Semi-Supervised Learning, Active Learning, Incremental Learning, Online-Learning
  - Explainability, Safety, Security, Reliability, Resilience
- Data- and AI-driven Methods in Simulation and Optimization
  - Machine Learning Methods for Complex Optimization
  - Surrogate Models in Simulation and Model Order Reduction
  - Kriging and Gaussian Processes for Engineering Applications
- Data- and AI-driven Methods in Data Analysis and Decision Making
  - Data Mining in Engineering Applications

Module Data- and AI-driven Methods in Engineering

Modul: Data- and AI-driven Methods in Engineering

- Predictive Maintenance, data-driven Digital Twins
- AI-driven Decision Making, Planning, Expert Systems
- Data- and AI-driven Methods for Physical Interaction
- Bayesian Methods for Sensor/Information Fusion
- Learning and Control in Dynamical Systems
- Collective Learning and Swarm Intelligence

Special features

Literature

S. L. Brunton and J. N. Kutz, Data-Driven Science and Engineering. Cambridge University Press, 2019. E. Alpaydin, Maschinelles Lernen, 3rd ed. Berlin, Boston: De Gruyter Oldenbourg, 2022. J. R. R. A. Martins and A. Ning, Engineering Design Optimization. Cambridge University Press, 2022.

Applicability in other degree programs

Module Data- and Learning-Based Control

Modul: Data- and Learning-Based Control

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	4	30 min	benotet
SL	Hausarbeit	1	Hausübung mit Präsentation	unbenotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr.-Ing. Matthias Müller
Lecturer	Prof. Dr.-Ing. Matthias Müller
Institute	Institut für Regelungstechnik
Faculty	Fakultät für Elektrotechnik und Informatik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Data- and Learning-Based Control - Vorlesung	2	Muendliche Pruefung
Data- and Learning-Based Control - Hörsaalübung	1	Hausarbeit

Requirements for participation:	Recommended for participation:
keine	Regelungstechnik I, Regelungstechnik II, Model Predictive Control, Nonlinear Control

Qualification goals

The students are familiar with state-of-the art methods for data- and learning-based control as well as the underlying theory. They are able to implement the presented methods and can read and discuss publications on past and ongoing research in this field.

Contents

In this course, different data- and learning-based control design techniques are considered. Data-based approaches compute controllers directly from the available input and output data, without the intermediate step of identifying a model of the system. In particular, we will discuss virtual reference feedback tuning, control design based on Willems fundamental lemma, and the data informativity framework. In learning-based control, some machine learning technique is employed to learn a model of the system (or unknown parts thereof) or directly a suitable controller. Within this course, we will in particular consider approaches from reinforcement learning, using Gaussian Processes, and neural networks.

Special features

For this course, a course credit must be taken (laboratory).

Literature

Applicability in other degree programs

Computational Methods in Engineering B.Sc.; Mechatronik und Robotik M.Sc.;

Module Design and Simulation of Optomechatronic Systems

Modul: Design and Simulation of optomechatronic Systems

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	5	90 min	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr.-Ing. Roland Lachmayer
Lecturer	Prof. Dr.-Ing. Roland Lachmayer
Institute	Institut für Produktentwicklung und Gerätebau
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Design and Simulation of optomechatronic Systems - Vorlesung	2	Klausur
Design and Simulation of optomechatronic Systems - Hörsaalübung	1	

Requirements for participation:	Recommended for participation:
keine	keine

Qualification goals

If completed successfully, the students are capable of • defining fundamentals of lighting technology • describing the physiology of the human visual system • differentiating individual advantages in optical materials (glasses and polymers) and their according processing technologies • analytically calculating basic optical elements such as mirrors and lenses • setting up concepts for optical systems • understanding and using an optical simulation software • knowing the working principle of light measurement devices • analyzing existing optical systems

Contents

- Fundamentals of light propagation and distribution
- Optical components and systems
- Optical simulation software
- Physiology of the human visual system
- Light sources, manipulators and sensors

Special features

Lecture and exercise will be held in English. Alongside the exercise there will be an optional project. Der alte Name des Moduls lautet Konstruktion Optischer Systeme.

Literature

Umdruck zur Vorlesung

Applicability in other degree programs

LbS/SprintING M.Ed.; Mechatronik und Robotik M.Sc.; Optische Technologien B.Sc.;

Module Diffractive Optics

Modul: Diffractive Optics

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe/SoSe	1 Semester	Englisch	4	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
SL	Studienleistung	4	Präsentation	unbenotet

Workload	120 h
Attendance study period	56 h
Self-study time	64 h
Module coordinator	Dr.-Ing. Reinhard Caspary
Lecturer	Dr.-Ing. Reinhard Caspary
Institute	Cluster of Excellence PhoenixD
Faculty	

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Diffractive Optics - Seminar	4	Studienleistung

Requirements for participation:	Recommended for participation:
none	Solid knowledge in geometrical optics and wave optics

Qualification goals

The students explain the basics of scalar wave theory and use it to describe diffraction effects in the approximations according to Fresnel and Fraunhofer. They describe and compare different approaches for the numerical calculation of wave propagation. They also use the theory to analyse diffraction effects in linear optical systems with coherent and incoherent light sources. They define the terms of the point spread function and the optical transfer function and use them to evaluate optical systems. Students name and explain different methods for static and dynamic modulation of optical wavefronts. They interpret holography as a diffraction effect and mathematically derive the recording and reproduction of holograms.

Contents

- Linear optical systems
- Scalar diffraction theory
- Fresnel and Fraunhofer diffraction
- Computational approaches
- Imaging systems
- Wavefront modulation
- Optical information processing
- Holography

Special features

Keine

Literature

J. W. Goodman: Introduction to Fourier Optics

Applicability in other degree programs

LbS/SprintING M.Ed.; Technische Informatik B.Sc.;

Module Economics of Development and Environment

Modul: Economics of Development and Environment

Type of module				Area of competence			
Wahlpflicht							
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	5. Semester	**Admission SoSe:**	5. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Klausur	4	60 min	benotet
SL	Studienleistung	1	Tutorium aus dem Maschinenbau	unbenotet

Workload	150 h
Attendance study period	28 h
Self-study time	122 h
Module coordinator	Prof. Dr. Ulrike Grote
Lecturer	Prof. Dr. Ulrike Grote
Institute	Institut für Umweltökonomik und Welthandel
Faculty	Fakultät für Wirtschaftswissenschaften

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Economics of Development and Environment - Vorlesung	2	Klausur Studienleistung

Requirements for participation:	Recommended for participation:
none	Empfohlen: Einführung in die Nachhaltigkeitswissenschaften

Qualification goals

Students are able to describe problems in development and environmental economics verbally and formally or offer possible solutions. They can characterise the different areas of environmental economics and to present, explain and analyse basic theories and concepts in these areas.

Die Studierenden können Problemstellungen aus der Entwicklungs- und Umweltökonomie verbal und formal beschreiben bzw. Lösungsansätze anbieten. Sie sind in der Lage, die verschiedenen Bereiche der Umweltökonomie zu charakterisieren sowie grundlegende Theorien und Konzepte in diesen Bereichen darzustellen, zu erklären und zu analysieren.

Contents

The course introduces the students into important fundamental economic aspects of development, environment and trade. It provides an overview of socioeconomic and demographic developments and world-wide trends (urbanization, digitalisation) which characterize the globalizing world. It focuses on environmental concepts and terms (e.g. externalities, public goods, optimal pollution). Economic growth theories for development and poverty concepts are discussed next to sustainability concepts. Interlinkages between development and environmental issues are identified and analysed. International framework conventions and organisations in charge of both development and environment are briefly introduced.

Die Veranstaltung führt die Studierenden in grundlegende wirtschaftliche Aspekte von Entwicklung, Umwelt und Handel ein. Sie gibt einen Überblick über sozioökonomische und demographische Entwicklungen und weltweite Trends (Urbanisierung, Digitalisierung), die die globalisierende Welt kennzeichnen. Die Veranstaltung konzentriert sich auf Umweltkonzepte und -begriffe (z.B. Externalitäten, öffentliche Güter, optimale Verschmutzung). Neben Nachhaltigkeitskonzepten werden wirtschaftliche Wachstumstheorien für Entwicklung und Armutskonzepte diskutiert. Verflechtungen zwischen

Entwicklungs- und Umweltfragen werden herausgearbeitet und analysiert. Internationale Rahmenkonventionen und Organisationen, die sowohl für Entwicklung als auch für Umwelt zuständig sind, werden kurz vorgestellt.

Module Economics of Development and Environment

Modul: Economics of Development and Environment

Special features
ACHTUNG: Die Studierenden wählen eine Lehrveranstaltung der folgenden drei Optionen in dem Modul "Introduction to Sustainability Economics " aus: Introduction to Sustainability Economics, Economics of Development and Environment oder Grundlagen der BWL II: Nachhaltiges Ressourcenmanagement. Die Klausur (60 Min), Klausur findet semesterbezogen statt (nur WS)! Die Veranstaltung wird in englischer Sprache gelehrt. Zum Einbringen des Moduls in den Wahlpflichtbereich muss zum Erreichen der benötigten 5 LP noch zusätzlich ein Tutorium absolviert werden. Studierende des Bachelors Nachhaltige Ingenieurwissenschaften müssen noch ein Tutorium aus dem Katalog des Maschinenbaus belegen, um das Modul in den Wahlpflichtbereich einbringen zu können.
Literature
Applicability in other degree programs
Informatik B.Sc.;

Module Electrical Machines for eAutomotive Traction Applications with Journal Club

Modul: Electrical Machines for eAutomotive Traction Applications with Journal Club

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	4	30 min	benotet
SL	Studienleistung	1	Journal Club	unbenotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof. Dr.-Ing. Bernd Ponick
Lecturer	Dr.-Ing. Boris Dotz Prof. Dr.-Ing. Bernd Ponick
Institute	Institut für Antriebssysteme und Leistungselektronik
Faculty	Fakultät für Elektrotechnik und Informatik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Electrical Machines for eAutomotive Traction Applications with Journal Club - Vorlesung	2	Muendliche Pruefung
Electrical Machines for eAutomotive Traction Applications with Journal Club - Seminar	2	Studienleistung

Requirements for participation:	Recommended for participation:
keine	keine

Qualification goals

The lecture " Electrical Machines for eAutomotive Traction Applications" enables students to understand key requirements as well as design challenges for electrical machines in the context of the eautomotive market. Next to fundamentals and working principles of electrical machines, several design aspects, manufacturing techniques and product costs are covered. Basic and new technologies are presented and compared according to market demands.

Contents

Introduction, Lecture Overview, Organization, Emobility Market Development & Overview, Power & Torque Requirements for Passenger Cars, WLTC Cycle + Simlified Mass & Drag Model of an Vehicle, Power & Torque Requirements for Electrical Machines, Complex Numbers, PM Machine: Working Principle, Rotating Fields 1: Why m Phases, Rotating Fields 2: Why N Slots, Windings Basic Topologies: Slot / Pole Combinations, Deep Dive: Harmonics 1 & 2, PM Machine: Motor Assembly, PM Machine: Electromagnetic Design, PM Machine: Key Performance Data, Losses and Efficiency, PM Machine: Manufacturing & Costs, Current Excited Synchronous Machine: Working Principle, Current Excited Synchronous Machine: Permance & Efficiency; Tutorials

Special features

mit Journal Club als Studienleistung

Literature

No information

Applicability in other degree programs

Module Engineering Dynamics and Vibrations

Modul: Engineering Dynamics and Vibrations

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	5	90 min	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Dr.-Ing. Matthias Wangenheim
Lecturer	
Institute	Institut für Dynamik und Schwingungen
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Engineering Dynamics and Vibrations - Vorlesung	2	Klausur
Engineering Dynamics and Vibrations - Hörsaalübung	1	

Requirements for participation:	Recommended for participation:
keine	Engineering Mechanics: Statics, Kinematics, Kinetics, Introduction to Mechanical Vibrations

Qualification goals

If completed successfully, students are capable of
•Utilizing the terms natural frequencies, mode shapes, modal transformation in the correct manner
•Describing MDOF systems in the form of matrix differential equations •Interpreting MDOF systems with respect to mode shapes, rigid body modes and effects like tuned mass damping
•Assessing critical operational states of machines and other dynamical systems like resonances, or instability regions
•Calculating transfer functions for MDOF systems
•Explaining the advantages to handle MDOF systems in modal space including proportional damping

Contents

Learning Objectives: In this module knowledge is imparted and consolidated in the field of describing and solving dynamical problems in systems with multiple degrees of freedom (MDOF).
•Single degree of freedom systems: natural frequencies, transfer function •Natural frequencies und mode shapes of systems with multiple degrees of freedom
•Rigid body modes
•Initial value problem
•Modal transformation
•Modal/proportional damping
•Modal decoupling

Special features

Integrated course containing lecture and tutorials. Contents equal to German course "Maschinendynamik" taught in winter term.

Literature

Gross et al.: Engineering Mechanics 3. Dynamics. Springer Inman: Engineering Vibration. Prentice Hall Meirovitch: Fundamentals of Vibrations. McGraw-Hill Tong: Theory of Mechanical Vibration, Literary Licensing, LLC

Applicability in other degree programs

Elektro- und Informationstechnik M.Sc.;

Module Fundamentals and Configuration of Laser Beam Sources

Modul: Fundamentals and Configuration of Laser Beam Sources

Type of module			Area of competence				
Wahl							
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Klausur	5	90 min.	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	
Lecturer	
Institute	Institut für Transport- und Automatisierungstechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Fundamentals and Configuration of Laser Beam Sources - Vorlesung	2	Klausur
Fundamentals and Configuration of Laser Beam Sources - Übung	1	

Requirements for participation:	Recommended for participation:
none	

Qualification goals

The lecture gives an overview of different types of laser beam sources. In the basic part the concepts for the generation of laser radiation in various active media for different applications as well as requirements for optical resonators are presented. Different pumping schemes and concepts are discussed for the various laser systems, especially gas-, diode and solid-state lasers. In addition, the operating modes continuous, pulsed and ultrashort pulsed will be explained in more detail. Based on the basic considerations and concepts, real laser beam sources are presented and analyzed.

Contents

The following contents will be taught in the course and through demonstrations: basics of laser beam sources, operation modes of lasers, laser characterization, laser diodes, optical resonators, CO2 lasers, excimer lasers, laser concepts and laser materials, rod lasers and disk lasers, fiber lasers and amplifiers, frequency conversion, lasers for space applications and ultrashort pulse lasers.

Special features

The lecture will take place at Laser Zentrum Hannover e.V. (LZH) Hollerithallee 8, 30419 Hannover. The course is taught in English. Contents equal to German course "Grundlagen und Aufbau von Laserstrahlquellen" taught in winter term. Students are only allowed to receive the 5 credit points once, either from this course or from "Grundlagen und Aufbau von Laserstrahlquellen" course.

Literature

Applicability in other degree programs

Optische Technologien B.Sc.;

Module Fundamentals of Laser Medicine and Biophotonics

Modul: Grundlagen der Lasermedizin und Biophotonik

Type of module				Area of competence			
Wahl							
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
WiSe	1 Semester	Deutsch/Englisch	5	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Klausur	4	90 min	benotet
SL	Studienleistung	1	Online Tests	unbenotet

Workload	150 h
Attendance study period	28 h
Self-study time	122 h
Module coordinator	Prof. Dr. Alexander Heisterkamp
Lecturer	Prof. Dr. Alexander Heisterkamp
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Grundlagen der Lasermedizin und Biophotonik - Vorlesung	2	Klausur Studienleistung

Requirements for participation:	Recommended for participation:
keine	Coherent Optics, Photonics or Nonlinear Optics recommended

Qualification goals

The lecture explains laser medicine with basics from biophotonics. The laser principle, types of medical lasers and their effects on biological tissue are presented. As current clinical application, laser surgery of the eye based on ultrashort pulse lasers is discussed. After a fundamental introduction to tissue optics with its various absorption and scattering processes, imaging techniques such as optical coherence tomography (OCT) and two-photon microscopy will be explained. After the lecture, an excursion with laboratory and company visit is offered.

Contents

- Laser systems for the application in medicine and biology
- Beam guiding systems and optical medical devices
- Optical properties of tissues
- Thermal properties of tissues
- Photochemical interaction
- Vaporization/coagulation
- Photoablation, optoacoustics
- Photodisruption, nonlinear optics
- Applications in ophthalmology, refractive surgery
- Laser-based diagnostics, optical biopsy
- Optical coherence tomography, theragnostic
- Clinical examples

Special features

Possible separate module: Block seminar with topics from Laser in Medicine (has to be selected separately).

Module Fundamentals of Laser Medicine and Biophotonics

Modul: Grundlagen der Lasermedizin und Biophotonik

Literature
Eichler, Seiler: "Lasertechnik in der Medizin"; Springer-Verlag Welch, van Gemert: "Optical-Thermal Response of Laser-Irradiated Tissue"; Plenum Press Berlien, Müller: "Angewandte Lasermedizin"; Bd. 1,2, eco med Verlag Berlien, Müller: "Applied Laser Medicine"; Springer-Verlag Berns, Greulich: "Laser Manipulation of Cells and Tissues"; Academic Press
Applicability in other degree programs
LbS/SprintING M.Ed.; Optische Technologien B.Sc.; Technische Informatik B.Sc.;

Module GIS and Remote Sensing

Modul: GIS and Remote Sensing

Type of module	Area of competence
Wahlpflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	6	**Admission WiSe:**	5. Semester	**Admission SoSe:**	5. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	5	90 min	benotet

Workload	180 h
Attendance study period	56 h
Self-study time	124 h
Module coordinator	Prof. Dr.-Ing. habil. Monika Sester
Lecturer	Prof. Dr.-Ing. habil. Monika Sester
Institute	Institut für Kartographie und Geoinformatik
Faculty	Fakultät für Bauingenieurwesen und Geodäsie

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
GIS and Remote Sensing - Vorlesung	2	Klausur
GIS and Remote Sensing - Hörsaalübung	2	

Requirements for participation:	Recommended for participation:
keine	Mathematik, Technische Mechanik, Wärmeübertragung, Thermodynamik

Qualification goals

The modul introduces the underlying principles and methods about Geographical Information Systems (GIS) and Remote Sensing. The overall focus is on spatial data, which are relevant to any environmental planning and management tasks. In this module the students will obtain an overview over the most important basics and applications of GIS and remote sensing. They will learn to work with GIS software (e.g. ArcGIS) and apply it to their spatial problems. In the end the students will have understood the central methodologies and will be able to make use of the employed techniques. By independently preparing and then presenting the lab work they will further develop their learning strategies and presentation skills. Upon completion of the module, students are able to apply GIS software and remote sensing techniques for analyses and manipulation of space related data from ground observation and remote sensing.

Contents

1. Geographical Information Systems: - data modelling: geometric, thematic, topologic - data analysis and geoprocessing - cartography: graphical variables, generalization, presentation - data capture, topography: digital elevation models, data interpolation, geomorphology - visualization, presentation and analysis: 2D, 3D, terrain Besides the theoretical lectures, there will be practical excercises to learn and train the GIS-skills. 2. Remote Sensing - basics: electromagnetic spectrum, interaction of electromagnetic waves and materials , limits of resolution, digital images - sensors: multi-spectral satellite sensors, hyper-spectral sensors, airborne laser scanning, synthetic aperture radar - processing: generation of thematic maps: classification of land cover using pattern recognition methods, determination of digital height models, in particular from laser scanner and radar data.

Special features

Studienleistung (weitere Informationen erfolgen im Kurs)

Literature

Jones, C., 1999. Geographical Information Systems and Computer Cartography Logman. T. Lillesand, R. Kiefer, 2015. Remote sensing and image interpretation.

Applicability in other degree programs

Informatik B.Sc.;

Module Image Analysis I

Modul: Image Analysis I

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	4	15 min	benotet
SL	Studienleistung	1	4 Ausarbeitungen mit Jupyter Notebooks	unbenotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	apl. Prof. Dr. techn. Franz Rottensteiner
Lecturer	M. Sc. Hubert Kanyamahanga
Institute	Institut für Photogrammetrie und Geoinformation
Faculty	Fakultät für Bauingenieurwesen und Geodäsie

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Image Analysis I - Vorlesung	3	Muendliche Pruefung
Image Analysis I - Übung	1	Studienleistung

Requirements for participation:	Recommended for participation:
none	Photogrammetric Computer Vision

Qualification goals

Das Modul vermittelt grundlegende Kenntnisse über Strategien der Bildanalyse auf Grundlage des maschinellen Lernens. Nach erfolgreicher Absolvierung des Moduls sind die Studierenden in der Lage, • die wesentlichen Schritte der Bildanalyse von der Bildaufnahme bis zur Bildinterpretation zu verstehen und zu erläutern, • die Grundlagen probabilistischer Klassifikatoren sowie von modernen Deep Learning Verfahren auf Basis von neuronalen Netzen zu verstehen und zu erläutern, • Vor- und Nachteile von Verfahren zur statistischen Bildanalyse zu analysieren und zu bewerten, • Ergebnisse von Bildanalyseverfahren anhand von Referenzdaten zu bewerten, • die nötigen Voraussetzungen für die Entwicklung eines Bilanalyseverfahrens in Hinblick auf die Sensordaten zu bewerten und festzulegen, • eigene Verfahren des maschinellen Lernens im Rahmen der Inhalte des Moduls für spezifische Aufgaben zu entwickeln, programmtechnisch umzusetzen und zu testen.

Contents

• Bildaufnahme und Bildvorverarbeitung
• Bewertung von Ergebnissen
• Merkmale aus Bildern und Punktwolken
• Überblick über Verfahren des maschinellen Lernens
• Probabilistische Klassifikationsverfahren: Bayes-Klassifikation, logistische Regression
• Neuronale Netze
• Neuronale Faltungsnetze, Deep Learning
• Applikationen von Deep Learning
• Domänenadaption, Lernen mit fehlerhaften Trainingslabels Die Übungen umfassen Programmieraufgaben in Python in Kombination mit Jupyter Notebooks, in denen die Inhalte der Vorlesung vertieft und um ihre praktische Anwendung ergänzt werden.

Special features

Zum Erreichen der 5 LP müssen die vorlesungsbegleitenden Übungen erfolgreich bestanden werden. This lecture is given in English.

Module Image Analysis I

Modul: Image Analysis I

Literature
Bishop, C. M., Pattern Recognition and Machine Learning, Springer, NY, 2006. Duda, R. O., Hart, P. E., Stork, D. G.: Pattern Classification. Second edition, Wiley & Sons, New York, USA, 2001. Goodfellow, I., Bengio, Y., Courville, A: Deep Learning. MIT Press, Cambridge, MA, USA, 2016.
Applicability in other degree programs

Module Image Analysis II

Modul: Image Analysis II

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	4	15 min	benotet
SL	Studienleistung	1	4 Ausarbeitungen mit Jupyter Notebooks	unbenotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	apl. Prof. Dr. techn. Franz Rottensteiner
Lecturer	M. Sc. Hubert Kanyamahanga
Institute	Institut für Photogrammetrie und Geoinformation
Faculty	Fakultät für Bauingenieurwesen und Geodäsie

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Image Analysis II - Vorlesung	3	Muendliche Pruefung
Image Analysis II - Übung	1	Studienleistung

Requirements for participation:	Recommended for participation:
none	Image Analys I

Qualification goals

Das Modul vermittelt grundlegende Kenntnisse über Strategien der Bildanalyse auf Grundlage des maschinellen Lernens, von Verfahren der Segmentierung, sowie die Modellierung von Objekten für die 3D Rekonstruktion. Nach erfolgreicher Absolvierung des Moduls sind die Studierenden in der Lage, • die Grundlagen nichtprobabilistischer Verfahren des Machine Learning sowie von Verfahren zur nichtsemantischen Segmentierung zu verstehen und zu erläutern, • Vor- und Nachteile von Verfahren zu analysieren und zu bewerten, • Ergebnisse von Bildanalyseverfahren anhand von Referenzdaten zu bewerten, • die nötigen Voraussetzungen für die Entwicklung eines Bilanalyseverfahrens in Hinblick auf die Sensordaten zu bewerten und festzulegen, • eigene Verfahren des maschinellen Lernens oder der nichtsemantischen Segmentierung im Rahmen der Inhalte des Moduls für spezifische Aufgaben zu entwickeln, programmtechnisch umzusetzen und zu testen.

Contents

• Überblick über Verfahren des maschinellen Lernens
• Nichtprobabilistische diskriminative Klassifikatoren: Random Forests, Boosting, Support Vector Machines
• Graphische Modelle
• Probabilistische Modelle von Kontext: Markov Random Fields, Conditional Random Fields
• Lernen mit fehlerhaften Trainingslabels
• Der Skalenraum
• Segmentierung: Extraktion von Punkten und Kanten
• Segmentierung: Extraktion von homogenen Regionen
• Modellierung von 3D Objekten Die Übungen umfassen Programmieraufgaben in Python in Kombination mit Jupyter Notebooks, in denen die Inhalte der Vorlesung vertieft und um ihre praktische Anwendung ergänzt werden.

Special features

Zum Erreichen der 5 LP müssen die vorlesungsbegleitenden Übungen erfolgreich bestanden werden. This lecture is given in English.

Literature

Bishop, C. M., Pattern Recognition and Machine Learning, Springer, NY, 2006. Duda, R. O., Hart, P. E., Stork, D. G.: Pattern

Module Image Analysis II

Modul: Image Analysis II

Classification. Second edition, Wiley & Sons, New York, USA, 2001. Forsyth, D.A., Ponce, J., Computer Vision, A Modern Approach, Prentice Hall, 2003.
Applicability in other degree programs

Module Image Sequence Analysis

Modul: Bildsequenzanalyse

Type of module	Area of competence
Wahlpflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	4	15 min	benotet
SL	Studienarbeit	1	Laborversuche	unbenotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof. Dr.-Ing. habil. Christian Heipke
Lecturer	Dr.-Ing. Max Mehltretter
Institute	Institut für Photogrammetrie und Geoinformation
Faculty	Fakultät für Bauingenieurwesen und Geodäsie

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Bildsequenzanalyse - Vorlesung	2	Muendliche Pruefung
Bildsequenzanalyse - Hörsaalübung	2	Studienarbeit

Requirements for participation:	Recommended for participation:
keine	Photogrammetric Computer Vision (from Institute of Photogrammetry and GeoInformation, IPI) or Computer Vision (from TNT) must have been successfully finished before this course can be taken. Prior knowledge on image processing, basics of adjustment theory and programming with Python.

Qualification goals

At the end of the course, students have a good insight into the goals, tasks and methods of image sequence analysis. They are able to evaluate monoscopic and stereoscopic image sequences with regard to 3D geometry and content and know the limits of the automatic methods used for this purpose: foreground/background separation, optical flow , object tracking etc. They are also able to integrate motion models into the evaluation, for example on the basis of Kalman filter, EKF; particle filters are also known in principle. In individual areas, the students have exemplary detailed knowledge, e.g. in the area of tracking-by-detection and data association. As a basis for further Master's studies, the students should develop their analytical and transfer skills through exercises, also from current research projects.

Contents

- Introduction to the field of image sequence analysis (incl. sensors and general considerations) - Background subtraction - Motion of pixels / points: Optical flow and Scene flow - Object detection and tracking (incl. motion models and filtering approaches) - Re-Identification - Body pose estimation

Special features

To achieve the 5 ETCS, the lab must be successfully completed. The course is taught in English

Literature

- David A. Forsyth and Jean Ponce (2003): Computer Vision, A Modern Approach. - Richard Hartley and Andrew Zisserman (2003): Multiple View Geometry in Computer Vision. - Wolfgang Förstner and Bernhard P. Wrobel (2016): Photogrammetric Computer Vision. - Ian Goodfellow, Yoshua Bengio and Aaron Courville (2016): Deep Learning. - Christopher M. Bishop (2006): Pattern Recognition and Machine Learning.

Applicability in other degree programs

Module Internal Flows

Modul: Internal Flows

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	5	90 min	benotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Dr.-Ing. Dajan Mimic
Lecturer	Dr.-Ing. Dajan Mimic
Institute	Institut für Turbomaschinen und Fluid-Dynamik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Internal Flows - Vorlesung	2	Klausur
Internal Flows - Übung	2	

Requirements for participation:	Recommended for participation:
keine	Empfohlen: Thermodynamik I+II, Strömungsmechanik I+II

Qualification goals

After successfully completing the module, students are able to:
- Understand and derive fundamental descriptions of internal flows
- Simplify complex internal-flow problems
- Identify characteristic flow regions and loss-generating mechanisms
- Model the interaction between characteristic flow regions
- Evaluate the local loss generation
- Assess the effect of local losses on the overall system behaviour

Contents

The module introduces the fundamental fluid dynamic principles and flow interactions necessary for analysing, understanding, and modelling complex internal-flow problems encountered in real-life applications. The module teaches how local flow phenomena affect loss generation and the overall system behaviour of, e.g., turbomachines.
- Boundary-layer theory
- Vortex theory and secondary flow
- Vortex–boundary-layer interaction
- Compressible flows and shocks
- Thermal effects
- Loss generation and effect on system behaviour

Special features

Course is in English.

Literature

Greitzer, E.M.; Tan, C.S.; Graf, M.B. (2004): Internal Flow. Cambridge University Press.

Applicability in other degree programs

Optische Technologien M.Sc.;

Module Internet GIS

Modul: Internet GIS

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	4	15 min	benotet
SL	Studienleistung	1	Übung	unbenotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	M.Sc. Udo Feuerhake
Lecturer	M.Sc. Udo Feuerhake
Institute	Institut für Kartographie und Geoinformatik
Faculty	Fakultät für Bauingenieurwesen und Geodäsie

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Internet GIS - Vorlesung	2	Muendliche Pruefung
Internet GIS - Hörsaalübung	1	Studienleistung

Requirements for participation:	Recommended for participation:
keine	Introductions into GIS and into Programming

Qualification goals

This course teaches the key technologies and main concepts for performing typical GIS operations on spatial data in the Internet. Main topics are the processes allowing representation, storage, access, analysis and visualization of heterogeneous, distributed spatial data sets. The lectures focus on the technical/practical realization of these aspects. Practical exercises on current web technologies allow the students to flexibly adapt to a multitude of requirements in the larger context of web applications. The learned practical knowledge is applied in a compulsory software project, in which groups of 3-4 students will work on a real web GIS application. After successfully completing this course, students will be able to create their own web map applications including static and dynamic parts of a client-server-architecture with server-side data storage and client-side data visualization and interaction.

Contents

Lecture content: Data and service provider standards and implementations; data formats for internet applications; internet-based data provision and access; current web technologies: HTML, JavaScript, PHP, XML, WebMap APIs OpenLayers and Leaflet, SQL, PostgreSQL DBMS, OGC Web Map Services/Web Feature Services.

Special features

This lecture is given in english.

Literature

Korduan, P., Zehner, M.L.: Geoinformation im Internet: Technologien zur Nutzung raumbezogener Informationen im WWW, Wichmann Verlag, Heidelberg, 2008, ISBN 3-87907-456-9, 314 Seiten. OGC web page: http://www.ogc.org E-Learning-Module: http://www.geoinformation.net

Applicability in other degree programs

Module Introduction to Computational Optics

Modul: Introduction to Computational Optics

Type of module	Area of competence
Pflicht	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	2. Semester	**Admission SoSe:**	. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur / Muendliche Pruefung	5	90 Min	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr. Antonio Calà Lesina
Lecturer	Prof. Dr. Antonio Calà Lesina
Institute	Institut für Transport- und Automatisierungstechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Introduction to Computational Optics - Vorlesung	2	Klausur / Muendliche Pruefung
Introduction to Computational Optics - Übung	1	

Requirements for participation:	Recommended for participation:
keine	Knowledge of electrodynamics and theoretical optics (Grundlagen der Optik I und II).

Qualification goals

The course introduces the programming language Python and presents the solution of several problems in optics by means of computational approaches. After successfully completing of the course, students are able to: - Use Python for data processing, visualization, and analysis. - Use numerical methods to solve analytical optics problems: transfer matrix method, plot of a plane wave (time and space), polarization (Jones formalism), diffraction, coherence, interference, diffraction, dipole emitter, techniques for waveguides and beam propagation. - Understand the basics of numerical methods.

Contents

Some optical problems can be solved analytically, but some involve complex geometries and must be solved numerically. In both cases, translating equations into a code that can be executed on a computer allows us to find solutions and post-process the data. This course introduces one of the main programming languages for scientific computing, Python, which is then used to solve many relevant optics problems. The content of the course is as follows: - Intro to the Python programming language - Intro Python libraries NumPy, SciPy and Matplotlib: arrays and matrices, numerical differentiation, integration, root finding, minimization/maximization, eigenvalue problems, discrete Fourier transform, differential equations, generation of figures, movies, read/write of files. - Examples from theoretical optics: transfer matrix method, plot of a plane wave (time and space), polarization (Jones formalism), diffraction, coherence, interference, diffraction, dipole emitter, techniques for waveguides and beam propagation. - Intro to numerical methods (e.g., FDTD: finite differences and finite elements). Implementation of 1D-FDTD. Ingredients for the numerical solution of Maxwell's equations: sources, material models, absorbing/symmetry/periodic boundary conditions, monitors.

Special features

Literature

Applicability in other degree programs

LbS/SprintING M.Ed.; Technische Informatik B.Sc.;

Module Introduction to Mechanical Vibrations

Modul: Introduction to Mechanical Vibrations

Type of module	Area of competence
Pflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	5	90 min	benotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Dr.-Ing. Matthias Wangenheim
Lecturer	
Institute	Institut für Dynamik und Schwingungen
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Introduction to Mechanical Vibrations - Vorlesung	2	Klausur
Introduction to Mechanical Vibrations - Übung	2	

Requirements for participation:	Recommended for participation:
keine	Statics, Elastostatics, Kinematics, Kinetics (Technische Mechanik 1 - 3)

Qualification goals

After successful participation, our students will be able to

- set up linearized equations of motion for single-degree-of-freedom (SDOF) systems
- characterize the properties of free vibrations by means of eigenvalues
- determine system responses for harmonic, periodic and transient excitation
- propose appropriate measures to improve the system's dynamical performance
- understand the properties of solutions of partial differential equations describing continuum vibrations

Contents

In this module, we give an introduction into the linear vibrations of mechanical systems.

- Free and forced vibrations of single-degree-of-freedom (SDOF) systems
- SDOF systems with damping
- System response functions in frequency and time domain
- Periodic and transient excitation of SDOF systems
- Systems with two degrees of freedom
- Vibration absorbers and tuned mass dampers
- Introduction to systems with multiple degrees of freedom (MDOF)
- Vibrations of strings, rods, shafts and beams

Special features

Integrated course containing lecture (2h) and tutorials (2h). Contents equal to German course „Technische Mechanik IV“ taught in summer term.

Literature

Gross et al.: Engineering Mechanics 3. Dynamics. Springer Inman: Engineering Vibration. Prentice Hall Meirovitch: Fundamentals of Vibrations. McGraw-Hill Tong: Theory of Mechanical Vibration, Literary Licensing, LL

Module Introduction to Mechanical Vibrations

Modul: Introduction to Mechanical Vibrations

Applicability in other degree programs
Elektro- und Informationstechnik M.Sc.; Energietechnik B.Sc.; Maschinenbau B.Sc.;

Module Introduction to Nanophotonics

Modul: Introduction to Nanophotonics

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	5	90 min.	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr. Antonio Calà Lesina
Lecturer	Prof. Dr. Antonio Calà Lesina
Institute	Institut für Transport- und Automatisierungstechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Introduction to Nanophotonics - Vorlesung	2	Klausur
Introduction to Nanophotonics - Übung	1	

Requirements for participation:	Recommended for participation:
none	Knowledge of electromagnetic theory (Maxwells equations, wave propagation, etc).

Qualification goals

After successfully completing the module, students are able to: - Understand the optical properties of dielectric/metals and the theory of surface plasmons. - Understand the theory of the scattering of light by a sphere (Mie theory) and multipoles and apply it to generic nanostructures. - Understand metasurfaces/metamaterials/photonic crystals and design such systems for light manipulation. - Understand some numerical techniques and use simulation software for nanophotonics modelling.

Contents

Nanophotonics studies how light behaves at the nanoscale, and how to engineer the properties of light by exploiting its exotic interaction with nanostructures. The course will focus on the theoretical foundations of nanophotonic systems, such as plasmonic nanoantennas, dielectric resonators, metasurfaces, metamaterials, and photonic crystals. The course is enriched with the use of simulation software for nanophotonics.
Module content:

- Optical properties of matter, fundamentals of plasmonics.
- Light scattering by metallic and dielectric nanostructures.
- Metasurfaces, metamaterials and photonic crystals.
- Numerical techniques and simulation software for nanophotonic systems.
- Selected topics of current research.

Special features

Literature

Novotny, L., & Hecht, B. (2012). Principles of Nano-Optics (2nd ed.). Cambridge: Cambridge University Press. Gaponenko, S. (2010). Introduction to Nanophotonics. Cambridge: Cambridge University Press. Maier, S. (2007). Plasmonics: Fundamentals and Applications. Springer, New York.

Applicability in other degree programs

LbS/Metalltechnik M.Ed.; LbS/SprintING M.Ed.; Optische Technologien B.Sc.;

Module Introduction to Optical Technologies

Modul: Introduction to Optical Technologies

Type of module	Area of competence
Wahlpflicht	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	5. Semester	**Admission SoSe:**	5. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur / Muendliche Pruefung	5	90 min	benotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof. Dr. Antonio Calà Lesina
Lecturer	Prof. Dr. Antonio Calà Lesina
Institute	Institut für Transport- und Automatisierungstechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Introduction to Optical Technologies - Vorlesung	2	Klausur / Muendliche Pruefung
Introduction to Optical Technologies - Übung	2	

Requirements for participation:	Recommended for participation:
keine	Knowledge of mathematics and physics (electricity and magnetism).

Qualification goals

After successfully completing the module, students are able to:
- Understand Maxwell's equations and the properties of light.
- Understand the optical properties of matter and the interaction of light with atter.
- Calculate reflection and transmission.
- Understand diffraction and interferenc
- Understand guided propagatio
- Understand the working principle of a selection of optical devices, such as LEDs, displays, LASERs, flat lenses, solar cells, etc.

Contents

Optical technologies use light for communication, lighting, sensing, material processing, and computing. This course provides an introduction to optical technologies with a focus on the theory necessary to understand and describe modern optical devices. Module content:

- Maxwell's equations and properties of light.
- Light propagation: reflection and refractio
- Optical properties of matter: anisotropy, absorption and dispersn.
- Guided propagation: introduction to waveguides and fiber opts.
- Examples of modern optical technologies

Special features

B.Sc. in Machanical Engineering, B.Sc. in Production and Logistics, B.Sc. in Mechatronics, and B.Sc. in Nanotechnology

Literature

Introduction to Optics I: Interaction of Light with Matter, K. Dolgaleva, Morgan & Claypool Publishers, 2020. Fundamentals of photonics, B.E.A. Saleh, M.C. Teich, Wiley, 2019. Optics, E. Hecht, Pearson, 2017.

Applicability in other degree programs

LbS/Metalltechnik M.Ed.; Mechatronik B.Sc.; Nanotechnologie B.Sc.; Produktion und Logistik B.Sc.;

Module Introduction to Sustainability Economics

Modul: Introduction to Sustainability Economics

Type of module				Area of competence			
Pflicht							
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
WiSe	1 Semester	Deutsch/Englisch	4	**Admission WiSe:**	3. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Klausur	4	90 min	benotet

Workload	120 h
Attendance study period	28 h
Self-study time	92 h
Module coordinator	
Lecturer	
Institute	Institut für Umweltökonomik und Welthandel
Faculty	Fakultät für Wirtschaftswissenschaften

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Introduction to Sustainability Economics - Vorlesung	2	Klausur

Requirements for participation:	Recommended for participation:
keine	Empfohlen: Einführung in die Nachhaltigkeitswissenschaften

Qualification goals

Option I: Introduction to Sustainability Economics Student learn the theoretical basis of sustainability as inter- and intra-generational issues and the tools to analyse the above and other questions associated with the notion of sustainability. They are able to describe the interactions between environmental and development challenges in developing countries. Option II Economics of Development and Enviroment: Option III: Grundlagen der BWL III: Nachhaltiges Ressourcenmanagement. Die Studierenden lernen theoretische Grundlagen der Nachhaltigkeit als inter- und intra-generationelle Fragen und die Werkzeuge, um Problemfelder im Zusammenhang mit dem Begriff der Nachhaltigkeit zu analysieren. Sie sind in der Lage, die Wechselwirkungen zwischen Umwelt- und Entwicklungsherausforderungen in Entwicklungsländern zu beschreiben.

Contents

Option I: Introduction to Sustainability Economics This course introduces and operationalizes the notion of sustainability from an economic perspective. It provides students with the theoretical basis of sustainability as inter- and intra-generational issues, and elaborates how sustainability can be operationalized in an economic context. It covers a range of topics focusing on the interactions between economic growth, development, and the environment. Development issues such as population growth, urbanization, and migration as well as environmental problems such as depletion of natural resources and degradation of environmental quality are taken into account. The lectures are designed in an interactive way, including theories, case studies, Option II Economics of Development and Enviroment: Option III: Grundlagen der BWL III: Nachhaltiges Ressourcenmanagement. Diese Veranstaltung führt in den Begriff der Nachhaltigkeit ein und operationalisiert ihn aus einer ökonomischen Perspektive. Sie vermittelt den Studierenden die theoretischen Grundlagen der Nachhaltigkeit als inter- und intragenerationelles Problemfeld und zeigt auf, wie Nachhaltigkeit in einem wirtschaftlichen Kontext behandelt werden kann. Das Modul deckt eine Reihe von Themen ab, die sich auf die Wechselwirkungen zwischen Wirtschaftswachstum, Entwicklung und Umwelt konzentrieren. Dabei werden sowohl Entwicklungsthemen wie Bevölkerungswachstum, Urbanisierung und Migration als auch Umweltprobleme wie die Erschöpfung natürlicher Ressourcen und die Verschlechterung der Umweltqualität berücksichtigt. Die Vorlesungen sind interaktiv gestaltet und beinhalten Theorien, Fallstudien, Übungen und Studierendenpräsentationen.

Module Introduction to Sustainability Economics

Modul: Introduction to Sustainability Economics

Special features
keine
Literature
Published articles from peer review journals will be provided ahead of the lectures
Applicability in other degree programs
Informatik B.Sc.;

Module Introduction to Sustainability Science

Modul: Einführung in die Nachhaltigkeitswissenschaft

Type of module	Area of competence
Pflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Deutsch/Englisch	5	**Admission WiSe:**	1. Semester	**Admission SoSe:**	2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Präsentation	2	30 min	benotet
SL	Klausur	3	90 min	unbenotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Dr. des. Stefan Nagel
Lecturer	Prof. Dr. Björn Maronga Dr. des. Stefan Nagel
Institute	Institut für Berufswissenschaften der Metalltechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Grundlagen der Nachhaltigkeitswissenschaft - Vorlesung	1	Präsentation
Grundlagen ddr Nachhaltigkeitswissenschaft - Übung	1	Klausur
Introduction to Meterology and Climatology - Vorlesung	1	

Requirements for participation:	Recommended for participation:
keine	keine

Qualification goals

The objective of this course is to impart fundamental knowledge about weather, climate and atmospheric phenomena. After successful completion of the module, students will have the ability to describe the atmosphere's composition and characteristics, to distinguish between different weather variabilities, and to solve problems regarding the atmospheric variables and processes, either analytically or with numerical methods. This also includes a brief review on instruments used in atmospheric sciences. Die Studierenden haben ein Begriffsverständnis von Nachhaltigkeit und kennen die zentralen Modelle der Nachhaltigkeitswissenschaften. Sie können anhand aktueller, gesellschaftlicher Fragestellungen die Relevanz von Nachhaltigkeit wissenschaftlich einordnen und bewerten.

Contents

Das Modul besthet aus dne Teilen Grundlagen der Nachhaltigkeitswissensschaften und Meterology and Climatology. Meteorology and Climatology: · Introduction to weather, climate and the atmopshere · Basic physical laws of the atmosphere and basic quantities (temperature, pressure, wind, and humidity) · Atmospheric processes and their interaction: e.g., radiation, thermodynamics including adiabatic processes, general circulation, formation of precipitation · Instruments to measure meteorological quantities · The climate of the past, climate variability and climate change Grundlagen der Nachhaltigkeitswissenschaften: · Historie des Nachhaltigkeitsbegriffs · Zentrale Konzepte, Modelle und Ideen von Nachhaltigkeit · Nachhaltige Entwicklung als politischer und wissenschaftlicher Diskurs · Deutsche und internationale Nachhaltigkeitsstrategien · Die drei Dimensionen von Nachhaltigkeit mit entsprechenden Vertiefungen wie CSR, Green Supply Chain Management, Resilienz, Suffizienz, Stoffkreisläufe, Nachhaltigkeitszertifizierungen von Unternehmen etc.
· Die wissenschaftliche Fundierung von Nachhaltigkeit anhand ausgewählter Beispiele aus den Ingenieurwissenschaften

Special features

Die Vorlesungen zu „Meteorology and Climatology" werden auf Englisch angeboten, der zweite Teil der Vorlesung hingegen findet auf Deutsch statt. Die Klausur kann sowohl in Englisch als auch in Deutsch bearbeitet werden. Unbenotete

Module Introduction to Sustainability Science

Modul: Einführung in die Nachhaltigkeitswissenschaft

Klausur: die Klausur erstreckt sich über beide Themenbereiche des Moduls. Prüfungsleistung: Präsentation
Literature
Wallace, J. M. and Hobbs, P. V. (2006): Atmospheric science: an introductory survey, 2nd Edition. Amsterdam: Elsevier. Heinrichs, H. und Michelsen, G. (2014): Nachhaltigkeitswissenschaften. Berlin, Heidelberg: Springer Spektrum.
Applicability in other degree programs
Informatik B.Sc.;

Module Introductory Biophysics for Physics

Modul: Introductory Biophysics for Physics

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Deutsch/Englisch	3	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**

Workload	90 h
Attendance study period	28 h
Self-study time	62 h
Module coordinator	Prof. Dr. Alexander Heisterkamp
Lecturer	Prof. Dr. Alexander Heisterkamp
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Introductory Biophysics for Physics - Vorlesung	2	

Requirements for participation:	Recommended for participation:
none	-

Qualification goals

Der Fokus liegt dabei auf einer detaillierten Darstellung der Zellbiologie, der zentralen Moleküle des Lebens und den physikalischen Grundlagen ihrer Interaktion. Als Beispiel wird die Struktur von Säugetierzellen analysiert und zelluläre Prozesse wie Replikation, Transkription und Translation erörtert. Im Weiteren werden dann experimentelle Techniken diskutiert, die im historischen Kontext und immer noch genutzt werden, um Information über die zentralen Moleküle des Lebens, die zelluläre Homöostase, Zellbewegung, oder die Entstehung von Kräften in einer Zelle, zu erschließen. Am Ende der Veranstaltung werden neue Forschungsfelder, wie Nanotechnologie oder Quantenphysik, in den Kontext Biophysik integriert.

Contents

•Was ist Leben? – Einheiten, Zeitskalen, Organismen
•Die Zelle und ihre Biologie
•zentrale Moleküle des Lebens DNA, RNA und Proteine
•Kristallstrukturanalyse zum Verständnis der zentralen Moleküle des Lebens
•Physikalische Prinzipien der Kristallstrukturanalyse
•”biophysikalischer Verkehr”: Membranen und Kanäle
•Wie misst man „biophysikalischen Verkehr“?
•Zellkräfte und Zellbewegung
•experimentelle Techniken zur Analyse von Zellbewegung und Kontraktion
•Wie Nanotechnologie unser Biologieverständnis ergänzt
•Wie Quantenphysik unser Biologieverständnis ergänzt In der Vorlesung werden grundlegende biophysikalische und biologische Konzepte eingeführt.

Special features

Die Prüfungsform ist eine unbenotete Studienleistung in Form eines Vortrags.

Literature

Grundlegende Literatur: •Molecular Biology of the Cell (Garland Science) •Biophysics: An Introduction (Springer) •Campbell Biology •Originalliteratur

Module Introductory Biophysics for Physics

Modul: Introductory Biophysics for Physics

Applicability in other degree programs
LbS/SprintING M.Ed.; Optische Technologien B.Sc.;

Module Jet Engines

Modul: Flugtriebwerke

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Deutsch/Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	5	90 min	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Dr.-Ing. Florian Herbst
Lecturer	
Institute	Institut für Turbomaschinen und Fluid-Dynamik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Flugtriebwerke - Vorlesung	2	Klausur
Flugtriebwerke - Übung	1	

Requirements for participation:	Recommended for participation:
keine	Strömungsmechanik II, Strömungsmaschinen I, Thermodynamik

Qualification goals

Nach erfolgreichem Abschluss der LV kennen die Studierenden die Zustandsänderungen in den einzelnen Komponenten eines Strahltriebwerks und sind in der Lage dieses Wissen bei der Bestimmung des Wirkungsgrades, der Optimierung des Kreisprozesses sowie der Theorie der Stufe und gerader Schaufelgitter anzuwenden. Des Weiteren erhalten sie Einblick in Phänomene wie die rotierende Ablösung und das Pumpen, Triebwerks-Aeroakustik sowie auch das dynamische Verhalten von Triebwerken und deren Regelung. Sie sind außerdem in der Lage, die Verluste in einem Triebwerk, Ähnlichkeitskennzahlen und die Kennfelder einzelner Komponenten zu bestimmen und zu bewerten.

Contents

Das Modul vermittelt grundlegendes ingenieurwissenschaftliches und physikalischen Verständnis für die Anforderungen, den Aufbau und die Vorauslegung einfacher Strahltriebwerke.

Special features

Begleitend zur Vorlesung wird eine Hausaufgaben angeboten. Studierende können freiwillig die Zusatzaufgaben erledigen, nach § 6 (6) der Prüfungsordnung. Dies wird bei erfolgreicher Teilnahme bei der Bewertung der Prüfungsleistung als Bonus berücksichtigt.

Literature

Bräunling: Flugzeugtriebwerke: Grundlagen, Aero-Thermodynamik, ideale und reale Kreisprozesse, thermische Turbomaschinen, Komponenten, Emissionen und Systeme. 3. Aufl., Berlin [u.a.] : Springer, 2009. Farokhi, S.: Aircraft Propulsion. 2. Aufl., Chichester: Wiley, 2014. Cumpsty, N., Heyes, A.: Jet Propulsion, Cambridge University Press, 2015.

Applicability in other degree programs

Optische Technologien M.Sc.;

Module Laser Laboratory

Modul: Laser Laboratory

Type of module	Area of competence
Pflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	2	**Admission WiSe:**	4. Semester	**Admission SoSe:**	. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
SL	Labor	2		unbenotet

Workload	60 h
Attendance study period	14 h
Self-study time	46 h
Module coordinator	M. Sc. Manmeet Singh
Lecturer	
Institute	
Faculty	

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Laser Laboratory - Labor	1	Labor

Requirements for participation:	Recommended for participation:
keine	keine

Qualification goals

Videoprojektortechnologie: A technical implementation of information transmission is represented by video projectors, which specifically generate light distributions on different surfaces. In particular, the requirements to reproduce a large colour spectrum and to achieve high contrast values are decisive for the quality of the projection. In the IPeG's optomechatronics experiment, the functionality of video projectors is investigated. The focus of the experiment is on the interaction of colour generation and human colour perception. Technical possibilities are discussed to realize defined colour spaces and colour impressions. The influences of the human eye and the resulting technical challenges are highlighted. Augmented Reality Labor Quanten Kryptographie Upon successful completion of the module, students will be able to, understand polarization of light, augmented reality glasses and quantum cryptography with singe photons.

Contents

Videoprojektortechnologie:
Optical technologies are regarded as one of the key technologies of the 21st century and are used, among other things, for the processing of materials, sensor technology, data transmission, the projection of information and lighting technology. Since humans obtain about 90 % of the information perceived from their environment from the visual, optical technologies provide a powerful interface in human-machine communication. One challenge here is to reproduce information optically. It must therefore be investigated which influencing variables of the optical systems can be used for targeted information transmission. Here, the influences of the human eye have to be considered.
Augmented Reality Labor Quanten Kryptographie:
The lab focuses on digital data transmission, encryption, and data transmission using light quants.
The module teaches basic knowledge of a digital encryption technique using the quantum properties of light. The lab consists of an analogy experiment with augmented reality glasses guidance.

Special features

keine

Literature

Applicability in other degree programs

Module Laser Material Processing

Modul: Laser Material Processing

Type of module	Area of competence
Wahlpflicht	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	5	90 min	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr.-Ing. Ludger Overmeyer
Lecturer	Prof. Dr.-Ing. Ludger Overmeyer
Institute	Institut für Transport- und Automatisierungstechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Laser Material Processing - Vorlesung	2	Klausur
Laser Material Processing - Übung	1	

Requirements for participation:	Recommended for participation:
keine	Basic optics, basics of laser sources recommended

Qualification goals

After successful completion of the module, the students are able
•to classify the scientific and technical basics for the use of laser systems and the interaction of the beam with different materials,
•to recognize the necessary physical requirements for laser processing and to select specific process, handling and control technology for this purpose,
-to explain the basic and current requirements for laser technology in production technology
•to estimate the process variables that can be realized by means of laser material processing.

Contents

- Photonic system technology
- Beam guiding and forming
- Marking - Removal and drilling
- Change material properties
- Cutting including process control
- Welding of metals including process control
- Hybrid welding processe
- Welding of nonmetals
- Bonding / soldering
- Additive manufacturing The module provides basic knowledge about the spectrum of laser technology in production as well as the potential of laser technology in future applications.

Special features

Lectures and exercises in the rooms of the Laser Zentrum Hannover e.V. (laboratories / experimental field). Lecture und examination are offered in English and German. The courses name on Stud.IP is Lasermaterialbearbeitung

Module Laser Material Processing

Modul: Laser Material Processing

Literature
Recommendation is given in the lecture, Lecture notes
Applicability in other degree programs
LbS/SprintING M.Ed.; Optische Technologien B.Sc.; Produktion und Logistik M.Sc.;

Module Laser Measurement Technology

Modul: Laser Measurement Technology

Type of module	Area of competence
Wahl	Energie- und Verfahrenstechnik

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Klausur	5	90 min	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr. Bernhard Roth
Lecturer	Dr. Axel Günther Prof. Dr. Bernhard Roth
Institute	Hannoversches Zentrum für Optische Technologien
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Laser Measurement Technology - Vorlesung	2	Klausur
Laser Measurement Technology - Hörsaalübung	1	

Requirements for participation:	Recommended for participation:
keine	Fundamentals of measurement technology, Basics of laser physics and laser technology

Qualification goals

The aim of this lecture course is the introduction to the basic principles and methods of state-of-the-art optical measurement technology based on laser sources. An overview of the broad spectrum of laser sources, measurement techniques, and typical practical applications for various optical measurement, monitoring, and sensing situations in research and development will be provided. The exercise course aims at consolidating the understanding of the basic principles and provides theoretical exercises according to selected example applications and practical laboratory training.

Contents

- Basic physics
- Optical elements/detection techniques
- Lasers for measurement applications
- Laser triangulation and interferometry
- Distance and velocity measurement

Special features

Recommended for second semester and higher (Master course)

Literature

A. Donges, R. Noll, Lasermesstechnik, Hüthig Verl.; M. Hugenschmidt, Lasermesstechnik, Springer Verl.; W. Lange, Einführung in die Laserphysik, Wissenschaftliche Buchgesellschaft, Darmstadt; Bei vielen Titeln des Springer-Verlages gibt es im W-Lan der LUH unter www.springer.com eine Gratis Online-Version.

Applicability in other degree programs

Computational Methods in Engineering B.Sc.; LbS/SprintING M.Ed.; Optische Technologien B.Sc.;

Module Laser Measurement Technology

Modul: Lasermesstechnik

Type of module	Area of competence
Pflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	5. Semester	**Admission SoSe:**	. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur / Muendliche Pruefung	5	90 min/20 min	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr. Bernhard Roth
Lecturer	Prof. Dr. Bernhard Roth
Institute	Hannoversches Zentrum für Optische Technologien
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Lasermesstechnik - Vorlesung Lasermesstechnik - Hörsaalübung	2 1	Klausur / Muendliche Pruefung

Requirements for participation:	Recommended for participation:
keine	Fundamentals of measurement technology, Basics of laser physics and laser technology

Qualification goals

The aim of this lecture course is the introduction to the basic principles and methods of state-of-the-art optical measurement technology based on laser sources. An overview of the broad spectrum of laser sources, measurement techniques, and typical practical applications for various optical measurement, monitoring, and sensing situations in research and development will be provided. The exercise course aims at consolidating the understanding of the basic principles and provides theoretical exercises according to selected example applications and practical laboratory training. Ziel der Vorlesung ist die Einführung in die Grundlagen und Methoden der modernen optischen Messtechnik auf der Basis von Laserquellen. Es wird ein Überblick über das breite Spektrum an Laserquellen, Messverfahren und typischen praktischen Anwendungen für verschiedene optische Mess-, Überwachungs- und Erkennungssituationen in Forschung und Entwicklung gegeben. Der Übungskurs zielt auf die Festigung des Verständnisses der Grundlagen und bietet theoretische Übungen anhand ausgewählter Anwendungsbeispiele und praktische Laborübungen.

Contents

- Basic physics
- Optical elements/detection techniques
- Lasers for measurement applications
- Laser triangulation and interferometry
- Distance and velocity measurement

Special features

keine

Literature

A. Donges, R. Noll, Lasermesstechnik, Hüthig Verl.; M. Hugenschmidt, Lasermesstechnik, Springer Verl.; W. Lange, Einführung in die Laserphysik, Wissenschaftliche Buchgesellschaft, Darmstadt; Bei vielen Titeln des Springer-Verlages gibt es im W-Lan der LUH unter www.springer.com eine Gratis Online-Version.

Applicability in other degree programs

Technische Informatik B.Sc.;

Module Laser Spectroscopy in Life Sciences

Modul: Laser Spectroscopy in Life Sciences

Type of module				Area of competence			
Wahl							
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Klausur	5	90 min	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr. Bernhard Roth
Lecturer	Dr. Axel Günther Prof. Dr. Bernhard Roth
Institute	Hannoversches Zentrum für Optische Technologien
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Laser Spectroscopy in Life Sciences - Vorlesung	2	Klausur
Laser Spectroscopy in Life Sciences - Hörsaalübung	1	

Requirements for participation:	Recommended for participation:
keine	Basic physics, optics and laser physics, laser applications optical components and measurement principles, spectroscopy, laser interferometry.

Qualification goals

The aim of this lecture course is the introduction to the fundamentals and methods in laser spectroscopy for application in the life sciences. The exercise course aims at consolidating the understanding of the basic principles given as well as at their application for practical examples.

Contents

Apart from the basic principles of laser spectroscopic techniques and methods applied in the various up-to-date areas of fundamental research, practical applications in the life sciences such as biology, chemistry, and medicine will be taught. The students will also gain insight into modern measurement devices and methods which are broadly employed. The main applications field will be presented in depth.

Special features

Recommended for second semester and higher (Master course).

Literature

Wolfgang Demtröder: Laserspektroskopie 1: Grundlagen (Springer), 2011
Wolfgang Demtröder: Laserspektroskopie 2: Experimentelle Techniken (Springer), 2012
Jürgen Eichler, Hans Joachim Eichler: Laser - Bauformen Strahlführung Anwendungen (Springer), 2006;
These and other sources are available as free download from www.springer.com, in German and English.

Applicability in other degree programs

Computational Methods in Engineering B.Sc.; LbS/SprintING M.Ed.; Optische Technologien B.Sc.;

Module Laserscanning - Modelling and Interpretation

Modul: Laserscanning - Modelling and Interpretation

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	3	15 mim	benotet
SL	Studienleistung	2	Übung	unbenotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	apl. Prof. Dr.-Ing. Claus Brenner
Lecturer	apl. Prof. Dr.-Ing. Claus Brenner
Institute	Institut für Kartographie und Geoinformatik
Faculty	Fakultät für Bauingenieurwesen und Geodäsie

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Laserscanning - Modelling and Interpretation - Vorlesung	2	Muendliche Pruefung
Laserscanning - Modelling and Interpretation - Hörsaalübung	1	Studienleistung

Requirements for participation:	Recommended for participation:
keine	Programming Skills

Qualification goals

This lecture imparts the basic principles about laser scanning and its respective application areas. After successful completion of the lecture, students are able to explain and apply selected techniques and algorithms for the low-, intermediate- and high-lever processing of laser scanning data

Contents

Airborne, terrestrial and mobile mapping laser scanning: scan geometry and technical characteristics. Low-, intermediate and high-level tasks. Representation of 3D rotations: matrix, angles, axis and angle, quaternions. Estimation of similarity transforms and the iterative closest point algorithm. Estimation and segmentation of lines and planes. Region growing, RANSAC and MSAC, Hough transform, scanline grouping. Scanning and segmentation in robotics applications. Decision trees and random forests for point cloud classification.Markov chains and Markov chain Monte Carlo methods and their use for high-level interpretation. Deep learning for point clouds. In the exercises, selected algorithms will be programmed.

Special features

Lecture is given in English

Literature

Skript

Applicability in other degree programs

LbS/SprintING M.Ed.; Optische Technologien B.Sc.; Technische Informatik B.Sc.;

Module Machine Learning for Material and Structural Mechanics

Modul: Machine Learning for Material and Structural Mechanics

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe/SoSe	1 Semester	Englisch	6	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	K/KA/MP/HA/PJ/VbP	5	90 min/ 20 min	benotet

Workload	180 h
Attendance study period	56 h
Self-study time	124 h
Module coordinator	Prof. Dr.-Ing. Fadi Aldakheel
Lecturer	Prof. Dr.-Ing. Fadi Aldakheel
Institute	Institut für Baumechanik und Numerische Mechanik
Faculty	Fakultät für Bauingenieurwesen und Geodäsie

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Machine Learning for Material and Structural Mechanics - Vorlesung	2	K/KA/MP/HA/PJ/VbP
Machine Learning for Material and Structural Mechanics - Hörsaalübung	2	

Requirements for participation:	Recommended for participation:
keine	Baumechanik A & B, Numerische Mechanik

Qualification goals

Artificial neural networks (ANN) have gained significant popularity in recent years for many applications in engineering science. Of particular interest are applications related to material and structural mechanics. These include, among others, solving partial differential equations PDEs, material modeling, structural optimization, pattern recognition and real-time simulation. After successful completion of the module the students are able to: - Use Machine Learning for the solution of PDEs - Write their own Machine Learning code - Predict material and structural properties using physics-informed Deep Neural Networks - Employ geometric learning via Convolutional Neural Networks for computational mechanics

Contents

This course presents an introduction to machine learning for engineering students. Course Outline: - Artificial neural networks (ANN) applications in mechanics - Supervised/unsupervised ANN approaches: RNN, FFNN, CNN, PINN - Simplified structural and material modeling (Basic, fundamental level) - Computer lap using Tensorflow program

Special features

keine

Literature

- Weekly: unfinished-slides will be filled out during the lecture time - Weekly: Computer lab exercises and projects related to the lecture - Presentations from researchers of university and industry

Applicability in other degree programs

Computational Methods in Engineering B.Sc.; Mechatronik und Robotik M.Sc.;

Module Machine Learning Models in Engineering Geodesy

Modul: Machine Learning Models in Engineering Geodesy

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	4	15 min	benotet
SL	Studienleistung	1	Übung	unbenotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	PD Dr.-Ing. Hamza Alkhatib
Lecturer	PD Dr.-Ing. Hamza Alkhatib
Institute	Geodätisches Institut Hannover
Faculty	Fakultät für Bauingenieurwesen und Geodäsie

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Machine Learning Models in Engineering Geodesy - Vorlesung	2	Muendliche Pruefung
Machine Learning Models in Engineering Geodesy - Hörsaalübung	2	Studienleistung

Requirements for participation:	Recommended for participation:
keine	Basic engineering mathematics and applied statistics, basic Python programming skills

Qualification goals

This course will introduce you to the principles and algorithms that allow you to use training data to effectively make automated predictions based on known geodetic data science techniques. We will cover regression, clustering, classification, probabilistic modelling, support vector machines, and neural networks/deep learning. You will be able to: - Understand principles behind machine learning problems - Implement and analyze different regression and classification techniques - Implement and organize machine learning projects, from training, validation to parameter tuning

Contents

Students will be familiarized with different machine learning problems such as classification, regression, clustering, and reinforcement learning. Known regression models such as linear regression models, robust regression, Ridge and LASSO regression, Bayesian regression and XGBoost regression methods will be presented. In addition, various known classification methods such as KNN, Random Forest and Support Vector Machines are demonstrated.

Special features

keine

Literature

Hastie, Trevor J.; Friedman, Jerome H.; Tibshirani, Robert (2017): The elements of statistical learning. Data mining, inference, and prediction. 2. ed.. New York: Springer. Brunton, Steven L.; Kutz, Jose Nathan (2019): Data-driven science and engineering. Machine learning, dynamical systems, and control. Cambridge, United Kingdom, New York, NY: Cambridge University Press.

Applicability in other degree programs

Module Manufacturing Systems Modeling and Analysis

Modul: Manufacturing Systems Modeling and Analysis

Type of module	Area of competence
Wahlpflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	5	60 min	benotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof. Dr. oec. Publ. Stefan Helber
Lecturer	Prof. Dr. oec. Publ. Stefan Helber
Institute	Institut für Produktionswirtschaft
Faculty	Wirtschaftswissenschaftliche Fakultät

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Manufacturing Systems Modeling and Analysis - Vorlesung	2	Klausur
Manufacturing Systems Modeling and Analysis - Hörsaalübung	2	

Requirements for participation:	Recommended for participation:
none	grundlegende Kenntnisse betriebswirtschaftlicher Funktionen und Methoden, insbesondere aus dem Modul Performance Analysis I, sind erforderlich.

Qualification goals

Students can analyze complex manufacturing systems with non-linear flow of material using queueing models to determine key performance indicators such as throughput, cycle time, and inventory. They can furthermore assess the economic consequences of design decisions.

Contents

This course focuses on the application of queueing theory models and results for the design and analysis of manufacturing systems producing discrete products. Key performance indicators of manufacturing systems such as throughput, inventory level, and waiting times are determined via analytical models of stochastic systems. Many of those analytical tools are approximations, i.e., of the expected waiting time or the coefficient of variation of the interdeparture times of jobs leaving a work station. The course covers multi-stage systems with both a linear and a non-linear flow of material for both the single- and the multi-product case. Mathematical programming packages such as Scilab or Matlab are used to perform the mathematical analysis.

Special features

Veranstaltung ist in Stud.IP unter folgendem Titel zu finden: " Manufacturing Systems Modeling and Analysis" (Vorlesung) und "Exercises for Manufacturing Systems Modeling and Analysis" (Übung)

Literature

Informationen zur Modulorganisation (insbes. Terminplan, Literaturempfehlungen, Durchführung der Modulprüfung) werden über die Homepage des Instituts sowie bei StudIP bereitgestellt.

Applicability in other degree programs

Module Micro- and Nanosystems

Modul: Micro- and Nanosystems

Type of module	Area of competence
Pflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Klausur	5	90 min	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr.-Ing. Marc-Christopher Wurz
Lecturer	Prof. Dr.-Ing. Marc-Christopher Wurz
Institute	Institut für Mikroproduktionstechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Micro- and Nanosystems - Vorlesung	2	Klausur
Micro- and Nanosystems - Übung	1	

Requirements for participation:	Recommended for participation:
keine	Mikro- und Nanotechnologie

Qualification goals

At the end of the lecture the students will be able to
- explain the term microtechnology and highlight its central advantages
- distinguish between micro- and nanotechnology
- explain relevant process technologies
- explain the basic functionality of different sensors, actuators and generators. This includes the underlying material properties which are exploited for the respective effects - select suitable effects and operating principles for given application examples

Contents

Students gain knowledge about the most important application areas of micro- and nano technology. A microtechnical system has the following components: micro sensor technology, micro actuating elements, microelectronics. Furthermore, the active principle and construction of micro components as well as requirements of system integration will be explained. Nanosystems usually use quantum mechanical effects. An example will be the display of the employment of nanotechnology in various areas

Special features

This lecture is given in English. The Module is equivalent to the module Mikro- und Nanosysteme, therefore credit can only be given for one.

Literature

- Corrêa Alegria, F. A. (2022). Sensors And Actuators. World Scientific. - Fraden, J. (2010). Handbook of modern sensors : physics, designs, and applications (Fourth edition). Springer. - Jain, V. K. (2022). Solid state physics (Third edition). Springer. - Ripka, P. (2021). Magnetic Sensors and Magnetometers. Second Edition. Artech. - Yang, B., Liu, H., Liu, J., & Lee, C. (2015). Micro and nano energy harvesting technologies. In Artech House microelectromechanical systems library. Artech House.

Module Micro- and Nanosystems

Modul: Micro- and Nanosystems

Applicability in other degree programs
Energietechnik M.Sc.; Informatik B.Sc.; Maschinenbau M.Sc.; Mechatronik und Robotik M.Sc.; Produktion und Logistik B.Sc.;

Module Model Predictive Control

Modul: Model Predictive Control

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	4	30 min	benotet
SL	Studienleistung	1	Programmierübung	unbenotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr.-Ing. Matthias Müller
Lecturer	Prof. Dr.-Ing. Matthias Müller
Institute	Institut für Regelungstechnik
Faculty	Fakultät für Elektrotechnik und Informatik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Model Predictive Control - Vorlesung	2	Muendliche Pruefung
Model Predictive Control - Hörsaalübung	1	Studienleistung

Requirements for participation:	Recommended for participation:
keine	Regelungstechnik I und II

Qualification goals

The students analyze and synthesize various types of model predictive controllers for different system classes and implement them in Matlab. They are able to derive systems-theoretic guarantees of MPC controllers, including closed-loop stability and robustness, and can assess the different properties, advantages, and disadvantages of different MPC schemes. The students have insight into current research topics in the field of model predictive control, which enables them to do their own first research projects in this area.

Contents

This lecture deals with Model Predictive Control (MPC), a modern optimization-based control technique which has been actively researched and widely applied in industry within the last years. After an introduction to the basic ideas and stability concepts of MPC, more recent and current advances in research, like tube-based MPC considering robustness issues, economic MPC, distributed MPC, and stochastic MPC are discussed.

Special features

Eine Studienleistung muss in der Form einer Programmierübung erbracht werden.

Literature

keine

Applicability in other degree programs

Mechatronik und Robotik M.Sc.; Optische Technologien M.Sc.;

Module MOOC Aircraft Engines

Modul: MOOC Aircraft Engines

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe/SoSe	1 Semester	Englisch	3	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Klausur	3	60 min	benotet

Workload	90 h
Attendance study period	28 h
Self-study time	62 h
Module coordinator	Dr.-Ing. Florian Herbst
Lecturer	Dr.-Ing. Florian Herbst
Institute	Institut für Turbomaschinen und Fluid-Dynamik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
MOOC Aircraft Engines - Vorlesung	2	Klausur

Requirements for participation:	Recommended for participation:
keine	Strömungsmechanik II, Strömungsmaschinen I, Thermodynamik

Qualification goals

After successful completion of the course, the students have knowledge of the thermodynamic changes of state taking place in the individual components of aircraft jet engines and are able to apply this knowledge to the calculation of the engine efficiency, the optimisation of the thermodynamic cycle and also stage theory and straight cascades. Moreover, the students are able to determine and evaluate the losses, dimensionless quantities, and characteristic maps of aircraft jet engines and their individual components.

Contents

The module introduces basic engineering and physical understanding of the requirements, components and preliminary design of simple aircraft jet engines. Furthermore, the students gain insight into phenomena such as rotating stall, surging, and engine aeroacoustics as well as the dynamic behaviour of jet engines and their control systems.

Special features

Sprache: Englisch Die Veranstaltung findet als Online-Vorlesung statt und ist ein Betandteil der "Flugtriebwerke"-Vorlesung. Studierende müssen daher bei Bedarf zwischen MOOC und Flugtriebwerke wählen.

Literature

Bräunling: Flugzeugtriebwerke: Grundlagen, Aero-Thermodynamik, ideale und reale Kreisprozesse, thermische Turbomaschinen, Komponenten, Emissionen und Systeme. 3. Aufl., Berlin [u.a.] : Springer, 2009. Farokhi, S.: Aircraft Propulsion. 2. Aufl., Chichester: Wiley, 2014. Cumpsty, N., Heyes, A.: Jet Propulsion, Cambridge University Press, 2015.

Applicability in other degree programs

Optische Technologien M.Sc.;

Module Nonlinear Control

Modul: Nonlinear Control

Type of module	Area of competence
Wahlpflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	4	120 min	benotet
SL	Studienleistung	1	Labor	unbenotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr.-Ing. Matthias Müller
Lecturer	Prof. Dr.-Ing. Matthias Müller
Institute	Institut für Regelungstechnik
Faculty	Fakultät für Elektrotechnik und Informatik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Nonlinear Control - Vorlesung	2	Klausur
Nonlinear Control - Hörsaalübung	1	Studienleistung

Requirements for participation:	Recommended for participation:
keine	Automatic Control Engineering I and II

Qualification goals

This course covers modern analysis and controller design methods for nonlinear systems. After this course, students should be able to identify and analyze nonlinear control problems, select suitable control approaches, carry out a controller design and implementation.

Contents

- Lyapunov stability
- Input-to-state stability
- Control Lyapunov functions
- Backstepping
- Sliding-mode control
- Input-Output linearization
- Passivity and Dissipativity
- Passivity-based controller desig

Special features

For this course, a course credit must be taken (laboratory).

Literature

Applicability in other degree programs

Maschinenbau M.Sc.; Optische Technologien M.Sc.;

Module Non-linear Optics

Modul: Nichtlineare Optik

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Deutsch/Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof. Dr. Silke Ospelkaus-Schwarzer
Lecturer	Prof. Dr. Silke Ospelkaus-Schwarzer
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Nichtlineare Optik - Vorlesung	3	
Nichtlineare Optik - Übung	1	

Requirements for participation:	Recommended for participation:
keine	Physik II, Experimentalphysik, Atom- und Molekülphysik / Physics II, Experimental Physics, Atomic and Molecular Physics

Qualification goals

The students acquire special knowledge of nonlinear laser optics and can apply the necessary mathematical methods themselves.

Contents

- Nonlinear optical susceptibility
- Crystal optics, tensor optics
- Wave equation with nonlinear source terms
- Frequency doubling, sum-, difference-frequency generation
- Optical parametric amplifier, oscillator
- Phase-matching schemes, quasi phase-matching
- Electro-optical effect
- Electro-acoustic modulator
- Frequency tripling, Kerr-effect, self-phase modulation, self-focusing
- Raman-, Brillouin-scattering, four wave mixing
- Nonlinear propagation, solitons

Special features

The courses name on Stud.IP is "Nichtlineare Optik"

Literature

Agrawal: Nonlinear Fiber optics, Academic Press; Boyd: Nonlinear Optics, Academic Press; Shen: Nonlinear Optics; Dmitriev: Handbook of nonlinear crystals, Springer;

Applicability in other degree programs

LbS/SprintING M.Ed.; Optische Technologien B.Sc.; Technische Informatik B.Sc.;

Module Operations Management and Research I: Operations Research

Modul: Operations Management and Research I: Operations Research

Type of module	Area of competence
Wahlpflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	5	60 min	benotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof. Dr. oec. Publ. Stefan Helber
Lecturer	Prof. Dr. oec. Publ. Stefan Helber
Institute	Institut für Produktionswirtschaft
Faculty	Wirtschaftswissenschaftliche Fakultät

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Operations Management and Research I: Operations Research - Vorlesung	2	Klausur
Operations Management and Research I: Operations Research - Hörsaalübung	2	

Requirements for participation:	Recommended for participation:
keine	Operations- und Logistikmanagement I

Qualification goals

Students will gain basic qualifications to model deterministic optimization problems and solve them using the GAMS modeling system in combination with some standard MIP solver. They will be able to describe and apply the improving search paradigm to numerically solve convex optimization problems. They can describe, justify and apply the two-phase simplex algorithm as a special case of an improvement algorithm. They can explain the relationship between a primal linear program and its dual as well as the complementary slackness condition. In addition, they can explain, justify and apply the branch & bound methodology for mixed-integer linear programs. Finally, they can explain and apply Bellman’s principle of optimality to solve dynamic programs in discrete time for the deterministic and the stochastic case.

Contents

This course treats fundamental aspects of algebraic modeling and using optimization methods in operations research. Students are introduced to the improving search paradigma, in particular over convex feasible sets. The simplex search for linear programming models are covered, including duality of LP models. With respect to discrete problems, the basic elements of the branch&bound method are introduced. Finally, the basic idea of multi-stage decision making via Dynamic Programming is treated. The GAMS modeling language is used in modeling exercises.This course treats fundamental aspects of algebraic modeling and using optimization methods in operations research. Students are introduced to the improving search paradigma, in particular over convex feasible sets. The simplex search for linear programming models are covered, including duality of LP models. With respect to discrete problems, the basic elements of the branch&bound method are introduced. Finally, the basic idea of multi-stage decision making via Dynamic Programming is treated. The GAMS modeling language is used in modeling exercises.

Special features

Veranstaltung ist in Stud.IP unter folgendem Titel zu finden: "Operations Research" (Vorlesung) und "Exercise in Operations Research" (Übung)

Module Operations Management and Research I: Operations Research

Modul: Operations Management and Research I: Operations Research

Literature
Informationen zur Modulorganisation (insbes. Terminplan, Literaturempfehlungen, Durchführung der Modulprüfung, Tutorium) werden über die Homepage des Instituts sowie bei StudIP bereitgestellt.
Applicability in other degree programs

Module Optical Clocks

Modul: Optische Uhren

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	2	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Muendliche Pruefung	2	30 min	benotet

Workload	60 h
Attendance study period	28 h
Self-study time	32 h
Module coordinator	Prof. Dr. Piet Schmidt
Lecturer	Prof. Dr. Piet Schmidt
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Optische Uhren - Vorlesung	2	Muendliche Pruefung

Requirements for participation:	Recommended for participation:
keine	Coherent optics, Atomic and molecular physics

Qualification goals

Students understand the basic concepts of optical clocks and their characterisation. They know advanced experimental methods of the field and can apply them under guidance. They are familiar with applications of optical clocks and can evaluate them independently and competently.
Achieving the competence goals of the laboratory exercise requires continuous participation.

Contents

-Introduction to optical clocks
-Atom-light interaction
-Trapped-ion physics
-Atoms in opitcal lattices
-Statistical uncertainty
-Clock laser
-Clock feedback loop
-Systematic effects& mitigation I - Neutrals
-Sysrematic effects& mitigation II - Ions
-Examples of clocks
-Frequency comb& directions

Special features

Hybrid lecture

Literature

Fritz Riehle, “Frequency standards: basics and applications”

Applicability in other degree programs

LbS/SprintING M.Ed.; Optische Technologien B.Sc.;

Module Optical Coatings and Layers for Engineering

Modul: Optische Schichten für Ingenieurwissenschaften

Type of module	Area of competence
Wahlpflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Deutsch/Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur / Muendliche Pruefung	4	90 min/30 min	benotet
SL	Studienleistung	1	Hausübungen	unbenotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr. Detlev Ristau
Lecturer	Prof. Dr. Detlev Ristau
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Optische Schichten für Ingenieurwissenschaften - Vorlesung	2	Klausur / Muendliche Pruefung
Optische Schichten für Ingenieurwissenschaften - Hörsaalübung	1	Studienleistung

Requirements for participation:	Recommended for participation:
none	Fundamentals of optics and physics recommended.

Qualification goals

The course offers a large variety of practical information on optical coatings, which may be of value for engineers and physicists heading towards a career in photonics.

Contents

•General basis (applications, impact, and functional principle of optical coatings, state of the art in coatings for laser technology)
•Theoretical fundamentals (compilation of formulae and consideration of fundamental phenomena, calculation of single layers and layer systems)
•Production of optical components (substrates, coating materials and techniques, control of coating processes)
•Optics characterization (measurement of optical transfer properties, optical losses: Total Scattering and absorption, laser induced damage thresholds of laser components, non-optical properties) Optical coatings can be considered as essential key-components in modern Photonics. For example, present laser sources, optical systems and products or even a major part of fundamental research could never be realized without optical coatings. In the course the fundamentals of coating design, production and characterization of functional layer systems will be presented. Recent research areas of optical coating technology, especially in the fields of high precision industrial production and the optimization of coating systems for high power lasers will be introduced and discussed.

Special features

Three exercise sheets for homework, solution of exercises discussed during the course, course assessment by written test. Both, exercises and written test have to be passed to finalise the course with 5 ECTS. The courses name on Stud.IP is Optische Schichten für Ingenieure.

Module Optical Coatings and Layers for Engineering

Modul: Optische Schichten für Ingenieurwissenschaften

Literature
Will be announced during the course, for an introduction: Macleod, H.A.: Thin Film Optical Filters, Fourth Edition, CRC Press 2010
Applicability in other degree programs
LbS/SprintING M.Ed.; Optische Technologien B.Sc.; Technische Informatik B.Sc.;

Module Optical Measurement Technology

Modul: Optische Messtechnik

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Deutsch/Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur / Muendliche Pruefung	5	90 min/20 min	benotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof Dr.-Ing. Eduard Reithmeier
Lecturer	Prof Dr.-Ing. Eduard Reithmeier
Institute	Institut für Mess- und Regelungstechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Optische Messtechnik - Vorlesung	2	Klausur / Muendliche Pruefung
Optische Messtechnik - Hörsaalübung	2	

Requirements for participation:	Recommended for participation:
keine	Messtechnik I / Measurement Technology I empfohlen

Qualification goals

After successful completion of the module, students are able
* to explain and apply basic concepts of optical metrology,
* to apply the basics of geometrical optics and wave optic,
* to compare different light sources and sensors and assign them to the measurement task,
* to explain fibre optic systems,
* to compare methods from the fields of surface metrology and geometric metrology and evaluate them for the application case.

Contents

The lecture gives an overview on theory, methods and devices in optical metrology. At the beginning, fundamentals of optics and photonics such as ray and wave optics are revised, which are essential for the understanding of concepts in optical metrology. Focusing on metrology in research and industrial applications, the lecture covers optical methods for measurement of topography, distance, and deformation as well as fiber optical sensors, which include concepts such as interferometry, holography and confocal microscopy. In addition, semi-optical methods such as atomic force microscopy and near field microscopy are addressed and compared to non-optical methods, e.g., scanning electron microscopy. To gain an in-depth understanding of the concepts involved in optical metrology, all devices and optical setups are explained in detail including light sources, cameras, and optical elements.

Special features

Examination depending on the number of participants: Individual examination 20 minutes orally or 90 minutes in writing.

Literature

Born, Wolf. Principles of Optics: Electromagnetic Theory of Propagation, Interference and Diffraction of Light; Demtröder: Experimentalphysik; Saleh, Teich: Grundlagen der Photonik; Lauterborn, Kurz: Coherent Optics; Goodman: Introduction to Fourier Optics; Hugenschmidt: Lasermesstechnik;
These and other sources are available as free download from www.springer.com, in German and English.

Module Optical Measurement Technology

Modul: Optische Messtechnik

Applicability in other degree programs
Computational Methods in Engineering B.Sc.; Computational Methods in Engineering M.Sc.; LbS/Metalltechnik M.Ed.; LbS/SprintING M.Ed.; Optische Technologien B.Sc.;

Module Optical Radiometry

Modul: Optische Radiometrie

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	3	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur / Muendliche Pruefung	1	60 min	benotet
SL	Studienleistung	2	Übung	unbenotet

Workload	90 h
Attendance study period	28 h
Self-study time	62 h
Module coordinator	apl. Prof. Dr. Milutin Kovacev
Lecturer	apl. Prof. Dr. Milutin Kovacev Prof. Dr. Andrea Trabattoni
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Optische Radiometrie - Vorlesung	2	Klausur / Muendliche Pruefung Studienleistung

Requirements for participation:	Recommended for participation:
none	none

Qualification goals

A new teaching concept will give the students the possibility to build their knowledge from hands-on projects. This concept aims to provide training for students in basic research skills like presenting, evaluating and analysing experimental research.

Contents

•Radiometry
•Photometry
•Optical devices for light measurement
•Laser safety
Example projects: Build up of a Power-Meter, Spectrscopy, Radiometry measurements of hazardous light sources, Light pulse detection, Coherent diffraction imaging, UV microscopy

Special features

Literature

Applicability in other degree programs

LbS/SprintING M.Ed.; Optische Technologien B.Sc.; Technische Informatik B.Sc.;

Module Philosophy of science and ethics of technical science

Modul: Wissenschaftsphilosophie und Ethik der Technikwissenschaft

Type of module	Area of competence
Pflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe/SoSe	1 Semester	Deutsch/Englisch	5	**Admission WiSe:**	2. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Veranstaltungsbegleitende Pruefung/ Hausarbeit	5		unbenotet

Workload	150 h
Attendance study period	28 h
Self-study time	122 h
Module coordinator	Prof. Dr. Thomas Reydon
Lecturer	Prof. Dr. Thomas Reydon
Institute	Institut für Philosophie & Centre for Ethics and Law in the Life Sciences (CELLS)
Faculty	Philosophische Fakultät

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Wissenschaftsphilosophie und Ethik der Technikwissenschaft - Seminar	2	Veranstaltungsbegleitende Pruefung/ Hausarbeit

Requirements for participation:	Recommended for participation:
keine	keine

Qualification goals

Nach Abschluss des Moduls kennen die Studierenden zentrale Ansätze, Fragestellungen und Begriffe aus der Wissenschafts- und Technikphilosophie sowie aus der Ethik zum breiten gesellschaftlichen Themenbereich „Umwelt, Klima, Nachhaltigkeit und Technologie“. Sie sind in der Lage die philosophischen Aspekte dieses Themenbereichs zu erläutern und diese mit der besonderen Verantwortung zu verknüpfen, die sich in der Forschung und Entwicklung innerhalb und aus den Technikwissenschaften heraus ergibt. Sie kennen ausgewählte Beispiele anhand derer sie die Thematik veranschaulichen können. Sie können das eigene ingenieurwissenschaftliche Tun reflektieren und vor dem Hintergrund philosophischer und insbesondere ethischer Aspekte abwägen.

Contents

In diesem Modul soll der Themenbereich „Umwelt, Klima, Nachhaltigkeit und Technologie“ aus der Perspektive der Wissenschafts- und Technikphilosophie, und der Ethik erörtert werden. Das Modul umfasst ein Angebot von Lehrveranstaltungen zu Umweltphilosophie und Nachhaltigkeit, Klimaproblematik, und Technikphilosophie. Studierende wählen eine Veranstaltung aus dem Angebot. Die Inhalte der Lehrveranstaltungen werden im aktuellen Vorlesungsverzeichnis (https://qis.verwaltung.uni-hannover.de/ und dort unter „Lehrveranstaltungen) bekanntgegeben.

Special features

• „Umweltphilosophie, Naturschutz und philosophische Aspekte der Nachhaltigkeit“ (Angebot jährlich im Sommersemester) oder • „Klimawandel als Problem für Wissenschaftsphilosophie und Wissenschaftsethik“ (Angebot alle zwei Jahre im Sommersemester) oder • „Technikphilosophie: Nachdenken über Technik, Mensch und Gesellschaft“ (Angebot jährlich im Wintersemester). Die Studierenden der Nachhaltigen Ingenieruwissenschaften müssen eine Veranstaltung des Moduls im Pflichtbereich des Bachelorstudiums einbringen. Sie haben die Möglichkeit die weiteren Veranstaltungen die nicht im Pflichtbereich belegt wurden, im Wahlpflichtbereich Nachhaltigkeitswissenschaften zu belegen. Die genaue Prüfungsleistungsform wird durch die Lehrperson bekanntgegeben. Prüfungsleistung wird in QIS-POS bzw. SAP angemeldet und verbucht (https://www.uni-hannover.de/nocache/de/studium/im-studium/pruefungsinfos-fachberatung/studiengang/detail/info/nachhaltige-ingenieurwissenschaft/).

Module Philosophy of science and ethics of technical science

Modul: Wissenschaftsphilosophie und Ethik der Technikwissenschaft

Literature
s. Literaturhinweis der betreffenden Lehrveranstaltung im kommentierten Vorlesungsverzeichnis des aktuellen Semesters
Applicability in other degree programs
Informatik B.Sc.;

Module Photogrammetric Computer Vision

Modul: Photogrammetric Computer Vision

Type of module	Area of competence
Wahlpflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	3	15 min	benotet
SL	Studienleistung	2	mehrere Hausübungen	unbenotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr.-Ing. habil. Christian Heipke
Lecturer	Prof. Dr.-Ing. habil. Christian Heipke
Institute	Institut für Photogrammetrie und Geoinformation
Faculty	Fakultät für Bauingenieurwesen und Geodäsie

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Photogrammetric Computer Vision - Vorlesung	2	Muendliche Pruefung
Photogrammetric Computer Vision - Übung	1	Studienleistung

Requirements for participation:	Recommended for participation:
none	Bachelorabschluss in einem Ingenieurfach empfohlen.

Qualification goals

After studying the module the students have a good overview and detailed knowledge of some exemplary methods of 3D reconstruction from images and image sequences (structure from motion, sfm). They understand the geometric transformations between image and object space, the usual procedures for pose estimation of moving sensors and basics of signal theory as applied to image matching. Students can thus evaluate pros and cons of sfm.
In the lab part, carried out in small groups, image sequences are captured using flying robots; these image sequences are being exploited using available software. In this way the students come to gain practical experience of digital image capture and geometric 3D reconstruction and can evaluate the obtained results.

Contents

Short introduction into aims, commonalities and differences of photogrammetry and computer vision, 3D image processing, projective geometry: transformation between image and object space, in linear models. Robust estimation (RANSAC). Different methods to represent 3D rotations (Euler angles axis-angle representation, quaternions). Structure from motion (sfm) from stereoscopic images and image sequences: interest operators (SIFT, SURF), sliding pose estimation, dense image matching, determination of object geometries. Methods for evaluation of results of image based approaches.

Special features

No information

Literature

David A. Forsyth and Jean Ponce (2003).
Computer Vision, A Modern Approach. Prentice Hall. Richard Hartley and Andrew Zisserman (2003).

Applicability in other degree programs

LbS/SprintING M.Ed.; Optische Technologien B.Sc.;

Module Photonics

Modul: Photonics

Type of module	Area of competence
Wahlpflicht	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	3	20 min	benotet
PL	Projektorientierte Prüfungsform	2	Seminarvortrag	benotet

Workload	150 h
Attendance study period	70 h
Self-study time	80 h
Module coordinator	Prof. Dr. Boris Chichkov
Lecturer	Prof. Dr. Boris Chichkov
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Photonics - Vorlesung	2	Muendliche Pruefung
Photonics - Übung	1	Projektorientierte
Photonics - Seminar	2	Prüfungsform

Requirements for participation:	Recommended for participation:
none	Kohärente Optik, Nichtlineare Optik

Qualification goals

The students gain special knowledge in nonlinear and integrated optics, and they can apply the corresponding mathematical methods. A special topic of photonics can be selected and deepened independently by the student. The topic shall be presented in the frame of a seminar with a subsequent discussion. Besides their technical competence, the students develop their methods in literature research, implementation of technical and scientific knowledge, as well as their presentation techniques together with their ability to lead scientific discussions.

Contents

- Waves in Media and at Boundaries
- Dielectric Waveguides (planar, fiber), Integrated Waveguides
- Waveguide Modes
- Nonlinear Fiber Optics
- Fiber optic components (Circulators, AWG, Fiber-Bragg-Gratings, Modulators), Optical Communication (WDM/TDM)
- Fiberlaser
- Laserdiodes, Photodetectors
- Plasmonics, Photonic Crystals
- Transformation Optics

Special features

Notenzusammensetzung: 80% Note der mündlichen Prüfung oder der Klausur; 10% Note für Inhalt und 10% Note für Form des Seminarvortrags

Literature

Literatur: Saleh: Fundamentals of Photonics, Wiley. Reider: Photonik, Springer; Menzel: Photonik, Springer. Originalliteratur.

Applicability in other degree programs

LbS/SprintING M.Ed.; Optische Technologien B.Sc.; Technische Informatik B.Sc.;

Module Physics of ultrasound and its applications

Modul: Physics of ultrasound and its applications

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	5	45 min	benotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Dr.-Ing. Jens Twiefel
Lecturer	
Institute	Institut für Dynamik und Schwingungen
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Physics of ultrasound and its applications - Vorlesung	2	Muendliche Pruefung
Physics of ultrasound and its applications - Labor	2	

Requirements for participation:	Recommended for participation:
none	none

Qualification goals

Students will be capable of
•Naming and describing the different effects of ultrasound
•Judging where the application of ultrasound is helpful
•Estimating the impact of ultrasound utilizing the methods used in class •Describing the necessary system design for the different applications and the ability to identify the operation principle of an unknown ultrasonic system

Contents

This lecture is complementary to the lecture "Ultraschalltechnik für industrielle Produktion, Medizin- und Automobiltechnik" in the summer semester, both lectures can be attended independently of each other and therefore in any order. This lecture focuses on the effects that can be achieved by ultrasound and their various applications, while the summer lecture deals with the basics and methods of the generation of ultrasound. The lecture is structured in three main parts
• Effects of ultrasound on: contact mechanics (vibro-impacts); friction reduction; acoustoplastic effect; dynamic recrystallization and atomic diffusion; cavitation in fluids; levitation
• Applications of power ultrasonics: Ultrasonic cleaning (atomization, defoaming); Sonochemistry (mixing, agglomeration, etc.); Metal joining and welding (incl. additive manufacturing); Plastic joining and forming; Ultrasonic metal forming and machining; Ultrasonic motors and transformers (incl. filters); Sensing with ultrasound
• Hands-on-Experience in Ultasound and its applications: Transducers and systems; Experiments on vibro-impact and nonlinearity; Experiments in Friction reduction; Bonding and welding with ultrasound; Cavitation for food and drinks; Experiments utilizing ultrasonic levitation; Crack detection with ultrasound

Special features

Weekly lecture: 90min and bi-weekly hands-on-lecture: 90min, Lecture will be given in English. § 6 MPO Students should prepare protocols for the experiments, which will be included in the grading.

Literature

Gallego-Juárez, J.A. and Graff, K.F.: Power ultrasonics: applications of high-intensity ultrasound. Elsevier. Heywang, W., Lubitz, K. and Wersing, W.: Piezoelectricity: evolution and future of a technology. Springer Science & Business Media.

Module Physics of ultrasound and its applications

Modul: Physics of ultrasound and its applications

Applicability in other degree programs
Computational Methods in Engineering B.Sc.; Computational Methods in Engineering M.Sc.; Mechatronik und Robotik M.Sc.; Produktion und Logistik M.Sc.;

Module Power Plant Engineering

Modul: Power Plant Engineering

Type of module	Area of competence
Wahlpflicht	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur / Muendliche Pruefung	4	90 min / 45 min	benotet
SL	Studienleistung	1	15 min Präsentation	unbenotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof. Dr.-Ing. Roland Scharf
Lecturer	
Institute	Institut für Kraftwerkstechnik und Wärmeübertragung
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Power Plant Engineering - Vorlesung	2	Klausur / Muendliche Pruefung
Power Plant Engineering - Hörsaalübung	1	Studienleistung
Power Plant Engineering - Tutorium	1	

Requirements for participation:	Recommended for participation:
keine	Thermodynamics I, Thermodynamics II

Qualification goals

The successful candidate will be able to:
•Understand the tension arising between meeting ecological and economical demands while providing secured supply
•Apply thermodynamics to processes in the power plant engineering sector •Know and compare different methods for power generation (fossil fuelled and renewable)
•Understand the structure and principle of operation of energy conversion technologies and analyse these using thermodynamics
•Understand multiple options to improve the energy conversion processes and to evaluate the realistic improvements using diagrams
•Discuss the advantages and disadvantages of combined energy conversion technologies

Contents

The module teaches the transformation of primary energy to electrical energy. The lecture focusses on sustainable use as well as the increase of efficiency in the consumption of raw materials and the contribution of thermal power plants to the „German Energiewende“.
•Conversion of primary energy to electrical energy
•Direct energy conversion
•Operation principles of simple heat- and incineration power plants •Operation principles of improved heat- and incineration power plants •Combined power generation technologies
•Combined heat- and power plants

Special features

The lecture is given in English;
In order to deepen the acquired knowledge from the lecture and the exercise, a short presentation on a topic from power plant engineering has to be given.

Literature

Baehr, H.D.; Kabelac, S.: Thermodynamik, 15. Aufl., Springer-Verlag, Berlin 2012 Strauß, K.:

Module Power Plant Engineering

Modul: Power Plant Engineering

Kraftwerkstechnik, 6. Aufl., Springer-Verlag, Berlin 2009 You will find many titles of the publishing house Springer free-of-charge in the W-Lan of the LUH stating www.springer.com
Applicability in other degree programs
Energietechnik M.Sc.;

Module Production of Optoelectronic Systems

Modul: Production of Optoelectronic Systems

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	5	90 min	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr.-Ing. Ludger Overmeyer
Lecturer	Prof. Dr.-Ing. Ludger Overmeyer
Institute	Institut für Transport- und Automatisierungstechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Production of Optoelectronic Systems - Vorlesung	2	Klausur
Production of Optoelectronic Systems - Übung	1	

Requirements for participation:	Recommended for participation:
none	none

Qualification goals

This module gives basic knowledge about processes and devices that are used in production of semiconductor packages and microsystems. The main focus is on the back-end-process that means the process thins wafer dicing. After successful examination in this module the students are able to

•correctly use the terms optoelectronic system, wafer production, front end and back end and to give an overview of production processes of semiconductor packages

•explain the production processes beginning from crude material sand and to have an idea about process relevant parameters

•visualize different packaging techniques and explain the corresponding basics of physics

•choose and classify different package types for an application

Contents

•Wafer production

•Mechanical Wafer treatment

•Mechanical connection methods (micro bonding, soldering, eutectic bonding) •Electrical connection methods (wire bonding, flip chip bonding, TAB) •Package types for semiconductors

•Testing and marking of packages

•Design and production of printed circuit boards

•Printed circuit board assembly and soldering techniques

Special features

Lecture, exercise and exam are offered in German and English.

Literature

Lau, John H.: Low cost flip chip technologies : for DCA, WLCSP, and PBGA assemblies. McGraw-Hill, New York 2000. Pecht, Michael: Integrated circuit, hybrid, and multichip module package design guidelines : a focus on reliability. Wiley, New York

Module Production of Optoelectronic Systems

Modul: Production of Optoelectronic Systems

1994. Bei vielen Titeln des Springer-Verlages gibt es im W-Lan der LUH unter www.springer.com eine Gratis Online-Version.
Applicability in other degree programs
Computational Methods in Engineering M.Sc.; Mechatronik und Robotik M.Sc.; Optische Technologien B.Sc.; Optische Technologien M.Sc.; Produktion und Logistik M.Sc.;

Module Programming and Software for Optics

Modul: Programming and Software for Optics

Type of module				Area of competence			
Pflicht							
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
WiSe	1 Semester	Englisch	4	**Admission WiSe:**	3. Semester	**Admission SoSe:**	. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
SL	Studienleistung	4	Testat	unbenotet

Workload	120 h
Attendance study period	28 h
Self-study time	92 h
Module coordinator	Prof. Dr. Antonio Calà Lesina
Lecturer	Prof. Dr. Antonio Calà Lesina
Institute	Hannoversches Zentrum für Optische Technologien
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Programming and Software for Optics - Übung	2	Studienleistung

Requirements for participation:	Recommended for participation:
keine	keine

Qualification goals

Understand and describe the advantages and limitations of various software packages and numerical techniques for photonics modelling. Use the main simulation software packages in photonics (ray optics, wave optics and multiphysics). Create complex geometries via CAD software. Implement scripts in Python/Matlab for pre-processing, post-processing, and optimization.

Contents

Simulation software and numerical techniques are powerful tools to model complex photonic systems, understand their behaviour, optimize their design and performance, and provide excellent support to experimental activities. This module introduces some of the programming tools and software packages that are used for optical and photonics simulations. Module content: Simulations in ray optics, wave optics and multiphysics: demos of commercial software, such as Zemax, Comsol Multiphysics, Ansys Lumerical. Scripting via Python/Matlab for pre-/post-processing, creation of compex geometries via CAD software, and design optimization.

Special features

keine

Literature

keine

Applicability in other degree programs

Technische Informatik B.Sc.;

Module Proseminar - Introduction to Microscopy

Modul: Proseminar - Grundlagen der Mikroskopie

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Deutsch/Englisch	3	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Projektorientierte Prüfungsform	3		benotet

Workload	90 h
Attendance study period	42 h
Self-study time	48 h
Module coordinator	Dr. Axel Günther
Lecturer	
Institute	Hannoversches Zentrum für Optische Technologien
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Proseminar - Grundlagen der Mikroskopie - Seminar	3	Projektorientierte Prüfungsform

Requirements for participation:	Recommended for participation:
keine	keine

Qualification goals

Im Rahmen dieses Moduls erlernen die Studenten grundlegende Kenntnisse zum Aufbau und der Funktionsweise von Mikroskopen die im Rahmen des praktischen Modulteils vertieft werden. Zu dem praktischen Teil des Moduls, der in Gruppen ausgeführt wird, sollen die Studenten Berichte anfertigen, die am Ende final diskutiert werden. Neben der fachlichen Kompetenz erlernen die Studierenden die selbstständige Arbeit im optischen Labor, die Umsetzung technischer und wissenschaftlicher Erkenntnisse und vertiefen ihre Fähigkeiten wissenschaftliche Diskussionen zu führen. In this module, students will learn basic knowledge about the construction and operation of microscopes, which is deepened in a practical part of the module. In the practical part, which is carried out in groups, the students are expected to prepare reports which are discussed at the end of the module. In addition to their technical competence, students will learn to work independently in the optical laboratory, to implement technical and scientific knowledge and their ability to lead scientific discussions.

Contents

- Grundlagen der Bildgebung
- Aberrationen und Beleuchtung
- Abbe-Theorie in der Bildgebung
- Kontrastmethoden
- Fluorescence Mikroskopie
- Das Spektrum des Lichts
- Moderne Mikroskopietechniken

- Introduction to optical Imaging
- Aberrations and Illumination
- Abbe theory of image formation
- Fluorescence microscopy
- Spectra and Filters
- Recent developments in microscopy

Module Proseminar - Introduction to Microscopy

Modul: Proseminar - Grundlagen der Mikroskopie

Special features
keine
Literature
Saleh und Teich: Grundlagen der Photonik Meschede: Optik, Licht und Laser
Applicability in other degree programs

Module Proseminar Biophotonics

Modul: Proseminar Biophotonik

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe/SoSe	1 Semester	Deutsch/Englisch	3	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
SL	Studienleistung	3	Präsentation	unbenotet

Workload	90 h
Attendance study period	28 h
Self-study time	62 h
Module coordinator	Prof. Dr. Uwe Morgner
Lecturer	Prof. Dr. Uwe Morgner Prof. Dr. Bernhard Roth
Institute	Hannoversches Zentrum für Optische Technologien
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Proseminar Biophotonik - Vorlesung	2	Studienleistung

Requirements for participation:	Recommended for participation:
keine	Basics of physics, Optical elements / Measurement techniques, Physical foundations of optics and laser technology, Basic knowledge in laser applications recommended

Qualification goals

- Students are able to search autonomously for the literature to a given topic from modern biophotonics

-Students are able to work out independently an actual science field

-Students are able to structure ande make a presentation about a complex issue from the modern physics, which could be followed by physical competent audience. By presenting the layout they are able to interest the audience for a complex special topic.

-Students are able to develop an appealing presentation (e.g. PowerPoint)

-Students are able to conduct a scientific discussion (on topics of theirs own and theirs classmates as well)

-Students are able to communicate fluently in German and English

Contents

The focus of the proseminar lies on the applications of optical technologies, methods and processes in the life sciences. The students acquire knowledge on both basic concepts and their implementation into real applications. Typical fields of application are optical microscopy and imaging for medical diagnosis or precision laser spectroscopy for the investigation of the functionality of biomolecules and molecular analytics. Furthermore, emphasis will be placed on modern optical technology for lab-on-chip applications and integrated laser methods for medical screening, among others.

Special features

Graded performance: oral examination and presentation slides Type of examination: oral (marked or unmarked, as required) The courses name on Stud.IP is "Proseminar Grundlagen der Biophotonik"

Literature

Applicability in other degree programs

LbS/SprintING M.Ed.; Optische Technologien B.Sc.;

Module Quantum computing and quantum logic with trapped ions

Modul: Quantencomputing und Quantenlogik mit gespeicherten Ionen

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Deutsch/Englisch	4	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	4	30 min	benotet
SL	Studienleistung	0	Übung	unbenotet

Workload	120 h
Attendance study period	42 h
Self-study time	78 h
Module coordinator	Prof. Dr. Christian Ospelkaus
Lecturer	Prof. Dr. Tobias Osborne Prof. Dr. Christian Ospelkaus
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Quantencomputing und Quantenlogik mit gespeicherten Ionen - Vorlesung	2	Muendliche Pruefung
Quantencomputing und Quantenlogik mit gespeicherten Ionen - Übung	1	Studienleistung

Requirements for participation:	Recommended for participation:
keine	• Grundlegende Vorlesung in Quantenmechanik oder Atom- und Molekülphysik • Elektrizität und Relativität oder vergleichbar

Qualification goals

die Studierenden können die Grundlagen der Speicherung von Ionen auf praktische Probleme anwenden (Coulomb-Kristalle, Normalmoden, Dynamik analysieren). Sie können die Vor- und Nachteile verschiedener atomarer Zustandspaare als Qubits analysieren. Die Studierenden verstehen die elementaren Gatteroperationen und können den Übergang von quantenoptischen Mechanismen zu abstrakten Quantengattern nachvollziehen. Sie sind mit den Skalierungsansätzen vertraut und können am Beispiel der Ionenfallentechnologie diskutieren, inwiefern diese einen skalierbaren Ansatz darstellt und wo die aktuellen Herausforderungen liegen. Es wird grundlegende Vertrautheit mit Algorithmen und Anwendungen sowie mit der Fehlerkorrektur erreicht.

Contents

- Ionenfallen, Dynamik von Ionen in elektromagnetischen Potentialen
- Qubits - optische und Hyperfein-Qubits, atomare Struktur
- Initialisierung und Detektion
- Quantenoptische Grundlagen und Quantengatter
- DiVincenzo Kriterien
- Skalierung und Mikrofabrikation, sympathetisches Kühlen
- Grundlegende Algorithmen und Fehlerkorrektur

Special features

Ohne Bestehen der Studienleistung ist eine Teilnahme an der Prüfungsleistung nicht möglich. Nach dem Bestehen beider Leistungsnachweise gibt es insgesamt 4 ECTS.

Literature

Ein Lehrbuch im eigentlichen Sinne existiert zu dem Thema noch nicht. Einzelne Aspekte der folgenden Materialien können hilfreich sein: - Nielsen and Chuang, Quantum Computation and Quantum Information, Cambridge - John Preskill, Lecture Notes, http://theory.caltech.edu/~preskill/ph229/ - Christopher J. Foot, Atomic Physics, Oxford - Ghosh, Ion Traps, Oxford -

Module Quantum computing and quantum logic with trapped ions

Modul: Quantencomputing und Quantenlogik mit gespeicherten Ionen

D.J. Wineland, Nobel Lecture: Superposition, entanglement, and raising Schrödinger's cat, Rev. Mod. Phys. 85, 1103 (2013) - D.J. Wineland et al., Experimental issues in coherent quantum-state manipulation of trapped atomic ions, J. Res. NIST 103,259 (1998) - R. Blatt and D. Wineland, Entangled States of Trapped Atomic Ions, Nature 453, 1008 (2008)
Applicability in other degree programs
LbS/SprintING M.Ed.;

Module Radar Remote Sensing

Modul: Radar Remote Sensing

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	4	15 min	benotet
SL	Studienleistung	1	mehrere Hausübungen	unbenotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof. Dr. Madhi Motagh
Lecturer	Prof. Dr. Madhi Motagh
Institute	Institut für Photogrammetrie und Geoinformation
Faculty	Fakultät für Bauingenieurwesen und Geodäsie

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Radar Remote Sensing - Vorlesung	2	Muendliche Pruefung
Radar Remote Sensing - Übung	2	Studienleistung

Requirements for participation:	Recommended for participation:
none	Some familiarity with a Linux operating system is beneficial for lab exercises

Qualification goals

The aim of this module is to provide an introduction to the technique of radar remote sensing with an emphasis on Synthetic Aperture Radar (SAR), Interferometry Synthetic Aperture Radar (InSAR), and multi-temporal interferometry (MTI) techniques. Given the increasing availability of SAR systems, the goal is to foster a better understanding of these systems and their applicability to various types of natural disasters and engineering tasks. At the end of the course the students have an overview of basic requirements of radar remote sensing methods, systems and applications and have an understanding of the fundamental concepts underlying radar remote sensing. They have gained the ability to implement different processing techniques in order to extract and evaluate information from SAR data in response to natural disasters and engineering applications.

Contents

Lecture content:

- Mathematical and physical principles of Radar remote sensing
- Introduction to Side Looking Radar, Radar Image Formation and Synthetic Aperture Radar (SAR)
- Radar Parameters (wavelength, polarization, incidence anagle)
- Geometric characteristics of SAR images and their distortions
- Backscattering mechanism and interpretation of SAR signatures
- Airborne and space-borne SAR sensor systems
- How to access SAR data sources?
- SAR image processing with SNAP
- SAR data analysis with Google Earth Engine: Flood mapping and land cover classification
- SAR interferometry (InSAR) and Differential InSAR (DInSAR) to measure Earth's surface topography and deformation
- Fundamental equation of Interferometry: Height ambiguity, sensitivity analysis, selection of baseline, critical baseline
- Typical processing chain: 2 and 3 pass Interferometry
- Interferometric phase quality: Coherence, temporal and spatial decorrelation
- Phase Unwrapping ➢ Error sources: Residual topography; Tropospheric error, ionospheric error
- Stripmap and TOPS InSAR analysis with SNAP

Module Radar Remote Sensing

Modul: Radar Remote Sensing

➢ Along-track interferometry; pixel offset tracking and multiple-aperture SAR interferometry
➢ Multi-temporal InSAR (MTI) theory: Stacking, Permanent/Persistent Scatterer Interferometry (PSI) and Small BAseline Subset (SBAS)
➢ Satellite SAR Interferometry for geophysical and engineering applications
➢ Cloud-based platforms for rapid InSAR and MTI analysis
➢ Optional excursions will be offered to GFZ Potsdam, towards the end of the semester.

Lab: lab assignments in Radar Remote Sensing.

Special features

This lecture is given in English.

Literature

• Massonnet, D., & Feigl, K. L. (1998). Radar interferometry and its application to changes in the earths surface. Reviews of Geophysics, 36, 441-500. • Bürgmann, R., Rosen, P., & Fielding, E. (2000). Synthetic Aperture Radar Interferometry to measure Earths surface topography and its deformation. Annual Review of Earth and Planetary Sciences, 28, 169-209. • Hanssen, Ramon F (2001). Radar interferometry: data interpretation and error analysis. Vol. 2. Springer Science & Business Media, 2001. • Ghiglia, D.C. and Pritt, M.D. (1998). Two-dimensional phase unwrapping: theory, algorithms, and software (Vol. 4). New York: Wiley • Dzurisin, D. (2007). Volcano Deformation: Geodetic Measuring Techniques. Berlin, Heidelberg: Springer-Verlag. ISBN 3540426426. • Simons, M. & Rosen, P. (2007). Interferometric Synthetic Aperture Radar Geodesy. In: Schubert, G. & Herring, T. (eds.). Treatise on Geophysics, Volume 3: Geodesy (pp. 391-446), New York: Elsevier Press. • Shimada, Masanobu, (2020), Imaging From Spaceborne And Airborne Aars, Calibration, And Applications, ISBN 9780367570798 • Crosetto, Michele et al. "Persistent scatterer interferometry: A review. ISPRS Jour¬nal of Photo¬gram¬metry and Remote Sensing 115 (2016): 78-89. • Berardino, Paolo, et al. "A new algorithm for surface deformation monitoring based on small baseline differential SAR interferograms." IEEE Transactions on geoscience and remote sensing 40, no. 11 (2002): 2375-2383.

Applicability in other degree programs

LbS/SprintING M.Ed.; Optische Technologien B.Sc.; Technische Informatik B.Sc.;

Module Recursive State Estimation for dynamic Systems

Modul: Recursive State Estimation for dynamic Systems

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	4	15 min	benotet
SL	Studienleistung	1	Übung	unbenotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	PD Dr.-Ing. Hamza Alkhatib
Lecturer	PD Dr.-Ing. Hamza Alkhatib
Institute	Geodätisches Institut Hannover
Faculty	Fakultät für Bauingenieurwesen und Geodäsie

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Recursive State Estimation for dynamic Systems - Vorlesung	2	Muendliche Pruefung
Recursive State Estimation for dynamic Systems - Hörsaalübung	2	Studienleistung

Requirements for participation:	Recommended for participation:
keine	Basic engineering mathematics and applied statistics, basic Matlab programming skills

Qualification goals

To present mathematical approaches to the best possible way of estimating the state of a general nonlinear dynamic system recursively, and

- to provide the implementation towards discrete-time systems in software based on typical applications in the field of object tracking and robotics After successful completion of this module, the students are able to
- give an overview of typical filtering approaches in a general discrete-time system;
- explain the principles of different Gaussian, Bayesian and particle filters;
- apply different filter approaches to data sets in the field of object tracking and robotic;
- analyse application problems with regard to adequate system and observation models;
- correctly interpret predicted and filtered states obtained from the aforementioned filters.

Contents

optimal recursive state estimation in discrete-time systems (Kalman filter)

- Gaussian filters (extended Kalman filter, unscented Kalman filter and ensamble Kalman Filter) for nonlinear systems
- introduction into Bayesian inference
- the Bayes filter
- introduction into Monte Carlo techniques
- the particle filter
- applications to a tracking problems (e.g., regarding the motion of robots)

Special features

Keine

Literature

Hastie, Trevor J.; Friedman, Jerome H.; Tibshirani, Robert (2017): The elements of statistical learning. Data mining, inference, and prediction. 2. ed.. New York: Springer.

Module Recursive State Estimation for dynamic Systems

Modul: Recursive State Estimation for dynamic Systems

Brunton, Steven L.; Kutz, Jose Nathan (2019): Data-driven science and engineering. Machine learning, dynamical systems, and control. Cambridge, United Kingdom, New York, NY: Cambridge University Press.
Applicability in other degree programs

Module Rheology and numerical methods in Tribology

Modul: Rheology and numerical methods in Tribology

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	5	20 min	benotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Dr.-Ing. Norbert Bader
Lecturer	Dr.-Ing. Norbert Bader
Institute	Institut für Maschinenkonstruktion und Tribologie
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Rheology and numerical methods in Tribology - Vorlesung	2	Muendliche Pruefung
Rheology and numerical methods in Tribology - Übung	2	

Requirements for participation:	Recommended for participation:
keine	Tribologie 1, Grundlagenfächer

Qualification goals

After this course students are able to distinguish different lubrication problems and develop own models for contacts based on state of the art lubrication science. The students learn to solve problems on their own using numerical methods. They thus, have a basic understanding enabling them to analyse and develop solutions for more complicated problems.

Contents

The module presents further studies on lubrication, tribology, and numerical methods to solve lubrication problems.
- Lubrication
- Film build up
- Reynolds equation
- common numerical methods in tribology The course uses home work and problems that should be solved by the students themselves to teach practical application of the problems.

Special features

Englische Vorlesung mit Übungen (selbst programmmieren)

Literature

High Pressure Rheology for Quantitative Elastohydrodynamics The Friction and Lubrication of Solids contact mechanics

Applicability in other degree programs

Mechatronik und Robotik M.Sc.;

Module Scientific Machine learning

Modul: Scientific Machine learning

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	2	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	1	20 min	benotet
SL	Studienleistung	1	Semester Project	unbenotet

Workload	60 h
Attendance study period	28 h
Self-study time	32 h
Module coordinator	Prof. Xiaoying Zhuang
Lecturer	Prof. Xiaoying Zhuang
Institute	Hannoversches Zentrum für Optische Technologien
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Scientific Machine learning - Vorlesung	2	Muendliche Pruefung Studienleistung

Requirements for participation:	Recommended for participation:
none	Probability, Matrix theory (linear algebra)

Qualification goals

Nowadays machine learning (ML) has revolutionized numerous scientific fields, as data-mining and learning has became a state-of-the-art technique. The aggravating complexity as well as the demands of data quality and quantity generated in contemporary scientific problems have drivens the need of employing ML techniques in scientific modeling. These machine learning-assisted techniques is able to accelerate, automate, and even improve the traditional workflows. Emerging at the forefront of this trend is a novel field called scientific machine learning (SciML). The central goal of SciML is to introduce existing scientific understanding into ML, producing powerful and generalized ML-informed to the prior knowledge. A plethora of approaches have been proposed for embedding scientific principles into ML and SciML has been successfully applied in a various research fields and is now expected to address some of the biggest challenges in science. Understanding the fundamentals and mathematics toward different machine learning tasks using the classical and state-of-the-art SciML methods for various applications are the goals of this course. The knowledge obtained from this course consitute an important qualification for students in physics, material science, chemistry and mechanical engineering. The course is of high relevance and importance in many applications, including materials processing, optical technology, machinary, biotechnology engineering, civil engineering, electric engineering, to name but a few. In these areas, SciML will assist scientists and engineers to build more generalized and robust machine learning predictive models from complex real-world raw data, to utilize various hetergeneous data sources, different data types and even discover new principles from all those data. In this course, the students will be introduced to the fundamental concepts, theories, computations as well as applications of SciML, starting from fundamental introduction of machine learning algorithms oriented to different learning tasks including regressions and classifications. The understanding of basic machine learning technique will be then applied to scientific computing where physical descriptions are made to be awared by the neural network. Variety of demonstrations of SciML in different engineering fields will be expounded for students from different backgrounds. Furthermore, the common computing platform that can be used for SciML and their limiations will also be shown and discussed. At the end of this course, students should be familiar with the classical machine learning models and able to setup their own models from open-source libraries. Furthermore, the students are expected to be able to utilize the prior knowledge in their own research filed in building the SciML models and understand the validity and limits of their results. They shall be experienced on understanding and discussing the state of the art literature in the scientific machine learning and on the defense of their findings by an oral presentation of a selected problem.

Module Scientific Machine learning

Modul: Scientific Machine learning

Contents
Part I Basics of Artificial Intelligence and Machine Learning 1. Introduciton 1: Review of the history of artificial intelligence and machine learning and state of the art applications 2. Introduction 2: Basic concepts and limitations of AI 3. Setup of the neural network architecture (including basic concepts and ingredients of a neural network, training process) 4. Commonly used types of network architecture e.g. ANN, CNN, RNN, including introduction to some open source tools 5. Regression, classification, optimization and parameters Part II Applications to Sciences and Engineering Problems 6. Machine learning for image processing and identification 7. Physics informed machine learning: collocation approach 8. Deep energy method: energy and potential based approach (nonlinear materials, transfer learning) 9. Machine learning for waveguide 10. Machine learning for materials design and engineering 11. Machine learning for classification and mining Students are also guided by practical exercises in the computer lab, assigning also specific projects to be solved through the implementation of codes. The codes will be written in Python language based on scikit-learn and pytorch libraries. A introduction and examples to using scientific machine learning for solving partial differential equations will be demonstrated.
Special features
Examination: Semester project and oral presentation
Literature
Applicability in other degree programs

Module Seminar Nonlinear Fiber Optics: Supercontinuum generation, Rogue Waves, and Black Holes

Modul: Seminar Nichtlineare Faseroptik: Superkontinuumserzeugung, Monsterwellen und Schwarze Löcher

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Deutsch/Englisch	3	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Projektorientierte Prüfungsform	3	Vortrag und Diskussion 60 min	benotet

Workload	90 h
Attendance study period	28 h
Self-study time	62 h
Module coordinator	apl. Prof. Dr. Ayhan Demircan
Lecturer	apl. Prof. Dr. Ayhan Demircan
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Seminar Nichtlineare Faseroptik: Superkontinuumserzeugung, Monsterwellen und Schwarze Löcher - Seminar	2	Projektorientierte Prüfungsform

Requirements for participation:	Recommended for participation:
keine	

Qualification goals

The students gain special knowledge in nonlinear fiber optics and to fiber optical analogies to phenomena in different fields in physics. A special topic has to be presented by the student with a subsequent discussion. Besides their technical competence, the students develop their methods in literature research, implementation of technical and scientific knowledge, as well as their presentation techniques together with their ability to lead scientific discussions.

Die Studierenden erwerben spezielle Kenntnisse in nichtlinearer Faseroptik und zu faseroptischen Analogien zu Phänomenen in verschiedenen Bereichen der Physik. Ein spezielles Thema ist von den Studierenden zu präsentieren und anschließend zu diskutieren. Neben der fachlichen Kompetenz entwickeln die Studierenden ihre Methoden der Literaturrecherche, der Umsetzung technischer und wissenschaftlicher Erkenntnisse sowie ihre Präsentationstechniken und ihre Fähigkeit, wissenschaftliche Diskussionen zu führen.

Contents

- Introduction to fiber optics
- Nonlinear fiber propagation
- Solitons
- Supercontinuum generation
- Optical event horizon
- Optical rogue waves
- Soliton interaction in fibers (collisions, molecules)
- Quantum effects in fiber optics
- Strong field effects in hollow core fibers

- Einführung in die Faseroptik
- Nichtlineare Propagation in Fasern
- Solitonen
- Superkontinuum-Erzeugung
- Optischer Ereignishorizont
- Optische Monsterwellen
- Soliton-Wechselwirkung in Fasern (Kollisionen, Moleküle)

Module Seminar Nonlinear Fiber Optics: Supercontinuum generation, Rogue Waves, and Black Holes

Modul: Seminar Nichtlineare Faseroptik: Superkontinuumserzeugung, Monsterwellen und Schwarze Löcher

- Quanteneffekte in der Faseroptik - Starkfeldeffekte in Hohlkernfasern
Special features
Literature
Applicability in other degree programs
LbS/SprintING M.Ed.;

Module Seminar Numerical Optics

Modul: Seminar Numerische Optik

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Deutsch/Englisch	3	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
SL	Projektorientierte Prüfungsform	3	60 min Vortrag und Diskussion	unbenotet

Workload	90 h
Attendance study period	28 h
Self-study time	62 h
Module coordinator	apl. Prof. Dr. Ayhan Demircan
Lecturer	apl. Prof. Dr. Ayhan Demircan
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Seminar Numerische Optik - Seminar	2	Projektorientierte Prüfungsform

Requirements for participation:	Recommended for participation:
none	Computational Photonics

Qualification goals

The students get introduced into numerical methods for the investigation of light matter interaction for weak and strong fields in optical media. A special topic has to be presented by the student with a subsequent discussion. Besides their technical competence, the students develop their methods in literature research, implementation of technical and scientific knowledge, as well as their presentation techniques together with their ability to lead scientific discussions.

Contents

Seminar covering selected topics for the calculation of light distributions in optical media
Contents:

- Spectral- and pseudospectral methods
- Runge-Kutta- and Split-Step-Integration
- Fast-Fourier Transform (FFT)
- Monte Carlo (MC) simulation
- Finite Difference Time Domain (FDTD)
- Finite Element Methods
- Ray Tracing
- Beam-propagation methods (BPM)
- Parallelization using MPI

Special features

-

Literature

-

Module Seminar Numerical Optics

Modul: Seminar Numerische Optik

Applicability in other degree programs
LbS/SprintING M.Ed.; Optische Technologien B.Sc.;

Module Seminar on nanophotonics

Modul: Seminar on nanophotonics

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	3	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
SL	Studienleistung	3	Präsentation	unbenotet

Workload	90 h
Attendance study period	42 h
Self-study time	48 h
Module coordinator	Prof. Dr. Antonio Calà Lesina
Lecturer	Prof. Dr. Antonio Calà Lesina
Institute	Institut für Transport- und Automatisierungstechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Seminar on nanophotonics - Seminar	3	Studienleistung

Requirements for participation:	Recommended for participation:
none	Wave-optics and photonics recommended.

Qualification goals

Discuss recent results in the field of nanophotonics and nano-optics, and understand the relevant theoretical background.

Contents

The seminar focuses on advanced topics in nanophotonics and nano-optics, such as optical metasurfaces, nonlinear metamaterials, flat lenses, computational nanophotonics, inverse design, nanoplasmonics and biosensing. The work consists in a literature review and final discussion of a topic of choice. The goal is to bring the students in contact with the current research topics in the field.

Special features

Keine

Literature

Novotny, L., & Hecht, B. (2012). Principles of Nano-Optics (2nd ed.). Cambridge: Cambridge University Press. Gaponenko, S. (2010). Introduction to Nanophotonics. Cambridge: Cambridge University Press. Maier, S. (2007). Plasmonics: Fundamentals and Applications. Springer, New York.

Applicability in other degree programs

LbS/Metalltechnik M.Ed.; LbS/SprintING M.Ed.; Optische Technologien B.Sc.;

Module Seminar Optics at Femto- and Attoscond Scales

Modul: Seminar Optik auf Femto- und Attosekunden-Zeitskalen

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe/SoSe	1 Semester	Deutsch/Englisch	3	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Projektorientierte Prüfungsform	1	Vortrag (40 min)	benotet
SL	Studienleistung	2	Vorbereitung, Präsenz	unbenotet

Workload	90 h
Attendance study period	28 h
Self-study time	62 h
Module coordinator	apl. Prof. Dr. Milutin Kovacev
Lecturer	apl. Prof. Dr. Milutin Kovacev
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Seminar Optik auf Femto- und Attosekunden-Zeitskalen - Seminar	2	Projektorientierte Prüfungsform Studienleistung

Requirements for participation:	Recommended for participation:
keine	Lectures on Nonlinear Optics / Ultrafast Lasers / Solid State Lasers recommended.

Qualification goals

-Students are able to research autonomously for a iterature to a given actual issue from systems -Students are able to work out independently an actual science field -Students are able to struture and make a presentation about a complex issue from the modern physical competent audience. By presenting the layout they are able to interest the audience for a complex special topic -Students are able to conduct a scientific discussion (on topics of theirs own and theirs classmates as well) -Students are able to communicate fluently in German and English

Contents

- Hochleistungs-Femtosekunden-Lasersysteme
- Wechselwirkung von Materie mit starken Feldern
- Filamentation
- Plasmakanäle
- Die absolute Trägerphase
- Quanten-Interferenz-Metrologie
- Modenkämme
- Relativistische Optik
- Laser-Teilchenbeschleunigung
- Erzeugung und Nachweis hoher Harmonischer
- Erzeugung und Nachweis von Attosekunden-Pulsen
- Atomare Fotografie
- Der Freie-Elektronen-Laser
- High-power femtosecond laser systems
- Interaction of matter with strong fields
- Filamentation
- Plasma channels
- The absolute carrier phase
- Quantum interference metrology

Module Seminar Optics at Femto- and Attoscond Scales

Modul: Seminar Optik auf Femto- und Attosekunden-Zeitskalen

- mode combs / Relativistic optics - laser particle acceleration - Generation and detection of high harmonics - Generation and detection of attosecond pulses - Atomic photography - The free-electron laser
Special features
Für optische Technologien. The courses name on Stud.IP is "Seminar Optik auf Femto- und Attosekunden-Zeitskalen". Die Studierenden haben in dem Seminar sowohl eine benotete Prüfungsleistung als auch eine Studienleistung zu absolvieren.
Literature
Applicability in other degree programs
LbS/SprintING M.Ed.; Optische Technologien B.Sc.;

Module Simulations in photonics (wave-optics)

Modul: Simulations in photonics (wave-optics)

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Projektorientierte Prüfungsform	5	225 min	benotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof. Dr. Antonio Calà Lesina
Lecturer	Prof. Dr. Antonio Calà Lesina
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Simulations in photonics (wave-optics) - Vorlesung	2	Projektorientierte
Simulations in photonics (wave-optics) - Übung	2	Prüfungsform

Requirements for participation:	Recommended for participation:
none	Knowledge of electrodynamics and theoretical optics (Grundlagen der Optik I und II).

Qualification goals

After successfully completing of the course, students are able to: - Understand the basics of wave optics simulation and identify the most appropriate solutions for specific problems. - Perform simulations on many relevant problems in the field of optics and photonics using current commercial software. - Implement scripts in Python/Matlab for pre- and post-processing - Present and discuss simulation results.

Contents

This course is the advanced version of the B.Sc. course "Programming and Software for Optics". It aims at presenting current software solutions for the simulation and design of photonic devices based on wave optics. Simulation tools from the commercial packages Ansys Lumerical (FDTD, FDFD, EME, varFDTD, CHARGE, DGTD, FEEM, HEAT, LumOpt, Interconnect) and Comsol Multiphysics (wave optics module) will be demonstrated for applications in integrated optics, nanophotonics, optical fibers and waveguides, including multiphysics scenarios and optimization techniques. Integration with Matlab/Python will also be demonstrated, as well as solutions for pre-/post-processing.

Special features

A project will be assigned. This requires simulations on a given topic with a final presentation and discussion.

Literature

none

Applicability in other degree programs

Module Solar Cell Physics

Modul: Physik der Solarzelle

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Deutsch/Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur / Muendliche Pruefung	5	90 min/20 min	benotet
SL	Studienleistung	0	Kurzklausuren	unbenotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof. Dr.-Ing. Rolf Brendel
Lecturer	Prof. Dr.-Ing. Rolf Brendel
Institute	Institut für Festkörperphysik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Physik der Solarzelle - Vorlesung	2	Klausur / Muendliche Pruefung
Physik der Solarzelle - Hörsaalübung	2	Studienleistung

Requirements for participation:	Recommended for participation:
keine	Einführung in die Festkörperphysik

Qualification goals

Die Studierenden erwerben spezielle Kenntnisse auf dem Gebiet der Photovoltaik und können diese selber anwenden. Photovoltaik stellt ein wichtiges Anwendungsgebiet der Nanotechnologie dar. Die Übungen fördern auch die Kommunikationsfähigkeit und die Methodenkompetenz bei der Umsetzung von Fachwissen.

Contents

-Halbleitergrundlagen
-Optische Eigenschaften von Halbleitern
-Transport von Elektronen und Löchern
-Mechanismen der Ladungsträgerrekombination
-Herstellungsferfahren für Solarzellen
-Charakterisierungsmethoden für Solarzellen
-Möglichkeiten und Grenzen der Wirkungsgradverbesserung

Special features

zusätzliche Studienleistung: Übungsaufgaben. Die Vorlesung und Übung zu „Physik der Solarzelle“ findet ausschließlich in deutscher Sprache statt. Die Vorlesungsfolien sind in Englisch.

Literature

Würfel, P.: Physik der Solarzellen, Spektrum Akademischer Verlag, 2000; Goetzberger, A.; Voß, B.; Knobloch, J.: Sonnenenergie: Photovoltaik, Teubner 1994

Applicability in other degree programs

Informatik B.Sc.; LbS/SprintING M.Ed.; Technische Informatik B.Sc.;

Module Strong Field Physics

Modul: Strong Field Physics

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Deutsch/Englisch	3	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur / Muendliche Pruefung	2	60 min	benotet
SL	Studienleistung	1	Laborübung	unbenotet

Workload	90 h
Attendance study period	56 h
Self-study time	34 h
Module coordinator	apl. Prof. Dr. Milutin Kovacev
Lecturer	apl. Prof. Dr. Milutin Kovacev
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Strong Field Physics - Vorlesung	2	Klausur / Muendliche Pruefung
Strong Field Physics - Übung	2	Studienleistung

Requirements for participation:	Recommended for participation:
none	Grundkenntnisse in Physik und Kohärenter Optik empfohlen.

Qualification goals

Die Studierenden verstehen die grundlegenden Konzepte von starken optischen Feldern und deren Wechselwirkung mit Materie. Sie lernen in der Vorlesung diese eigenständig auf ausgewählte Probleme anzuwenden. Sie kennen fortgeschrittene experimentelle Methoden des Gebietes und können diese unter Anleitung anwenden.

Contents

Die Vorlesung beinhaltet auch eine Laborübung zur Förderung der Forschungskompetenz von Studierenden durch projektorientierte Lernformate. Das Erreichen der Kompetenzziele der Laborübung erfordert eine kontinuierliche Teilnahme •Kohärente und inkohärente Strahlungsquellen •Röntgen-Optik •Detektion von Röntgen-Strahlung •Laser-Materie-Wechselwirkung •Erzeugung von Harmonischen höherer Ordnung / Attosekundenpulse •Anwendungen in Atom-, Molekül- und Festkörperphysikestkörperphysik Students understand the basic concepts of strong optical fields and their interaction with matter. They learn to apply these independently to selected problems in the lecture. They know advanced experimental methods of the field and can apply them under guidance. The lecture also includes a laboratory exercise to enhance students research skills through project-based learning formats. Achieving the competency objectives of the laboratory exercise requires continuous participation -Coherent and incoherent radiation sources-X-ray optics -detection of X-ray radiation -Laser-matter interaction -Generation of higher order harmonics / attosecond pulses -Applications in atomic, molecular and solid state physics

Special features

Um das Modul zu bestehen, muss sowohl die Prüfungsleistung als auch die Studienleistung erfolgreich bestanden sein.

Literature

Z. Chang, „Fundamentals of Attosecond Optics“, CRC Press 2011 D. Attwood, “Soft x-rays and extreme ultraviolet radiation”, Cambridge University Press 1999 T. Brabec, “Strong Field Laser Physics”, 2008 Springer

Applicability in other degree programs

LbS/SprintING M.Ed.; Optische Technologien B.Sc.;

Module Sustainability assessment I

Modul: Sustainability assessment I

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Hausarbeit	5	20 content pages + figures etc.	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr.-Ing. Hans-Josef Endres
Lecturer	Prof. Dr.-Ing. Hans-Josef Endres M. Eng. Sebastian Spierling M. Sc. Venkateshwaran Venkatachalam
Institute	Institut für Kunststoff- und Kreislauftechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Sustainability assessment I - Vorlesung	3	Hausarbeit

Requirements for participation:	Recommended for participation:
none	-

Qualification goals

Upon successful completion of the module, students will be able to, define and explain terms in the field of sustainability; name methods for assessing sustainability; explain how to carry out a life cycle assessment according to ISO 14040/44; define balance sheet boundaries according to requirements; analyze life cycle assessments for products and processes; define methods for Design for Recycling/Ecodesign and Circular Economy.

Contents

The module provides knowledge about sustainability assessment (especially the environmental aspects) of products, processes and technologies. The methods as well as practical applications and areas of use will be explained:
•Sustainability, Sustainable Development Goals (SDG's) and sustainability assessment.
•Methods for assessing the different dimensions of sustainability
•Procedure for conducting a life cycle assessment according to ISO 14040/44 (target and study framework, functional units, system boundaries, life cycle inventory and data collection, impact assessment (midpoint and endpoint), evaluation, scenario and sensitivity analyses)
•Evaluation of LCA results
•Case studies on life cycle assessments (especially with focus on plastics) •Overview of available software systems and databases
•Life cycle assessments at the interface to Design for Recycling/Ecodesign/Circular Economy

Special features

Term paper as examination performance. Attention: In winter semster the lecture will take place in english (Sustainability assessment I). In summer the course will be tought in german (Nachhaltigkeitsbewertung I). Please notice: the number of participants is limited to 25.

Literature

Life Cycle Assessment Theory and Practice (ISBN 978-3-319-56475-3) Life Cycle Assessment Handbook: A Guide for Environmentally Sustainable Products (ISBN 1118528271) Life Cycle Assessment (LCA) A Guide to Best Practice (ISBN 978-3-527-32986-1) EcoDesign Von der Theorie in die Praxis (ISBN 978-3-540-75437-4) Design for Sustainability (ISBN 9780429456510)

Module Sustainability assessment I

Modul: Sustainability assessment I

Applicability in other degree programs
Optische Technologien M.Sc.; Produktion und Logistik M.Sc.;

Module Sustainability assessment II

Modul: Nachhaltigkeitsbewertung II

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Hausarbeit	5	20 Seiten Inhalt + Abbildungen etc.	benotet

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr.-Ing. Hans-Josef Endres
Lecturer	Prof. Dr.-Ing. Hans-Josef Endres M. Eng. Sebastian Spierling M. Sc. Venkateshwaran Venkatachalam
Institute	Institut für Kunststoff- und Kreislauftechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Nachhaltigkeitsbewertung II - Vorlesung	3	Hausarbeit

Requirements for participation:	Recommended for participation:
keine	Nachhaltigkeitsbewertung I

Qualification goals

Nach erfolgreicher Absolvierung des Moduls sind die Studierenden in der Lage,

- Die Vorgehensweise zur Erstellung von Nachhaltigkeitsbewertungen zu benennen und zu erläutern
- Verschiedene Softwarefunktionen zur Nachhaltigkeitsbewertung zu verstehen
- Datenbanken und Datensätze im Zusammenspiel mit der Software zu verstehen
- Softwarebasierte Ökobilanzen für Produkte eigenständig vorzunehmen
- Den Einfluss von verschiedenen End-of-Life-Situationen für unterschiedliche Produkte auf die ökologischen Gesamtauswirkungen zu bewerten
- Ökobilanz-Berichte basierend auf den Ergebnissen zu erstellen

Contents

Das Modul vermittelt praktische Kentnisse über die Durchführung von softwarebasierten Nachhaltigkeitsbewertungen und deren Dokumentation (insbesondere die ökologischen Aspekte) von Produkten, Prozessen und Technologien. Das Modul baut hierbei direkt auf Nachhaltigkeitsbewertung 1 auf. Die Methoden sowie praktische Anwendungen und Einsatzgebiete werden erläutert:

- Übersicht zu Softwaresystemen zur Nachhaltigkeitsbewertung
- Durchführung von Nachhaltigkeitsbewertungen mittels Softwaresystemen •Zusammenspiel zwischen Softwaresystem und Bewertung
- Bewertung von unterschiedlichen Produkten und Lebenszyklusphasen (Herstellungsphase, Nutzungsphase, End-of-Life-Phase)
- Anwendungsweise und Funktionen eines Softwaresystems zur Nachhaltigkeitsbewertung •Erstellung einer Produktökobilanz

Special features

Hausarbeit als Prüfungsleistung. Bitte beachten Sie, dass die Teilnehmendenzahl auf 25 Personen limitiert ist. Als Zugangsvoraussetzung muss die Nachhaltigkeitsbewertung I erfolgreich absolviert worden sein.

Literature

Life Cycle Assessment Theory and Practice (ISBN 978-3-319-56475-3) Life Cycle Assessment Handbook: A Guide for

Module Sustainability assessment II

Modul: Nachhaltigkeitsbewertung II

Environmentally Sustainable Products (ISBN 1118528271) Life Cycle Assessment (LCA) A Guide to Best Practice (ISBN 978-3-527-32986-1)
Applicability in other degree programs
Informatik B.Sc.; Maschinenbau B.Sc.; Optische Technologien M.Sc.; Produktion und Logistik M.Sc.;

Module Sustainable Combustion

Modul: Sustainable Combustion

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	4	90 min	benotet
SL	Studienleistung	1	Laborveranstaltung	unbenotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof. Dr. Friedrich Dinkelacker
Lecturer	Prof. Dr. Friedrich Dinkelacker
Institute	Institut für Technische Verbrennung
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Sustainable Combustion - Vorlesung	2	Klausur
Sustainable Combustion - Hörsaalübung	1	Studienleistung
Sustainable Combustion - Labor	1	

Requirements for participation:	Recommended for participation:
keine	Thermodynamics I

Qualification goals

The modul teaches the fundamentals of combustion together with its implication to the questions of environmental impact and the challenges in this respect. After successfully completing the course, students will be able to

•know about the challenges of combustion with respect to environmental topics,
•differentiate between types of combustion and describe different types in detail,
•make up the balance for combustion processes,
•explain typical examples of applications for various types of combustion,
•identify potentials for reducing emissions and to evaluate them,<iv>
•be able to discuss the potentials and challenges of sustainable fuels with respect to the environmental impact for different application fields.

Contents

•Importance and problems of combustion - also for sustainable energy
•Fundamentals, types and spread of flames
•Balance of amount of substance, mass and energy
•Chemical kinetics and ignition processes
•Laminar and turbulent combustion
•Liquid and solid fuels - Sustainable fuels
•Emissions
•Technical applications
•Sustainable combustion approaches

Special features

For passing this course the participation in a laboratory experiment is needed. Either the course "Sustainable Combustion Technology" or "Sustainable Combustion" can be taken. It is not possible to take both. Please also note whether the

Module Sustainable Combustion

Modul: Sustainable Combustion

module is to be recognized as an elective or compulsory elective in your degree program. The English module Sustainable combustion in the winter semester can only be taken as an elective. Wurde dieses Modul bereits im Bachelorstudiengang Nachhaltige Ingenieurwissenschaft belegt, ist eine erneute Teilnahme im Masterstudiengang Nachhaltige Ingenieurwissenschaft nicht möglich.
Literature
Turns: An Introduction to Combustion: Concepts and Application - Warnatz, Maas, Dibble: Combustion
Applicability in other degree programs
Energietechnik M.Sc.; Informatik B.Sc.; Maschinenbau B.Sc.; Mechatronik und Robotik M.Sc.; Optische Technologien M.Sc.;

Module Technology, Development & Sustainability of Car Tires

Modul: Technology, Development & Sustainability of Car Tires

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	3	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	3	20 min	benotet

Workload	90 h
Attendance study period	28 h
Self-study time	62 h
Module coordinator	Dr.-Ing. Burkhard Wies
Lecturer	
Institute	Institut für Dynamik und Schwingungen
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Technology, Development & Sustainability of Car Tires - Vorlesung	2	Muendliche Pruefung

Requirements for participation:	Recommended for participation:
none	keine

Qualification goals

Learning Objectives Completing this module, students will be able to •describe the role of a passenger car tire and its history
•analyse the car tire market
•explain the tire construction and its production
•understand the tire's material properties and chemistry
•set up mechanical models and understand simulation procedures with respect to noise and vibration
•plan tire testing set-ups

Contents

•History of Car Tires
•Role of the Tire
•Tire Market
•Tire Construction
•Tire Production
•Material Properties & Friction
•Rubber Chemistry
•Basics of Tire Mechanics
•Tire Testing
•Tire Models, Simulation & Prediction Tools
•Noise, Vibration & Harshness of Tires
•Innovation and Sustainability

Special features

Blockveranstaltung; Exkursion zur Continental AG (FE, Produktion, Contidrom) für teilnehmende Studierende

Module Technology, Development & Sustainability of Car Tires

Modul: Technology, Development & Sustainability of Car Tires

Literature
Vorlesungsfolien; Backfisch: Das große (neue) Reifenbuch; Braess, Seiffert: Handbuch Kraftfahrzeugtechnik. Bei vielen Titeln des Springer-Verlages gibt es im W-Lan der LUH unter www.springer.com eine Gratis Online-Version.
Applicability in other degree programs
Mechatronik und Robotik M.Sc.; Optische Technologien M.Sc.;

Module Ultrashort laser pulses

Modul: Ultrakurze Laserpulse

Type of module	Area of competence
Wahl	

Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Deutsch/Englisch	2	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Klausur	2	90 min	benotet

Workload	60 h
Attendance study period	28 h
Self-study time	32 h
Module coordinator	Priv.-Doz. Dr. Ihar Babushkin
Lecturer	Priv.-Doz. Dr. Ihar Babushkin
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Ultrakurze Laserpulse - Vorlesung	2	Klausur

Requirements for participation:	Recommended for participation:
keine	Optik, Atomphysik und Quantenphänomene; Empfohlen: Kohärente Optik

Qualification goals

In this course, students shall gain an understanding for the generation of ultrashort laser pulses, including ist properties and areas of application.

Contents

Representation of ultrashort light pulses Propagation equations, Causality and dispersion, Origin of the refractive index Propagation in dispersive media, Pulse front distortions, Chirp management: Angular dispersion, Chirped mirrors, Pulse shapers Ultrafast nonlinear optics: Second-order effects, Phase matching, Broadband frequency conversion, OPA; Third-order effects: SPM, Self-focusing, Propagation in waveguides, Solitons, Filamentation Pulse characterization Ultrashort pulse generation: Resonators, Laser dynamics, Relaxation oscillations, Q-switching, Mode locking Short pulse amplification, High-energy laser systems

Special features

The courses name on Stud.IP is "Ultrakurze Laserpulse"

Literature

D. Meschede: Optik, Licht und Laser, Vieweg+Teubner, 3. Aufl. 2008.

Applicability in other degree programs

LbS/SprintING M.Ed.; Optische Technologien B.Sc.; Technische Informatik B.Sc.;