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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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.;