Course	Institute	Semester	ECTS	Course Scope	Lecturer	Module description	Previous knowledge	Special feature
Advanced Thermodynamics / ThermoLab	Institut für Thermodynamik	Summer	5	V2/Ü2/L1	Prof. Dr.-Ing. habil. Kabelac	This module competes the basic foundation of technical thermodynamics by applying the laws of thermodynamics to a variety of energy conversion processes. 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. 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	Basics of Thermodynamics (Thermodynamics I)	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.
Analysis of deformation measurments	Geodätisches Institut Hannover	Winter/ Summer	4	V2/Ü1	Prof. Dr.-Ing. Neumann	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. Module Contents · Deformation measurements · 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) · evaluation and analysis strategies practical example in civil structures (bridges, tunnels, dams, ...)	Knowledge in adjustment computations is necessary (e.g. from the course Schätz-und Optimierungsverfahren). Furthermore, programming skills are helpful but not mandatory for the exercises (i.e. MATLAB).	Practical excercises for deepening the knowledge with the aid of practical examples. Veranstaltung wird in Englisch gegeben
Applied elasticity theory in the aviation	Institut für Kontinuumsmechanik	Winter	5	V2/Ü1	Dr.-Ing.Habil. Jacob	Der Kurs Angewandte Elastizitätstheorie in der Luftfahrt vermittelt, neben den aerodynamischen und flugmechanischen Belastungen spezifischer Bauteile von Flugkörpern, vor allem die mechanische Berechnung der von den aerodynamischen Kräften und den beim Start- und Landevorgang auftretenden Kräften belasteten Strukturen von Flugzeugen. Hierbei werden solche Strukturen untersucht, die in der Luftfahrt häufig verwendet werden. Es handelt sich dabei um Membranen, Scheiben, Platten und Schalen, die auf ganz spezifische Arten belastet werden können. Auch Faser-Verbund-Leichtbaustrukturen werden behandelt. Lokale und globale Spannungen und Dehnungen sind dabei ebenso im Fokus wie Schwingungen von Ein- und Mehrmassensystemen sowie Kontinuumsschwingungen (Aeroelastik). Der Kurs soll zudem vermitteln, wie der Anwender die physikalische Theorie bezüglich der in der industriellen Praxis vorkommenden Probleme umsetzen und nutzen kann.	Technische Mechanik I - IV, von Vorteil aber nicht zwingend notwendig sind Kontinuumsmechanik I und Finite Elements I	
Applied elasticity theory in the aviation	Institut für Kontinuumsmechanik	Winter	5	V2/Ü1	Dr.-Ing. Aldakheel	Der Kurs Angewandte Elastizitätstheorie in der Luftfahrt vermittelt, neben den aerodynamischen und flugmechanischen Belastungen spezifischer Bauteile von Flugkörpern, vor allem die mechanische Berechnung der von den aerodynamischen Kräften und den beim Start- und Landevorgang auftretenden Kräften belasteten Strukturen von Flugzeugen. Hierbei werden solche Strukturen untersucht, die in der Luftfahrt häufig verwendet werden. Es handelt sich dabei um Membranen, Scheiben, Platten und Schalen, die auf ganz spezifische Arten belastet werden können. Auch Faser-Verbund-Leichtbaustrukturen werden behandelt. Lokale und globale Spannungen und Dehnungen sind dabei ebenso im Fokus wie Schwingungen von Ein- und Mehrmassensystemen sowie Kontinuumsschwingungen (Aeroelastik). Der Kurs soll zudem vermitteln, wie der Anwender die physikalische Theorie bezüglich der in der industriellen Praxis vorkommenden Probleme umsetzen und nutzen kann.	Technische Mechanik I - IV, von Vorteil aber nicht zwingend notwendig sind Kontinuumsmechanik I und Finite Elements I	
Applied Wave Optics	Cluster of Excellence PhoenixD	Winter/	4	L2	Dr.-Ing. Caspary	This lecture starts with a fast introduction to wave optics. It covers the theory from Maxwell`s equations to	Electromagnetism, Maxwell's	Recommended for first semester and higher of
Aspects of Process Design in Forming Technology	Institut für Umformtechnik und Umformmaschinen	Winter	5	V2/Ü1	Dr.-Ing. Krimm	This module provides an insight into the process of metal forming. Objectives: - Understanding of the basic principles for material characterisation and numerical simulation used for the analysis of forming processes Ability to apply digital design tools to solve problems related to forming technology. Content: After an introduction into the fundamentals of forming technology, the development of forming processes, the computer aided design process and the finite element analysis will be addressed. Experimentally determined parameters build the input for these analyses. The forming process takes place by use of various forming machines and peripheral devices. Subsequently, process-integrated quality assurance methods will be presented.		Vorlesungssprache: Englisch / Language of lectures: English
Aspects of Process Design in Forming Technology	Institut für Umformtechnik und Umformmaschinen	Winter	5	V2/Ü1	Prof. Dr.-Ing. Behrens	This module provides an insight into the process of metal forming. Objectives: - Understanding of the basic principles for material characterisation and numerical simulation used for the analysis of forming processes Ability to apply digital design tools to solve problems related to forming technology. Content: After an introduction into the fundamentals of forming technology, the development of forming processes, the computer aided design process and the finite element analysis will be addressed. Experimentally determined parameters build the input for these analyses. The forming process takes place by use of various forming machines and peripheral devices. Subsequently, process-integrated quality assurance methods will be presented.		Vorlesungssprache: Englisch / Language of lectures: English

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Atom Optics for Optical Technologies	Institut für Quantenoptik	Summer	5	V2/Ü1	Dozenten der Quantenoptik	The aim of this lecture course is the introduction of engineering students to the basic principles of atom optics. As a foundation, the fundamental aspects and concepts of quantum mechanics, such as wave functions, Schrödinger equation and the principle of superposition are provided. Afterwards, fundamental and technological aspects and applications of matter wave interferometers are discussed and put into context with their optical analogons. The exercise course aims at consolidating the understanding of the basic principles and provides theoretical exercises according to selected example applications and delivers intensified direct context to quantum optics laboratories. Contents: Foundations of quantum mechanics Mathematical methods Wave functions & Schrödinger equation Principle of superposition Matter wave interferometry Fundamental aspects, atom-light interaction Technological aspects, e.g. in the context of noise in atom interferometers Applications Matter wave interferometry Fundamental aspects, atom-light interaction Technological aspects, e.g. in the context of noise in atom interferometers Applications	Basics of laser physics and laser technology, “Optik, Atomphysik und Quantenphänomene" (Exphy 3)	Recommended for second semester and higher (Master course)
Atom Optics for Optical Technologies	Institut für Quantenoptik	Summer	5	V2/Ü1	Prof. Dr. Rasel	The aim of this lecture course is the introduction of engineering students to the basic principles of atom optics. As a foundation, the fundamental aspects and concepts of quantum mechanics, such as wave functions, Schrödinger equation and the principle of superposition are provided. Afterwards, fundamental and technological aspects and applications of matter wave interferometers are discussed and put into context with their optical analogons. The exercise course aims at consolidating the understanding of the basic principles and provides theoretical exercises according to selected example applications and delivers intensified direct context to quantum optics laboratories. Contents: Foundations of quantum mechanics Mathematical methods Wave functions & Schrödinger equation Principle of superposition Matter wave interferometry Fundamental aspects, atom-light interaction Technological aspects, e.g. in the context of noise in atom interferometers Applications Matter wave interferometry Fundamental aspects, atom-light interaction Technological aspects, e.g. in the context of noise in atom interferometers Applications	Basics of laser physics and laser technology, “Optik, Atomphysik und Quantenphänomene" (Exphy 3)	Recommended for second semester and higher (Master course)
Atom Optics for Optical Technologies	Institut für Quantenoptik	Summer	5	V2/Ü1	Dr. Schlippert	The aim of this lecture course is the introduction of engineering students to the basic principles of atom optics. As a foundation, the fundamental aspects and concepts of quantum mechanics, such as wave functions, Schrödinger equation and the principle of superposition are provided. Afterwards, fundamental and technological aspects and applications of matter wave interferometers are discussed and put into context with their optical analogons. The exercise course aims at consolidating the understanding of the basic principles and provides theoretical exercises according to selected example applications and delivers intensified direct context to quantum optics laboratories. Contents: Foundations of quantum mechanics Mathematical methods Wave functions & Schrödinger equation Principle of superposition Matter wave interferometry Fundamental aspects, atom-light interaction Technological aspects, e.g. in the context of noise in atom interferometers Applications Matter wave interferometry Fundamental aspects, atom-light interaction Technological aspects, e.g. in the context of noise in atom interferometers Applications	Basics of laser physics and laser technology, “Optik, Atomphysik und Quantenphänomene" (Exphy 3)	Recommended for second semester and higher (Master course)

Course	Institute	Semester	ECTS	Course Scope	Lecturer	Module description	Previous knowledge	Special feature
Atomic Optics	Institut für Quantenoptik	Summer	4	V2/E1	Prof. Dr. Ospelkaus	Recent experimental procedures to investigate the physics of ultracold gases, lasermanipulation of single atoms and quantum engineering are discussed experimentally and theoretically. Students will gain insight in recent developments in the field of atomic physics. Contents: 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	Atom and Molecular Physics, Quantumoptics	The course's name on Stud.IP is "Atomoptik"
Audio and Speech Signal Processing	Institut für Informationsverarbeitung	Winter	5	V2/Ü1	Prof. Dr.-Ing. Nogueira-Vazquez	Das Modul setzt sich aus drei Teilen zusammen. Eine Vorlesung (2 SWS), eine Übung (1 SWS) und einer Laborübung (1 SWS). Das Modul vermittelt die Grundlagen der Sprachakustik. Nach erfolgreicher Absolvierung des Modulssind die Studierenden in der Lage, eine Methodik zur Analyse von Code, Erkennung und Synthese von Audiosignalen mithilfe von Signalverarbeitungstechniken zu entwickeln. Sie haben die theoretischen und praktischen Kompetenzen erworben in Bezug auf: Grundlagen der Akustik, Physiologie und xnehmung von Schall, Grundlagen der digitalen Signalverarbeitung von Audiosignalen, Methoden zur Modellierung und Verarbeitung von Audio- und Sprachsignalen. Die Modulinhalte sind Mechanismen der Sprachproduktion, Klangklassifikation, Klangrepräsentation. Sowie Grundlagen der xnehmung: Tonhöhe, Intensität und Klangfarbe, Spektralanalyse von Audio- und Sprachsignalen und Sprachmodelle: Physikalische Sprachmodelle, Grundlagen der Sprachxnehmung sowie Spektrale Transformation von Audio- und Sprachsignalen.	Grundlagen der digitalen Signalverarbeitung; Empfohlen: "Digitale Signalverarbeitung", "Statistische Methoden der Nachrichtentechnik", "Informationstheorie" und "Quellencodierung", Grundlagen von Matlab.	Englischsprachige Lehrveranstaltung
Automotive Lighting	Institut für Dynamik und Schwingungen	Winter	5	V2	Prof. Dr.-Ing. Wallaschek	The course offers an introduction into automotive lighting technology and teaches the technological and physiological fundamentals which are necessary to understand and evaluate lighting systems. In addition to the required optical variables the state of the art and future trends of automotive lighting will be presented. Important technologies like for example new light sources and their application in automotive front and signal lights as well as in further optical systems will be considered. One main aspect of the lecture focusses on light-based driver assistance systems (e.g. glare free high beam, marking light) which are one core aspect of today's technological development. Physiological and psychological basics like the structure of the human eye and the visual system complete the course. Contents: Light sources, headlights, rear lights Mechanical and electronical components Light-based driving assistance systems Visual system of humans Structure of the human eye Photopic, mesopic and scotopic vision Disability and discomfort glare Environment sensor systems Image processing Active lighting systems		The course language is English. The course consists of two parts: 1. An introductory part on the basics of lighting technology (2 lectures) and on human vision and visual perception (1 lecture) 2. A further lecture part on current topics in automotive lighting technology (3 lectures)
Bachelor Thesis	Diverse	Winter/ Summer	13	390h	Professorinnen und Professoren der Fakultät für Maschinenbau (ErstprüferIn)	Nach erfolgreichem Absolvieren des Moduls sind Studierende in der Lage ein gestelltes Forschungsthema unter Anwendung ingenieurwissenschaftlicher Methoden selbstständig zu bearbeiten, den wissenschaftlichen Kenntnisstand zu erweitern und die Ergebnisse in schriftlicher und mündlicher Form mit hohem wissenschaftlichen Anspruch zu präsentieren Das Modul besteht aus der wissenschaftlichen Ausarbeitung der Bachelorarbeit (Bachelor Thesis) und der erfolgreichen Präsentation der Arbeit. Aktuelle Aufgabenstellungen können der Forschung der Institute der Fakultät entspringen oder durch Studierenden selbst an die Fachgebiete und die jeweiligen Institute herangetragen werden. Durch die Bachelorarbeit demonstrieren Studierende, dass sie in der Lage sind, durch eigenständige Bearbeitung einer komplexen Forschungsfrage ingenieurwissenschaftliche Ergebnisse zu entwickeln, zu dokumentieren und die mögliche Implikation der Lösungen valide darzustellen. Sie wenden hierbei im Studium erworbene wissenschaftliche Methodenkenntnisse an. Die Präsentation verlangt die strukturierte Vorstelltung der erlangten Ergebnisse vor einer Fachzuhörerschaft und die Verteidigung der erreichten Ergebnisse.	Vorpraktikum und mind. 120 Leistungspunkte	Maschinenbau BSc und Produktion und Logistik BSc: Zum Modul gehören die Präsentation der Abschlussarbeit (1 LP) sowie das Tutorium "Einführung in das wissenschaftliche Arbeiten" (1 LP) Mechatronik BSc: Die Bachelorarbeit und die Präsentation gibt 15 LP

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Biointerface Engineering	Institut für Mehrphasenprozesse	Summer	5	V2/Ü2	Prof. Prof. h.c. Dr.-Ing. Glasmacher	Qualifikationsziele: Das Modul vermittelt spezifische Kenntnisse zur anwendungsorientierten Charakterisierung und Modifikation von Werkstoffen sowie Produkten (z.B. Implantaten) hinsichtlich Biokompatibilität für die Medizintechnik. Nach erfolgreicher Absolvierung des Moduls sind die Studierenden in der Lage, • aufgrund der Kenntnisse von grundlegenden physikalischen und mechanischen Eigenschaften der unterschiedlichen Werkstoffgruppen eine anwendungsbezogene Auswahl zu treffen, • unterschiedliche Verfahren zur Modifikation und Charakterisierung von Werkstoffoberflächen und Grenzflächen (Biointerfaces) zu erläutern, • spezifische Biointeraktionen zwischen Werkstoff und biologischem Milieu zu erläutern und bewerten, • aufbauend auf dokumentierten Schadensfällen (BfArM, FDA) eine Strategie zur Optimierung des Biointerfaces zu erarbeiten und dieses durch ein wissenschaftliches Poster zu präsentieren. Inhalte: • Werkstoffe für die Biomedizintechnik • Verfahren zur Charakterisierung und Modifikation von Implantatoberflächen • Prüfverfahren zur Beurteilung der Biointeraktion (Bio-/Hämokompatibilität) • Strategien zur Beurteilung und Manipulation der Zell-Implantat-Interaktion • Verfahren zur Erzeugung von funktionalem Gewebeersatz • Qualitätskriterien wissenschaftlicher Präsentationen	Empfohlen: Biokompatible Werkstoffe, Biokompatible Polymere, Medizinische Verfahrenstechnik	In der Übung wird das Wissen vermittelt, wie ein wissenschaftliches Poster für Fachtagungen vorbereitet wird. Aufgrund der aktuellen Situation des Online-Lernens wird die Präsentation online gehalten. Vorlesung und Übung sind in Englisch.
Biomedical Engineering for Engineers II	Institut für Mehrphasenprozesse	Summer	5	V2/Ü2	Prof. Prof. h.c. Dr.-Ing. Glasmacher	Qualifikationsziele: Das Modul vermittelt spezifische Kenntnisse über medizintechnische Geräte und Systeme zur Diagnose und Therapie von Krankheitsbildern. Nach erfolgreicher Absolvierung sind die Studierenden in der Lage, •die Funktionsprinzipien von Diagnose und Therapiesystemen zu erläutern. •eine anwendungsbezogene Auswahl der geeigneten Verfahren zu treffen. •Optimierungspotential aktueller Systeme zu erkennen. •Konzepte für neuartige Systeme zu erarbeiten. Inhalte: •Geschichtliche Entwicklung der biomedizinischen Technik •Funktionsweisen diagnostischer Geräte wie EKG, EEG, EMG, Ultraschall, CT und Röntgen •Therapieverfahren, wie Herzunterstützungssysteme •Herstellungsverfahren •aktuelle Entwicklungen und Innovationen	Biomedizinische Technik für Ingenieure I	Die Vorlesung beinhaltet eine praktische Übung. In deren Rahmen werden, aufbauend auf einem Anforderungsprofil und Herstellungskonzept, Implantatprototypen hergestellt. Der Herstellungsprozess wird anschließend qualitativ bewertet
Biophotonics - Imaging Physics and Manipulation of Biological Cells	Institut für Quantenoptik	Summer	4+1	V2/Ü1/P1	Prof. Dr. Heisterkamp	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, as well as optical coherence tomography, and laser scanning microscopy and super resolution approaches. Furthermore, application within biotechnology, such as biochips, cell sorting and cell surgery and interaction with nanoparticles and nanostructures will be discussed. The students will acquire knowledge within this interdisciplinary field of physics, engineering, life science and medicine. The covered areas will be exemplarily discussed using examples of current research themes investigated at joint projects with the MHH and the excellence cluster REBIRTH (From Regenerative Biology to Reconstructive Therapy).Aside from teaching the fundamentals and facts of biophotonics, the lecture introduces the students to the search and understanding of original research articles. With each topic covered within the lecture, recent articles from research journals will be discussed in monthly tutorials. In one of these tutorials the article search using internet search engines will be covered (at the RRZN). The other tutorials will take place at the seminar room of theIQ, in which the relevant article will be discussed.	Basic knowledge in coherent optics, Possibly Fundamentals of Lasers in Medicine and Biomedical Optics (WS), Laserphysics	To reach the 5 LP you have to pass an exam (4LP) and a presentation (1LP). In addition to the lecture tutorials are offered in monthly intervals regarding e.g. literature research on the internet, Fourier transformation or image processing. The course's name on Stud.IP is "Biophotonik - Bildgebung und Manipulation von biologischen Zellen"
Business, Technology & Development of Vehicle Tires	Institut für Dynamik und Schwingungen	Winter	3	V2	Dr.-Ing. Wies	Learning Objectives Completing this module, students will be able to describe the role of a passenger car tire and its history analyse the car tire market explain the tire construction and its production understand the tire's material properties and chemistry set up mechanical models and understand simulation procedures with respect to noise and vibration plan tire testing set-ups Contents History of Car Tires Role of the Tire Tire Market Tire Construction Tire Production Material Properties & Friction Rubber Chemistry Basics of Tire Mechanics Tire Testing Tire Models, Simulation & Prediction Tools Noise, Vibration & Harshness of Tires		Blockveranstaltung; Exkursion zur Continental AG (FE, Produktion, Contidrom) für teilnehmende Studierende
Combustion Technology	Institut für Technische Verbrennung	Winter	5	V2/Ü1/L1	Prof. Dr. Dinkelacker	This course conveys fundamentals of combustion technology and its applications. After successfully completing the course, students will be able to •differentiate between types of combustion and describe different types in detail, •make up the balance for combustion processes, •explain typical examples of applications for various types of combustion, •identify potentials for reducing emissions and to evaluate them. Content: •Fundamentals, types and spread of flames •Balance of amount of substance, mass and energy •Chemical kinetics •Ignition processes •Characteristic numbers •Calculation and model approaches •Emissions •Technical applications	Basic knowledge in Thermodynamics and in Fundamentals of Chemistry	For passing this course the participation in a laboratory expertiment is needed
Combustion Technology	Institut für Technische Verbrennung	Winter	5	V2/Ü1/L1	Dr. Kuppa	This course conveys fundamentals of combustion technology and its applications. After successfully completing the course, students will be able to •differentiate between types of combustion and describe different types in detail, •make up the balance for combustion processes, •explain typical examples of applications for various types of combustion, •identify potentials for reducing emissions and to evaluate them. Content: •Fundamentals, types and spread of flames •Balance of amount of substance, mass and energy •Chemical kinetics •Ignition processes •Characteristic numbers •Calculation and model approaches •Emissions •Technical applications	Basic knowledge in Thermodynamics and in Fundamentals of Chemistry	For passing this course the participation in a laboratory expertiment is needed

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Computational Photonics	Institut für Quantenoptik	Summer	6	V2/Ü2	apl. Prof. Dr. Demircan	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. Topic: 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)		Prüfungsleistung: Die Note ergibt sich aus 40% der Berwertung der Leistungen in den Computerübungen und 60% der Klausurnote.
Continuum Mechanics I	Institut für Kontinuumsmechanik	Winter	5	V2/Ü2	Dr.-Ing. Aldakheel	Description of the module: In Continuum Mechanics I basic tensor algebra and tensor analysis will be discussed. Based on that, concepts of kinematics, e.g. deformation, deformation gradient, strain tensor and polar decomposition will be introduced to account for 3D continuum. Finally the balance equations (mass balance, linear and angular momentum balance, 1st and 2nd law of thermodynamics) will be illustrated. Intended skills: For new technical development, understanding of the basic concepts of mechanics is essential to design a new product or process in an optimal way. Therefore, realistic modeling is needed. This subject handles the theoretical basics to estimate the real processes. It formulates along with the module "Finite Elements I-II" the basis for computational engineering. The course contents: •Introduction to tensor calculus, •Kinematics and stresses in 3D setting, •Curvilinear coordinate system, •Balance equations.	Technische Mechanik I - IV	The lectures are given in English.
Continuum Mechanics II	Institut für Kontinuumsmechanik	Summer	5	V2/Ü2	Dr.-Ing. Aldakheel	The course Continuum Mechanics II describes material models at small and finite strains. It advances the topics of the core course Continuum Mechanics I. Basic contents are: Thermodynamics of a general internal variable formulation of inelasticity, linear and nonlinear elasticity (isotopic spectral forms, anisotropic models based on structural tensors), viscoelasticity (linear and nonlinear models, stress update algorithms and consistent linearization), Rate-independent and rate-dependent plasticity (theoretical formulations, stress update algorithms and local variational formulations, consistent linearization) and damage mechanics.	Continuum Mechanics I , Basics of Finite Elements I	Language: English For better understanding of the computational mechanics of materials and structures that will be discussed in "Continuum Mechanics II", an accompanying course "Numerical Implementation of Constitutive Models" is offered in summer semesters. This accompanying course is not obligatory but highly recommended.
Cryoengineering and Cryobiology	Institut für Mehrphasenprozesse	Winter	5	V2/Ü1/L1	Prof. Prof. h.c. Dr.-Ing. Glasmacher	Qualifikationsziele: Das Modul vermittelt grundlegende Kenntnisse über Kryotechnik und Kryobiologie, wie Prozesse zur Bereitstellung von tiefkalten Räumen sowie Konservierungsmethoden für Zellen und Gewebe. Nach erfolgreichem Abschluss des Moduls sind die Studierenden in der Lage: • Die physikalischen und thermodynamischen Grundlagen der Kältechnik und Kreisprozesse zu erläutern. • Grundlegende Vorgänge während der Kryokonservierung suspendierter Zellen und Gewebe zu erläutern. • Protokolle zum gezielten Einfrieren von Stammzellen und roten Blutkörperchen zu erarbeiten und zu beurteilen. • Verfahren wie Kryochirurgie, Kryotherapie und Kryokonservierung zu erläutern. • Prozesskennwerte und Qualitätskriterien zu berechnen und zu deuten. • Praktische Experimente durchzuführen. Inhalte: • Grundlagen der Kältetechnik, Kreisprozesse in der Kältetechnik, Methoden in der Kältetechnik, Kryotechnik • Grundlagen der Biokältetechnik, Physikalische Grundlagen und Messtechniken • Zellbiologische Grundlagen, Zellbiologische Messmethoden • Technische Kryoverfahren, Kryokonservierung von Zellsuspensionen wie z.B. Blut und Geweben/Organen • Kryobanking für Reproduktions- und regenerative Medizin, Kryochirurgie • Laborversuch zur Kryokonservierung von roten Blutkörperchen	Thermodynamik, Wärmeübertragung	Vorlesung und Übung auf Englisch möglich. Zur erfolgreichen Absolvierung des Moduls ist die erfolgreiche Teilnahme am Masterlabor "Kryo- und Biokältetechnik" notwendig. Dieses wird im Rahmen der Vorlesung angeboten.
Design and Simulation of Optomechatronic Systems	Institut für Produktentwicklung und Gerätebau	Summer	5	V3/Ü1	Prof. Dr.-Ing. Lachmayer	Qualifikation: In the lecture design and simulation of optomechatronic systems the construction, manufacturing and dimensioning of optical devices will be handled. This English lecture is especially designed for master students of optical technologies. Goals: The students get to know the fundamentals of lighting technology can describe the physiology of the human visual system get to know optical materials (glasses and polymers) and the according manufacturing and processing technologies learn the analytical calculation of simple optical elements such as mirrors and lenses set up concepts for optical systems use an optical simulation software learn the working principle of light measurement devices can analyze existing optical systems		Vorlesung ist auf Englisch. This lecture is given in english. Alter Titel: "Konstruktion Optischer Systeme / Optischer Gerätebau". Old heading: "Konstruktion Optischer Systeme / Optischer Gerätebau"
Design and Simulation of Optomechatronic Systems	Institut für Produktentwicklung und Gerätebau	Summer	5	V3/Ü1	Dr.-Ing. Wolf	Qualifikation: In the lecture design and simulation of optomechatronic systems the construction, manufacturing and dimensioning of optical devices will be handled. This English lecture is especially designed for master students of optical technologies. Goals: The students get to know the fundamentals of lighting technology can describe the physiology of the human visual system get to know optical materials (glasses and polymers) and the according manufacturing and processing technologies learn the analytical calculation of simple optical elements such as mirrors and lenses set up concepts for optical systems use an optical simulation software learn the working principle of light measurement devices can analyze existing optical systems		Vorlesung ist auf Englisch. This lecture is given in english. Alter Titel: "Konstruktion Optischer Systeme / Optischer Gerätebau". Old heading: "Konstruktion Optischer Systeme / Optischer Gerätebau"

Course	Institute	Semester	ECTS	Course Scope	Lecturer	Module description	Previous knowledge	Special feature
Electrical Maschines and Drives	Institut für Antriebssysteme und Leistungselektronik	Winter	5	V2/Ü1/L1	Jun.-Prof. Dr.-Ing. Ebrahimi	Fundamental of electromagnetics, Maxwell equations, Biot-Savart Formulation, Faraday law of induction, Lorentz Force. Fundamental of electromechanical energy conversion. Magnetic equivalent circuit for flux calculation in magnetic structures, magnetomotive force law, permanent magnet Materials, Ferromagnetic materials, non-linear BH-curves, Hysteresis and eddy current losses. Permanent magnet DC motor, separately excited DC motor, series DC motors, Universal motors, equivalent circuits and load calculation, lap and wave winding, armature reaction. Fundamentals of rotating field theory, three phase synchronous motor, permanent magnet synchronous motor, BLDC motors. Basics of control of electrical machines, basics of power electronic devices, pulse width modulation, basics of gearing and mechanical components in mechatronic systems, basic of sensory systems. Design of a mechatronic device, Biomechanical calculation, electromechanical drive calculation, selection of motor, gearing, battery, power electronics and sensory systems.	Basic knowledge of electrical engineering and electrical machines would be helpful.	
Engineering Dynamics and Vibrations	Institut für Dynamik und Schwingungen	Summer	5	V2/Ü1/T1	Dr.-Ing. Wangenheim	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). 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 Explaining the advantages to handle MDOF systems in modal space including proportional damping Using the Jeffcott rotor model (Laval shaft) to describe and calculate basic dynamic effects in rotor dynamics such as self-centering, anisotropic bearing rigidity, internal damping instability, gyroscopic effects. Contents 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 Laval shaft/Jeffcott rotor with unbalance excitation Damping and stability in rotor dynamics	Engineering Mechanics: Statics, Kinematics, Kinetics, Introduction to Mechanical Vibrations	Integrated course containing lecture and tutorials. Contents equal to German course "Maschinendynamik" taught in winter term. Individual homewok as part of witten exam: solution of case studies in MDOF vibration problems using Matlab and Simulink
Engineering Dynamics and Vibrations	Institut für Dynamik und Schwingungen	Summer	5	V2/Ü1/T1	Prof. Dr.-Ing. Wallaschek	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). 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 Explaining the advantages to handle MDOF systems in modal space including proportional damping Using the Jeffcott rotor model (Laval shaft) to describe and calculate basic dynamic effects in rotor dynamics such as self-centering, anisotropic bearing rigidity, internal damping instability, gyroscopic effects. Contents 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 Laval shaft/Jeffcott rotor with unbalance excitation Damping and stability in rotor dynamics	Engineering Mechanics: Statics, Kinematics, Kinetics, Introduction to Mechanical Vibrations	Integrated course containing lecture and tutorials. Contents equal to German course "Maschinendynamik" taught in winter term. Individual homewok as part of witten exam: solution of case studies in MDOF vibration problems using Matlab and Simulink
Finite Elements I	Institut für Kontinuumsmechanik	Winter	5	V2/Ü2	Dr.-Ing. Soleimani	During the last decades, the Finite Element Method (FEM) has become the most important industrial simulation tool because it is applicable to a huge amount of problems in many engineering disciplines. In "Finite Elements 1", the basic concept applied to linear elasticity is taught. Contents: - Introduction to the FEM rationale - The FEM for rods and beams - The FEM for 2D/3D continuum mechanics - Isoparametric mapping and numerical quadrature - Equivalent nodal forces and boundary conditions - Post-processing and error estimation - Variational principles and stress recovery - Time-dependent problems After successful completion of the course, students are able to: - Develop, implement and analyze 1D FEM models: applications to rods and beams - Develop, implement and analyze 2D and 3D FEM models: applications to continuum mechanics - Post-process and analyse results	Technische Mechanik I-IV	The lectures are given in English. In addition to the lectures, exercises and practical classes are offered in which the methods taught in class are applied and programmed using the finite element research program FEAP.

Course	Institute	Semester	ECTS	Course Scope	Lecturer	Module description	Previous knowledge	Special feature
Finite Elements II	Institut für Kontinuumsmechanik	Summer	5	V2/Ü2	Dr.-Ing. Soleimani	Qualifikationsziele / Qualification objectives Building upon the course Finite Elements I, the topics of Finite Elements II are nonlinear problems in structural mechanics and solid mechanics. A special focus are geometrically and materially nonlinearities, which might lead to instabilities that are of great importance in industrial applications. Numerical methods to solve nonlinear problems like the Newton-Raphson method, line search methods and different arc-length methods are treated. Using two-dimensional finite element formulations, hyperelastic and inelastic material models are presented and their algorithmic treatment is discussed. Accompanying the lecture there will be exercise lectures . Examination will be based on an oral discussions.	Finite Elements I	Language: English
Fracture of Materials and Fracture Mechanics	Hannoversches Zentrum für Optische Technologien	Winter	5	V2/Ü2	Prof. Zhuang	1. Introduciton: Review of the history of materials failure and fracture mechanics including historial cases and state of the art 2. Fracutre modes and characteristics: mode I, II and III cracks 3. Brittle and ductile fractures in different materials 4. Characterization of frcture toughness 5. Solution of elastic stress around the crack tip: Kolosov-Muskhelishvili formulus and Westergaard solution 6. Stress intensity factor in 2D and 3D problems and crack handbook 7. Computation of Stress intensity factor: J-integral and a general Eshelby's energy momentum tensor for crack enegy release 8. Computational methods for fractue modelling: meshless methods, XFEM and peridynamics and commercial software for fracture modelling 9. Computational methods for fracture modelling Students are also guided by practical exercises in the computer lab, assigning also specific projects to be solved through the implementation of numerical codes. The codes will be written in Mathematical/Matlab language at the continuum level and in Matlab language when FE discretization are needed. A introduction and examples to using commerical software such as ABAQUS for crack modelling will be demonstrated.	Engineering Mechanics Student should have learned one of the following coures: Continuum Mechanics; Solid Mechanics	Semester project and oral presentations
Fundamentals and Configuration of Laser Beam Sources	Institut für Transport- und Automatisierungstechnik	Winter	5	V2	Dr. Wienke	The lecture gives an overview of different types of laser beam sources. In the basic part the concepts for the generation of laser radiation in various active media for different applications as well as requirements for optical resonators are presented. Different pumping schemes and concepts are discussed for the various laser systems, especially gas-, diode and solid-state lasers. In addition, the operating modes continuous, pulsed and ultrashort pulsed will be explained in more detail. Based on the basic considerations and concepts, real laser beam sources are presented and analyzed. The following contents will be taught in the course and through demonstrations: basics of laser beam sources, operation modes of lasers, laser characterization, laser diodes, optical resonators, CO2 lasers, excimer lasers, laser concepts and laser materials, rod lasers and disk lasers, fiber lasers and amplifiers, frequency conversion, lasers for space applications and ultrashort pulse lasers.		Die wöchentliche Vorlesung findet im Laser Zentrum Hannover e.V. (LZH) Hollerithallee 8 30419 Hannover Die Vorlesung wird in englischer Sprache gehalten.
Fundamentals of Laser Medicine and Biophotonics	Institut für Quantenoptik	Winter	4	L2	apl. Prof. Dr. Lubatschowski	The lecture explains laser medicine with basics from biophotonics. The laser principle, types of medical lasers and their effects on biological tissue are presented. As current clinical application, laser surgery of the eye based on ultrashort pulse lasers is discussed. After a fundamental introduction to tissue optics with its various absorption and scattering processes, imaging techniques such as optical coherence tomography (OCT) and two-photon microscopy will be explained. After the lecture, an excursion with laboratory and company visit is offered. Contents: Laser systems for the application in medicine and biology Beam guiding systems and optical medical devices Optical properties of tissues Thermal properties of tissues Photochemical interaction Vaporization/coagulation Photoablation, optoacoustics Photodisruption, nonlinear optics Applications in ophthalmology, refractive surgery Laser-based diagnostics, optical biopsy Optical coherence tomography, theragnostic Clinical examples	Coherent Optics, Photonics or Nonlinear Optics	Examination: The students present current publications in the field within the scope of a block seminar. This will be followed by an examination on the publication and on lecture contents. Study achievement: Participation in lecture and block seminar.

Course	Institute	Semester	ECTS	Course Scope	Lecturer	Module description	Previous knowledge	Special feature
Fundamentals of Laser Medicine and Biophotonics	Institut für Quantenoptik	Winter	4	L2	Prof. Dr. Heisterkamp	The lecture explains laser medicine with basics from biophotonics. The laser principle, types of medical lasers and their effects on biological tissue are presented. As current clinical application, laser surgery of the eye based on ultrashort pulse lasers is discussed. After a fundamental introduction to tissue optics with its various absorption and scattering processes, imaging techniques such as optical coherence tomography (OCT) and two-photon microscopy will be explained. After the lecture, an excursion with laboratory and company visit is offered. Contents: Laser systems for the application in medicine and biology Beam guiding systems and optical medical devices Optical properties of tissues Thermal properties of tissues Photochemical interaction Vaporization/coagulation Photoablation, optoacoustics Photodisruption, nonlinear optics Applications in ophthalmology, refractive surgery Laser-based diagnostics, optical biopsy Optical coherence tomography, theragnostic Clinical examples	Coherent Optics, Photonics or Nonlinear Optics	Examination: The students present current publications in the field within the scope of a block seminar. This will be followed by an examination on the publication and on lecture contents. Study achievement: Participation in lecture and block seminar.
Image Analysis I	Institut für Photogrammetrie und Geoinformation	Summer	5	V2 /Ü1/ L1	apl. Prof. Dr. techn. Rottensteiner	Das Modul vermittelt grundlegende Kenntnisse über modellbasierte Strategien der Bildanalyse. Nach erfolgreicher Absolvierung des Moduls sind die Studierenden in der Lage, die wesentlichen Schritte der modellbasierten Bildanalyse von der Bildaufnahme bis zur Bildinterpretation zu verstehen und zu erläutern, die Vor- und Nachteile von Verfahren zur 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 zur modellbasierten Bildanalyse für spezifische Aufgaben zu entwickeln und zu testen. Modulinhalte Bildaufnahme und Bildvorverarbeitung; Skalenraum Bildsegmentierung: Extraktion von Punkten, Linien und homogenen Regionen, polymorphe Merkmalsextraktion Merkmale aus Bildern und Punktwolken Modelle in der Bildanalyse Formale Konzepte für die Wissensrepräsentation, wissensbasierte Bildanalyse Bewertung von Ergebnissen	Photogrammetric Computer Vision (empfohlen)	Zum Erreichen der 5 LP muss das vorlesungsbegleitende Labor erfolgreich bestanden werden. This lecture is given in English.
Image Analysis II	Institut für Photogrammetrie und Geoinformation	Winter	5	V2/Ü1	apl. Prof. Dr. techn. Rottensteiner	Lecture content The first part of this module covers supervised and unsupervised methods for classification. This block starts with a discussion of Bayesian classification, including aspects of generative modeling of probabilities and the estimation of the parameters of these models. After that, there is a transition to discriminative classifiers, introducing logistic regression, Support Vector Machines, Boosting, and Random Forests. Artificial neural networks and the theory of Dempster-Shafer are also presented in this context. This is followed by an introduction into unsupervised techniques for an analysis of clusters in feature space. Graphical models, in particular Bayes networks and statistical models of context as provided by Markov Random Fields and Conditional Random Fields are also discussed. The lecture finishes with a block on active contours and their applications in image analysis. Lab course: Analysis of scientific papers. Goals The students should get to know and understand modern statistical methods of pattern recognition, along with their theoretical foundations and current applications. By analyzing state-of-the art scientific papers in the lab, the students' analytic and methodological skills should be strengthened	Bildanalyse I (empfohlen)	Zum Erreichen der 5 LP muss das vorlesungsbegleitende Labor erfolgreich bestanden werden. This lecture is given in English.
Industrial surveying	Geodätisches Institut Hannover	Summer	5	2V/1Ü	Prof. Dr.-Ing. Neumann	Students should be aware of the current approaches of the high-precision surveying in a close range interdisciplinary environment, and have practice skills in related topics. The students should develop in practically relevant exercises the problem-solving ability and transferability of the general approaches from the lecture. This course introduces additional and substituting characteristics of sensor systems in the field of engineering sciences as well as the representation of engineering analysis chain from the original measurements to the final results with representative uncertainty measures. Topics and sensors covered: Coordinate measurement machines, theodolite measurement systems (TMS), polar measurement systems (especially: Laser tracker, laser tracer, laser radar, gauge arm), coordinate measurement techniques, determination of measurement, shape analysis as well as tolerance check and measurement uncertainty. Practical tutorial: three-dimensional object surveying by mean of laser tracking and interpretation of their measurement uncertainties.	Basic knowledge of sensor systems are helpfull (i.e. laser scanner, camera) but not mandatory. Programming skills are helpful for the exercises (i.e. MATLAB)	Practical excercises in the lab.

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Internet GIS	Institut für Kartographie und Geoinformatik	Winter	5	V2/Ü1/L1	M.Sc. Feuerhake	Aim of the module: This course teaches the key technologies and main concepts for performing typical GIS operations on spatial data in the Internet. Main topics are the processes allowing representation, storage, access, analysis and visualization of heterogeneous, distributed spatial data sets. The lectures focus on the technical/practical realization of these aspects. Practical exercises on current web technologies allow the students to flexibly adapt to a multitude of requirements in the larger context of web applications. The learned practical knowledge is applied in a compulsory software project, in which groups of 3-4 students will work on a real web GIS application. After successfully completing this course, students will be able to create their own web map applications including static and dynamic parts of a client-server-architecture with server-side data storage and client-side data visualization and interaction. Lecture content: Data and service provider standards and implementations; data formats for internet applications; internet-based data provision and access; current web technologies: HTML, JavaScript, PHP, XML, WebMap APIs OpenLayers and Leaflet, SQL, PostgreSQL DBMS, OGC Web Map Services/Web Feature Services.	Introductions into GIS and into Programming	This lecture is given in english.
Introduction to Mechanical Vibrations	Institut für Dynamik und Schwingungen	Winter	5	V2/Ü2	Dr.-Ing. Wangenheim	Learning Objectives In this module, we give an introduction into the linear vibrations of mechqanical systems. After successful participation, our students will be able to set up linearized equations of motion for single-degree-of-freedom (SDOF) systems characterize the properties of free vibrations by means of eigenvalues determine system responses for harmonic, periodic and transient excitation propose appropriate measures to improve the system's dynamical performance understand the properties of solutions of partial differential equations describing continuum vibrations Contents Free and forced vibrations of single-degree-of-freedom (SDOF) systems SDOF systems with damping System response functions in frequency and time domain Periodic and transient excitation of SDOF systems Systems with two degrees of freedom Vibration absorbers and tuned mass dampers Introduction to systems with multiple degrees of freedom (MDOF) Vibrations of strings, rods, shafts and beams	Statics, Elastostatics, Kinematics, Kinetics (Technische Mechanik 1 - 3)	Integrated course containing lecture (2h) and tutorials (2h). Contents equal to German course „Technische Mechanik 4 / Technische Schwingungslehre“ taught in summer term.
Introduction to Nanophotonics	Hannoversches Zentrum für Optische Technologien	Summer	5	V2/Ü2	Prof. Dr. Cala Lesina	Nanophotonics (also known as nano-optics) studies the behavior of light on the nanometer-scale, and the effect of its interaction with nanostructures. This course provides an introduction to nanophotonics, with a focus on material optical properties arising from nano-scale effects. After successfully completing the module, students are able to (Qualification goals) -Understand the optical properties of metals and the theory of plasmonic resonances. -Understand the theory of the scattering of light from a sphere (Mie theory) and calculate absorption/scattering and extinction coefficients. -Understand how metasurfaces work, and design a distribution of sub-wavelength emitters for light structuring/shaping. -Calculate analytically/numerically the reflectance/transmittance by a multi-layer. -Simulate a basic nanophotonic problem. Module content -Optical properties of metals, fundamentals of plasmonics.	Optics and waves (Maxwell's equations, plane wave propagation).	
Jet Engines	Institut für Turbomaschinen und Fluid-Dynamik	Summer	5	V2/Ü1	Dr.-Ing. Herbst	Das Modul vermittelt grundlegendes ingenieurwissenschaftliches und physikalischen Verständnis für die Anforderungen, den Aufbau und die Vorauslegung einfacher Strahltriebwerke. 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.	Strömungsmechanik II, Strömungsmaschinen I, Thermodynamik	Begleitend zur Vorlesung werden zwei Hausaufgaben angeboten.

Course	Institute	Semester	ECTS	Course Scope	Lecturer	Module description	Previous knowledge	Special feature
Laser Material Processing	Institut für Transport- und Automatisierungstechnik	Summer	5	V2/Ü2	Prof. Dr.-Ing. Overmeyer	The module provides basic knowledge about the spectrum of laser technology in production as well as the potential of laser technology in future applications. 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. Content : - Photonic system technology - Beam guiding and forming - Marking - Removal and drilling - Change material properties - Cutting including process control	Basic optics, basics of laser sources recommended	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 course's name on Stud.IP is "Lasermaterialbearbeitung"
Laser Measurement Technology	Hannoversches Zentrum für Optische Technologien	Summer	5	V2/Ü1	Dr. habil. Roth	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. Content: Basic physics Optical elements/detection techniques Lasers for measurement applications Laser triangulation and interferometry Distance and velocity measurement	Fundamentals of measurement technology, Basics of laser physics and laser technology	Recommended for second semester and higher (Master course)
Laser Spectroscopy in Life Sciences	Hannoversches Zentrum für Optische Technologien	Winter	5	V2/Ü1	Dr. habil. Roth	The aim of this lecture course is the introduction to the fundamentals and methods in laser spectroscopy for application in the life sciences. Apart from the basic principles of laser spectroscopic techniques and methods applied in various up-to-date areas of fundamental research also practical applications in the life sciences such as biology, chemistry, and medicine, will be taught. The students will also gain insight into modern measurement devices and methods which are broadly employed. The exercise course aims at consolidating the understanding of the basic principles given as well as at their application for practical examples.	Mandatory: Basic physics, optics and laser physics, laser applications Recommended: optical components and measurement principles, spectroscopy, laser interferometry, (ultra) short pulse laser	Recommended for second semester and higher (Master course).
Laserscanning - Modelling and Interpretation	Institut für Kartographie und Geoinformatik	Winter	5	V2/Ü1	apl. Prof. Dr.-Ing. Brenner	Aim of the module: This lecture imparts the basic principles about laser scanning and its respective application areas. After successful completion of the lecture, students are able to explain and apply selected techniques and algorithms for the low-, intermediate- and high-lever processing of laser scanning data. Lecture content: Airborne, terrestrial and mobile mapping laser scanning: scan geometry and technical characteristics. Low-, intermediate and high-level tasks. Representation of 3D rotations: matrix, angles, axis and angle, quaternions. Estimation of similarity transforms and the iterative closest point algorithm. Estimation and segmentation of lines and planes. Region growing, RANSAC and MSAC, Hough transform, scanline grouping. Scanning and segmentation in robotics applications. Decision trees and random forests for point cloud classification. Markov chains and Markov chain Monte Carlo methods and their use for high-level interpretation. In the exercises, selected algorithms will be programmed.	Programmierkenntnisse	Lecture is given in English
Master Thesis	Diverse	Winter/ Summer	30	900h	Professorinnen und Professoren der Fakultät für Maschinenbau (ErstprüferIn)	Nach dem erfolgreichen Absolvieren des Moduls sind Studierende in der Lage an einer wissenschaftlichen Problemstellung aus den Themenfeldern des Master-Studiums mitzuarbeiten, Teilprobleme in bestehende Theorien einzuordnen und im Studium erlernte Methoden geeignete Methoden zu identifizieren. Sie können erreichte Ergebnisse wissenschaftlich formulieren und dabei übliche Zitierregeln und Recherchemethoden anwenden. Durch die Teilnahme am Modul Masterarbeit üben Studierende gängige Tätigkeiten von Ingenieurinnen und Ingenieuren aus, die in der Forschung, der Industrie oder dem Entrepreneurwesen tätig sind.		Zum Modul gehört das erfolgreiche Präsentieren der Abschlussarbeit (1 LP)

Course	Institute	Semester	ECTS	Course Scope	Lecturer	Module description	Previous knowledge	Special feature
MasterLab: Attenuation in optical fibers	Institut für Transport- und Automatisierungstechnik	Winter	1	L1	M.Sc. Schrein	In this lab course, the optical attenuation of optical fibers is investigated. Three LEDs with different wavelengths are used. The LEDs are first characterized electrically and optically and then coupled into the light waveguides. By measuring the optical power before and after the waveguide, the wavelength dependence of the optical attenuation can be demonstrated.		When registering, please note that groups with less than 4 participants may be split between other dates. The lab course is located in the ITA in Garbsen and is led by Daniel Schrein (daniel.schrein@ita.uni-hannover.de). On lab day, we will meet in the foyer of the institute.
MasterLab: Emission Spectra	Institut für Quantenoptik	Winter	1	L1	Dr. Weber	In this experiment you will use a diffraction grating within a goniometer setup to analyse the spectra of different light sources. Thereby the concept of interference is central. Moreover you will determine the resolution power of the diffraction grating by analysis of the Sodium D-lines. It is necessary to prepare the content for the experiment. Your preparation will be tested with an assessment during the Lab. The Lab is located in room 143A of building 1105. If you have further questions regarding the experiment, please contact Kim Weber (weber@iqo.uni-hannover.de).		
MasterLab: Michelson Interferometer	Institut für Quantenoptik	Winter	1	L1	Dr. Weber	The Michelson interferometer is a basic configuration for optical interferometry. The experiment enables you to study interference phenomena. The aim of the lab course is to develop an elaborate and sustainable concept of coherence. You will utilize the experimental setup as a precise apparatus to measure differences in optical path length. Moreover you will train your skills in adjusting of optical components. It is necessary to prepare the content for the experiment. Your preparation will be tested with an assessment during the Lab. The Lab is located in room -141 of building 1105. If you have further questions regarding the experiment, please contact Kim Weber (weber@iqo.uni-hannover.de).		
MasterLab: Speckle Interferometer	Hannoversches Zentrum für Optische Technologien	Winter	1	L1	M.Sc. Suar	Electronic Speckle Pattern Interferometry (ESPI) is a laser based optical technique which enables the full-field measurement of small deformations of object surfaces with sub-wavelength accuracy. ESPI is successfully applied to many other fields, e.g. automotive, aerospace, electronics and materials research. In this experiment, a rough surface is illuminated with coherent laser light and the subsequent imaging is observed by using a CCD camera which generates the statistical interference patterns, the so-called speckles. A reference light is also generated by the split out from the original laser source and then superimposed with the speckles from object beam to result in an interferogram. The speckle interferogram also changes when the object under test is deformed by mechanical means. Comparing the interferogram of the surface before and after mechanical loading will result on a fringe pattern which reveals the displacement of the surface during loading as contour lines of deformation. The details about the lab experiment is provided in the problem sheet. The master lab is carried out at the HOT (Hannoversches Zentrum für Optische Technologien). You will be picked up at the institute entrance by the respective supervisors and taken to the laboratory. If you have further questions regarding the experiment, please send an e-mail to Monali Suar (monali.suar@hot.uni-hannover.de).		
MasterLab: Video Project Technology	Institut für Produktentwicklung und Gerätebau	Winter	1	L1	M.Sc. Leuteritz	Optical technologies are regarded as one of the key technologies of the 21st century and are used, among other things, for the processing of materials, sensor technology, data transmission, the projection of information and lighting technology. Since humans obtain about 90 % of the information perceived from their environment from the visual, optical technologies provide a powerful interface in human-machine communication. One challenge here is to reproduce information optically. It must therefore be investigated which influencing variables of the optical systems can be used for targeted information transmission. Here, the influences of the human eye have to be considered. A technical implementation of information transmission is represented by video projectors, which specifically generate light distributions on different surfaces. In particular, the requirements to reproduce a large colour spectrum and to achieve high contrast values are decisive for the quality of the projection. In the IPeG's optomechatronics experiment, the functionality of video projectors is investigated. The focus of the experiment is on the interaction of colour generation and human colour perception. Technical possibilities are discussed to realize defined colour spaces and colour impressions. The influences of the human eye and the resulting technical challenges are highlighted. The MasterLab is carried out at the Institute of Product Development (Building 1105). You will be picked up at the institute entrance by the respective supervisors and taken to the laboratory. Please keep yourself up to date regarding changes of dates via Stud.IP, as it is possible that the lab days will be postponed due to the Garbsen move. If you have further questions regarding the experiment, please send an e-mail to Georg Leuteritz (leuteritz@ipeg.uni-hannover.de).		

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Micro- and Nanosystems	Institut für Mikroproduktionstechnik	Winter	5	V2/Ü1	Dr.-Ing. Wurz	Students gain knowledge about the most important application areas of micro- and nano technology. A microtechnical system has the following components: micro sensor technology, micro actuating elements, microelectronics. Furthermore, the active principle and construction of micro components as well as requirements of system integration will be explained. Nanosystems usually use quantum mechanical effects. An example will be the display of the employment of nanotechnology in various areas	Mikro- und Nanotechnolgie	This lecture is given in English. In addition to a separate exam (4 credits), an online test will be conducted (1 credits). Both must be performed to pass the module. The grade is composed proportionate.
Model Predictive Control	Institut für Regelungstechnik	Summer	5	V2/Ü1/L1	Prof. Dr.-Ing. Müller	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.	Regelungstechnik I und II	
MOOC Aircraft Engines	Institut für Turbomaschinen und Fluid-Dynamik	Winter/ Summer	3	V2	Dr.-Ing. Herbst	The module introduces basic engineering and physical understanding of the requirements, components and preliminary design of simple aircraft jet engines. 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. 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. Moreover, the students are able to determine and evaluate the losses, dimensionless quantities, and characteristic maps of aircraft jet engines and their individual components.	Strömungsmechanik II, Strömungsmaschinen I, Thermodynamik	Sprache: Englisch Die Veranstaltung findet als Online-Vorlesung statt und ist ein Betandteil der "Flugtriebwerke"-Vorlesung. Studierende müssen sich daher bei Bedarf zwischen der MOOC und Flugtriebwerke wählen.
Nonlinear Control	Institut für Regelungstechnik	Winter	5		Prof. Dr.-Ing. Müller	This course covers modern analysis and controller design methods for nonlinear systems. After this course, students should be able to identify and analyze nonlinear control problems, select suitable control approaches, carry out a controller design and implementation. Lyapunov stability Input-to-state stability Control Lyapunov functions Backstepping Sliding-mode control Input-Output linearization Passivity and Dissipativity Passivity-based controller desig	Automatic Control Engineering I and II	
Non-linear Optics	Institut für Quantenoptik	Summer	5	V3/Ü1	Prof. Dr. Morgner	The students acquire special knowledge of nonlinear laser optics and can apply the necessary mathematical methods themselves. 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	Physik II, Experimentalphysik, Atom- und Molekülphysik / Physics II, Experimental Physics, Atomic and Molecular Physics	The course's name on Stud.IP is "Nichtlineare Optik"
Numerical Implementation of Constitutive Models	Institut für Kontinuumsmechanik	Summer	1	L1	Dr.-Ing. Aldakheel	Qualifikationsziele / Qualification objectives The module covers implementation and testing of material models. After successful completion of the module the students are able to: - Code subroutines that describe material behavior - Test the subroutines in a finite element software Inhalte / Contents: - Material modeling - Fortran programming - Finite element calculations using FEAP (Finite Element Analysis Program) Key goal of this course is the link between the continuum mechanics and the Finite Element method for solving the resulting partial differential equations PDEs, by using Fortran and FEAP as a numerical tools.	Continuum Mechanics II (simultaneous attendance)	Simultaneous attendance of Continuum Mechanics II is required to successfully complete this course Language: English

Course	Institute	Semester	ECTS	Course Scope	Lecturer	Module description	Previous knowledge	Special feature
Optical Coatings and Layers	Laser Zentrum Hannover e.V.	Winter	4+1	V2/Ü2/P1	Prof. Dr. Ristau	Optical coatings can be considered as essential key-components in modern Photonics. For example, present laser sources, optical systems and products or even a major part of fundamental research could never be realized without optical coatings. In the course the fundamentals of coating design, production and characterization of functional layer systems will be presented. Recent research areas of optical coating technology, especially in the fields of high precision industrial production and the optimization of coating systems for high power lasers will be introduced and discussed. The course offers a large variety of practical information on optical coatings, which may be of value for engineers and physicists heading towards a career in photonics. Contents: General basis (applications, impact, and functional principle of optical coatings, state of the art in coatings for laser technology) Theoretical fundamentals (compilation of formulae and consideration of fundamental phenomena, calculation of single layers and layer systems) Production of optical components (substrates, coating materials and techniques, control of coating processes) Optics characterization (measurement of optical transfer properties, optical losses: Total Scattering and absorption, laser induced damage thresholds of laser components, non-optical properties)	Fundamentals of optics and physics.	Three exercise sheets for homework, solution of exercises discussed during the course, major course assessment alternatively by colloquium, oral examination, or by written test Compulsory internship (1 CP) with a duration of approx. 16 hours. The internship can only be completed after successful completion of the examination. The internship includes a general introduction to technological aspects of optical thin-film production taking about 4 hours and a technical part. The technical part will usually be directed to the production of an exemplary layer system and its analysis. The internship can be completed in three short blocks of 4 hours each at the LZH. The course's name on Stud.IP is "Optische 3D Messtechnik"
Optical Measuring Technology	Hannoversches Zentrum für Optische Technologien	Winter	5	V2/Ü2	Dr.-Ing. Rahlves	The lecture gives an overview on theory, methods and devices in optical metrology. At the beginning, fundamentals of optics and photonics such as ray and wave optics are revised, which are essential for the understanding of concepts in optical metrology. Focusing on metrology in research and industrial applications, the lecture covers optical methods for measurement of topography, distance, and deformation as well as fiber optical sensors, which include concepts such as interferometry, holography and confocal microscopy. In addition, semi-optical methods such as atomic force microscopy and near field microscopy are addressed and compared to non-optical methods, e.g., scanning electron microscopy. To gain an in-depth understanding of the concepts involved in optical metrology, all devices and optical setups are explained in detail including light sources, cameras, and optical elements.	Messtechnik I / Measurement Technology I	Prüfung je nach Teilnehmerzahl: Einzelprüfung mündlich 20 Min. oder schriftlich 90 Min.
Optical properties of Micro- and Nanostructures	Hannoversches Zentrum für Optische Technologien	Winter	5	V2/Ü2	Prof. Dr. Cala Lesina	Optical devices based on micro- and nanostructures are progressively replacing conventional optical systems (such as bulky lenses) due to their small dimensions and ease of integration. This course provides the basic knowledge of micro- and nano-optics (or nanophotonics) to understand and design such miniaturized optical systems, as well as examples of their applications. After successfully completing the module, students are able to (Qualification goals) -Understand Maxwell's equations and describe light propagation. -Understand the optical properties of matter and the interaction of light with matter. -Know the main categories of micro- and nano-structures and describe their optical properties. -Simulate a simple micro- or nanostructured system and understand its optical properties. Module content -Maxwell's equation, wave equation, reflection and refraction. -Optical properties of metals and dielectrics, fundamentals of plasmonics. -Metasurfaces, photonic crystals, diffraction gratings, micro-lenses, nano-films	Mathematics and Physics (First year courses)	
Optical Radiomerty	Institut für Quantenoptik	Summer	-	V2	apl. Prof. Dr. Kovacev	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		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.

Course	Institute	Semester	ECTS	Course Scope	Lecturer	Module description	Previous knowledge	Special feature
Photogrammetric Computer Vision	Institut für Photogrammetrie und Geoinformation	Winter	5	V2/Ü2	Prof. Dr.-Ing. habil. Heipke	Lecture content Short introduction into aims, commonalities and differences of photogrammetry and computer vision, 3D image processing, projective geometry: transformation between image and object space, in linear models. Robust estimation (RANSAC). Different methods to represent 3D rotations (Euler angles axis-angle representation, quaternions). Structure from motion (sfm) from stereoscopic images and image sequences: interest operators (SIFT, SURF), sliding pose estimation, dense image matching, determination of object geometries. Methods for evaluation of results of image based approaches. Aims of the lecture After studying the module the students have a good overview and detailed knowledge of some exemplary methods of 3D reconstruction from images and image sequences (structure from motion, sfm). They understand the geometric transformations between image and object space, the usual procedures for pose estimation of moving sensors and basics of signal theory as applied to image matching. Students can thus evaluate pros and cons of sfm. In the lab part, carried out in small groups, image sequences are captured using flying robots; these image sequences are being exploited using available software. In this way the students come to gain practical experience of digital image capture and geometric 3D reconstruction and can evaluate the obtained results.	Bachelorabschluss in einem Ingenieurfach.	This lecture is given in English
Photonics	Institut für Quantenoptik	Winter	5	L2/E1	Dozenten der Quantenoptik	The students gain special knowledge in nonlinear and integrated optics, and they can apply the corresponding mathematical methods. A special topic of photonics can be selected and deepened independently by the student. The topic shall be presented in the frame of a seminar with a subsequent discussion. Besides their technical competence, the students develop their methods in literature research, implementation of technical and scientific knowledge, as well as their presentation techniques together with their ability to lead scientific discussions. Contents: Waves in Media and at Boundaries Dielectric Waveguides (planar, fiber), Integrated Waveguides Waveguide Modes Nonlinear Fiber Optics Fiber optic components (Circulators, AWG, Fiber-Bragg-Gratings, Modulators), Optical Communication (WDM/TDM) Fiberlaser Laserdiodes, Photodetectors Plasmonics, Photonic Crystals Transformation Optics	Basic knowledge in coherent optics, Nonlinear Optics Lecture	Final mark: 80% oral exam, 20% seminar.
Photonics	Institut für Quantenoptik	Winter	5	V2/Ü1/S2	Prof. Dr. Chichkov	The students gain special knowledge in nonlinear and integrated optics, and they can apply the corresponding mathematical methods. A special topic of photonics can be selected and deepened independently by the student. The topic shall be presented in the frame of a seminar with a subsequent discussion. Besides their technical competence, the students develop their methods in literature research, implementation of technical and scientific knowledge, as well as their presentation techniques together with their ability to lead scientific discussions. Contents: Waves in Media and at Boundaries Dielectric Waveguides (planar, fiber), Integrated Waveguides Waveguide Modes Nonlinear Fiber Optics Fiber optic components (Circulators, AWG, Fiber-Bragg-Gratings, Modulators), Optical Communication (WDM/TDM) Fiberlaser Laserdiodes, Photodetectors Plasmonics, Photonic Crystals Transformation Optics	Kohärente Optik, Nichtlineare Optik	Notenzusammensetzung: 80% Note der mündlichen Prüfung oder der Klausur; 10% Note für Inhalt und 10% Note für Form des Seminarvortrags
Power Electronics	Institut für Antriebssysteme und Leistungselektronik, FG El. Masch. u. Antr.	Winter	5	V2/Ü2/L1	Jun.-Prof. Dr.-Ing. Friebe	The lecture gives an introduction into the general topics of modern power electronics with a strong focus on the operation principle of power electronic circuits and their components. After participation the students will be able to explain the basic characteristics of power semiconductors, design passive components for typical applications and calculate and simulate converter stages. They will also be able to understand and characterize the interaction between one or multiple converters and the grid.	Power Electronics for high efficient energy conversion, Applications, Components, Line-commutated converter, dc/dc-Converter, dc/ac-Converter	Covered within “Energy Technologies” and “International Mechatronics.

Course	Institute	Semester	ECTS	Course Scope	Lecturer	Module description	Previous knowledge	Special feature
Power Plant Engineering	Institut für Kraftwerkstechnik und Wärmeübertragung	Summer	5	V2/Ü1/T1	Prof. Dr.-Ing. Scharf	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“. 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 Content •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	Thermodynamics I, Thermodynamics II	The lecture is given in English
Production of Optoelectronic Systems	Institut für Transport- und Automatisierungstechnik	Winter	5	L2/E2	Prof. Dr.-Ing. Overmeyer	Outcomes: This module gives basic knowledge about processes and devices that are used in production of semiconductor packages and microsystems. The main focus is on the back-end-process that means the process thins wafer dicing. After successful examination in this module the students are able to correctly use the terms optoelectronic system, wafer production, front end and back end and to give an overview of production processes of semiconductor packages explain the production processes beginning from crude material sand and to have an idea about process relevant parameters visualize different packaging techniques and explain the corresponding basics of physics choose and classify different package types for an application Contents: Wafer production Mechanical Wafer treatment Mechanical connection methods (micro bonding, soldering, eutectic bonding) Electrical connection methods (wire bonding, flip chip bonding, TAB) Package types for semiconductors Testing and marking of packages Design and production of printed circuit boards Printed circuit board assembly and soldering techniques		
Radar Remote Sensing	Institut für Photogrammetrie und Geoinformation	Winter	3	2V/Ü1	Prof. Dr. Motagh	Lecture content ⍰ Introduction to two-dimensional radar imaging and Synthetic Aperture Radar (SAR) ⍰ Geometric and physical properties of SAR images ⍰ SAR interferometry to measure Earth’s surface topography and deformation ⍰ Fundamental equation of Interferometry: ⍰ Interferometric phase quality: Coherence, Phase Unwrapping, error spurces Lab: lab assignments in Operational Remote Sensing and in Radar Remote Sensing. ⍰ Optional excursions will be offered to DLR Oberpfaffenhofen and to GFZ Potsdam, both towards the end of the semester. Goals In this this course, students shall gain an understanding for the technique of radar remote sensing with an emphasis on Synthetic Aperture Radar (SAR), Interferometry Synthetic Aperture Radar (InSAR), and multi-temporal interferometry (MTI) techniques and their applicability to various types of natural disasters and engineering tasks.	Some familiarity with a Linux operating system is beneficial for lab exercises	This lecture will be given in English.
Recursive State Estimation for dynamic Systems	Geodätisches Institut Hannover	Winter	5	V2/Ü2	Dr.-Ing. Alkhatib	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. Module 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)	Basic engineering mathematics and applied statistics	This module is offered first-time in WS 2019/20

Course	Institute	Semester	ECTS	Course Scope	Lecturer	Module description	Previous knowledge	Special feature
Remote Sensing I	Institut für Meteorologie und Klimatologie	Winter	4	V2/Ü1	Dr. rer. Nat. Melsheimer	Overview:Overview: - Fundamentals for measurements from satellites and their application for the acquisition of atmospheric processes - Remote sensing methods using satellite instruments. Derivation of temperature, cloud and trace gas measurements with remote sensing instruments from satellite and ground. - Derivation of radiation measurements from satellite data	Mandatory: Remote Sensing I, Radiation I, Recommended: Radiation II, Introduction to Meteorology	The course's name on Stud.IP is "Fernerkundung I"
Remote Sensing II	Institut für Meteorologie und Klimatologie	Winter	4	V2/Ü1	Dr. rer. Nat. Melsheimer	Qualification Goal The Students deepen their basic knowledge about remote sensing (cf. lecture Remote Sensing I), beyond the domain of meteorology - area of application are now the geosciences in a broad sense. They are enabled to efficiently make use of remote sensing (satellite-based, ground-based or on other platforms) in scientific problems in the geosciences. Contents: Basics about measurements with remote sensing instruments (at the ground, on satellites, on other platforms), using visible and infrared light and microwaves: Electromagnetic radiation, its generation and measurement; radiative transfer; important methods and instruments for remote sensing of(1) solid earth surface (e.g.,monitoring of vegetation, surface temperature)(2) the oceans (e.g., determining primary production, wind, sea state)(3) the atmosphere (e.g., trace gas measurement, determining the temperature profile)	Mandatory: Remote Sensing I, Radiation I, Recommended: Radiation II, Introduction to Meteorology	The course's name on Stud.IP is "Fernerkundung II"
Rheology and numerical methods in Tribology	Institut für Maschinenkonstruktion und Tribologie	Summer	5	V2/Ü2	Dr.-Ing. Bader	The module presents further studies on lubrication, tribology, and numerical methods to solve lubrication problems. 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. Topics: - 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.	Tribologie 1, Grundlagenfächer	Englische Vorlesung mit Übungen (selbst programmmieren)
Scientific Research Work: Mechatronics Lessons	Institut für Mechatronische Systeme	Winter/ Summer	5	Ü	Prof. Dr.-Ing Ortmaier	The scientific and research work enables each student to practise research techniques, literature review, academic discussion, scientific writing and the practical application of specialist knowledge. After completion of the course, each student becomes familiar with a current research theme and assumes responsibility for a small project. The project is completed under guidance, with the student documenting the results in written form, giving a presentation and finally leading an academic discussion on the subject.		
Seminar Numerical Optics	Institut für Quantenoptik	Summer	3	S2	apl. Prof. Dr. Demircan	Seminar covering selected topics for the calculation of light distributions in optical media Contents: Spectral- and pseudospectral methods Runge-Kutta- and Split-Step-Integration Fast-Fourier Transform (FFT) Monte Carlo (MC) simulation Finite Difference Time Domain (FDTD) Finite Element Methods Ray Tracing Beam-propagation methods (BPM) Parallelization using MPI		
Seminar Optics at Femto- and Attoscond Scales	Institut für Quantenoptik	Winter/ Summer	3	S2		Hochleistungs-Femtosekunden-Lasersysteme Wechselwirkung von Materie mit starkenFeldern Filamentation/Plasmakanäle Die absolute Trägerphase Quanten-Interferenz-Metrologie /Modenkämme Relativistische Optik / Laser-Teilchenbeschleunigung Erzeugung und Nachweis hoher Harmonischer Erzeugung und Nachweis vonAttosekunden-Pulsen Atomare Fotografie Der Freie-Elektronen-Laser		Für optische Technologien. The course's name on Stud.IP is "Seminar Optik auf Femto- und Attosekunden-Zeitskalen"
Seminar Optics at Femto- and Attoscond Scales	Institut für Quantenoptik	Winter/ Summer	3	S2	apl. Prof. Dr. Kovacev	Hochleistungs-Femtosekunden-Lasersysteme Wechselwirkung von Materie mit starkenFeldern Filamentation/Plasmakanäle Die absolute Trägerphase Quanten-Interferenz-Metrologie /Modenkämme Relativistische Optik / Laser-Teilchenbeschleunigung Erzeugung und Nachweis hoher Harmonischer Erzeugung und Nachweis vonAttosekunden-Pulsen Atomare Fotografie Der Freie-Elektronen-Laser		Für optische Technologien. The course's name on Stud.IP is "Seminar Optik auf Femto- und Attosekunden-Zeitskalen"
Solid State Lasers	Institut für Quantenoptik	Summer	2	V2	Dr. Weßels	Within this lecture the fundamentals needed for the understanding of modern solid state lasers will be developed. In particular, the optical properties and typical parameters of different solid state laser designs will be developed. Furthermore, the application potential of the various solid laser designs will be treated. Contents: Solid state laser media optical resonators laser modes of operation diode pumped solid state lasers laser designs: fiber, rod, disc; tunable lasers single-frequency lasers ultrashort-pulse lasersfrequency conversion	Basic knowledge in physics and coherent optics.	This course is equivalent to the german taught module “Fundamentals and Configuration of Laser Beam Sources”. Only one of these modules may be credited for the master course, respectively.

Course	Institute	Semester	ECTS	Course Scope	Lecturer	Module description	Previous knowledge	Special feature
Spray Technology	Institut für Technische Verbrennung	Winter	3	V2	Dr. Kawaharada	This course conveys fundamentals of spray technology and its applications. After successfully completing the course, students will be able to •explain and differentiate spray processes in detail including characteristic numbers, •sketch experimental and numerical approaches to spray investigations, •explain typical examples of applications for various sprays and atomizers. Content: •Fundamentals and types of sprays •Atomizers and injectors •Measurements techniques •Spray modeling •Applications • Lab exercises	Needed: Basics of fluid mechanics; Wanted: Multiphaseflows, Verbrennungstechnik	
Sustainability assessment I	Institut für Kunststoff- und Kreislauftechnik	Winter	5	V2/Ü1	Prof. Dr.-Ing. Endres	The module provides knowledge about sustainability assessment (especially the environmental aspects) of products, processes and technologies. The methods as well as practical applications and areas of use will be explained: •Sustainability, Sustainable Development Goals (SDG's) and sustainability assessment. •Methods for assessing the different dimensions of sustainability •Procedure for conducting a life cycle assessment according to ISO 14040/44 (target and study framework, functional units, system boundaries, life cycle inventory and data collection, impact assessment (midpoint and endpoint), evaluation, scenario and sensitivity analyses) •Evaluation of LCA results •Case studies on life cycle assessments (especially with focus on plastics) •Overview of available software systems and databases •Life cycle assessments at the interface to Design for Recycling/Ecodesign/Circular Economy Upon successful completion of the module, students will be able to, define and explain terms in the field of sustainability; name methods for assessing sustainability; explain how to carry out a life cycle assessment according to ISO 14040/44; define balance sheet boundaries according to requirements; analyze life cycle assessments for products and processes; define methods for Design for Recycling/Ecodesign and Circular Economy.		Term paper as examination performance
Sustainability assessment II	Institut für Kunststoff- und Kreislauftechnik	Winter	5	V2/Ü1	Prof. Dr.-Ing. Endres	Inhalte: •Übersicht zu Softwaresystemen zur Nachhaltigkeitsbewertung •Durchführung von Nachhaltigkeitsbewertungen mittels Softwaresystemen •Zusammenspiel zwischen Softwaresystem und Bewertung •Bewertung von unterschiedlichen Produkten und Lebenszyklusphasen (Herstellungsphase, Nutzungsphase, End-of-Life-Phase) •Anwendungsweise und Funktionen eines Softwaresystems zur Nachhaltigkeitsbewertung •Erstellung einer Produktökobilanz Ziele: Nach erfolgreicher Absolvierung des Moduls sind die Studierenden in der Lage, •Die Vorgehensweise zur Erstellung von Nachhaltigkeitsbewertungen zu benennen und zu erläutern •Verschiedene Softwarefunktionen zur Nachhaltigkeitsbewertung zu verstehen •Datenbanken und Datensätze im Zusammenspiel mit der Software zu verstehen •Softwarebasierte Ökobilanzen für Produkte eigenständig vorzunehmen •Den Einfluss von verschiedenen End-of-Life-Situationen für unterschiedliche Produkte auf die ökologischen Gesamtauswirkungen zu bewerten •Ökobilanz-Berichte basierend auf den Ergebnissen zu erstellen	Nachhaltigkeitsbewertung I	Hausarbeit als Prüfungsleistung
Ultrashort laser pulses	Institut für Quantenoptik	Summer	2	V2	Prof. Dr. Morgner	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	Zwingend: Optik, Atomphysik und Quantenphänomene; Empfohlen: Kohärente Optik	The course's name on Stud.IP is "Ultrakurze Laserpulse"