Module manual

Laser Technology / Physical Engineering (M.Sc.)

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Note on the appointment of the examiners:

The persons responsible named in the module handbook are appointed as examiners for the respective module examination.

Forms for preliminary examination performances and examination services:

Types of PEP: A = Attestation, w = written, o = oral, WS = Work Sample, LA = Laboratory Attestation, P = Presentation, types of examination: M = Module Examination, EP = Examination Performance, w = written, o = oral, a = alternative, op = other performances, RP = Research Paper, C = Colloquium, MT = Master's Thesis, PT = Project Thesis

Other Abbreviations:

L = Lecture (WSH), S = Seminar/Exercise (WSH), P = Practical Laboratory Course (WSH), T = Tutorial (WSH), PEP = Pre-Examination Performance, EP = Examination Performance, CP = Credit Points, WSH = Weekly Semester Hours, MNo = Module Number, MC = Module Code

2901 Solid State Physics

Module name:	**Solid State Physics**	Classroom language:	German, English
Module number:	2901	Degree:	M.Sc.
Module code:	02-FEST-18	Frequency:	Winter Semester
Obligation/Elective:	Mandatory	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	1
Training objectives:	The module teaches the experimental and theoretical principles of solid-state physics. Students will be enabled to understand the essential solid-state physical phenomena and to use the mathematical apparatus for their theoretical description. Based on this, selected problems or tasks will be analysed and solved. All areas of solid-state physics are covered. Special emphasis is also placed on the further promotion of the physical way of thinking during the development of the material and the imparting of necessary factual knowledge for the application of the presented material. The students are enabled to convert solid state physics into technical applications.		
Teaching contents:	Structure of solid bodies - Ideal crystals and real structure; Electrons in the solid state - Quantum mechanical description in the approximation of free electrons and of electrons in the periodic lattice potential, energy band model and distinction of conductors, semiconductors and insulators, properties and dynamics of crystal electrons; Lattice dynamics of the solid - Lattice vibrations and phonons, one-dimensional treatment of the lattice vibrations; Specific heat capacity - General approach to calculation and theory according to Debye; Heat conduction - Proportion of phonons and free electrons in metals; Metals and metallic alloys - State diagrams, electrical conductivity and superconductivity; Semiconductors - Band model and statistics of the free charge carriers in intrinsic and impurity semiconductors, p/n transition in equilibrium and non-equilibrium, metal-semiconductor contacts, semiconductor photo effects; Insulators - Theoretical principles of dielectric properties, conduction processes and electrical breakdown; Magnetic properties of solids; Optical properties of solids - Optical material sizes and principles of classical theory; Dispersion curves of metals, semiconductors and molecular and ion crystals and their interpretation, Fundamentals of nonlinear crystal optics.		
Learning methods:	The teaching content is presented in the lectures, followed by the students in self-study and deepened by solving selected tasks in the seminar. Furthermore, examples of the application of the acquired knowledge in praxis are discussed.		
Literature:	1. Weißmantel, C., Hamann, C.: Grundlagen der Festkörperphysik, J. H. Barth Verlag Heidelberg 1995 (Neuauflage), ISBN 3-335-00421-3. 2. Kittel. C.: Einführung in die Festkörperphysik, Oldenbourg Wissenschaftsverlag 2005 (Neuauflage), ISBN-10: 3486577239, ISBN-13: 978-3486577235. 3. Kopitzki, K., Einführung in die Festkörperphysik, Vieweg und Teubner Verlag 2007, ISBN-10: 3835101447, ISBN-13: 978-3835101449		
Workload:	**60** hours of courses **90** hours preparation and wrap-up of courses, exam preparation		
Provider:	02 Faculty Engineering Sciences		
Lecturers team (roles):	Prof. Dr. rer. nat. Steffen Weißmantel (Lecturer, content manager, examiner)		
Module unit forms and examinations:	see below		

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Solid State Physics	3	1	0	0		Mo/30	5

2902 Quantum Mechanics / Statistical Physics

Module name:	**Quantum Mechanics / Statistical Physics**	Classroom language:	German, English
Module number:	2902	Degree:	M.Sc.
Module code:	02-QMSP-18	Frequency:	Winter Semester
Obligation/Elective:	Mandatory	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	1
Training objectives:	Building on the lecture series "Physics" and the modules in the subject Mathematics, the basics of Quantum Mechanics and Statistical Physics are taught. The basic purpose of the module is to explain the mathematical apparatus, to present the fields of quantum mechanics or statistical physics necessary for the understanding of a variety of physical phenomena and to promote physical thinking during the development of the material. The student is enabled to apply the knowledge of quantum mechanics to the treatment of the atomic structure of matter and of radiation transitions. In statistical physics, students can incorporate their knowledge of quantum mechanics and apply it to thermo-dynamic processes, phase transformations, chemical reactions, and solid-state physical phenomena.		
Teaching contents:	The failure of classical physics and the quantization of physical quantities; Fundamentals of quantum mechanical formalism, Hilbert space; the probability character of quantum mechanics and the correspondence principle; Heisenberg's uncertainty relation; matter waves and wave packets; Schrödinger equation; particles in the potential box; passage of a particle through a potential barrier; harmonic oscillator; rigid rotator; angular momentum and spin; the electron shell of atoms; perturbation theory; absorption and emission of photons. Basic principles of statistical physics, thermodynamic quantities, entropy and thermodynamic probability, kinetic gas theory, partition function and Boltzmann distribution function, thermodynamic potentials, molar heat according to the Einstein and Debye model, chemical reactions, heat conduction equation, Fermi-Dirac distribution, Bose Einstein distribution, electrons and phonons in the solid state.		
Learning methods:	The teaching content is presented in the lectures, followed by the students in self-study and deepened by solving tasks in the seminar. In particular, the application of quantum mechanical methods for the physical description of intraatomic processes and the generation and interaction of electromagnetic radiation and the application of statistical methods for the physical description of thermodynamic processes, distribution functions for relevant physical quantities as well as phase transformations and chemical reactions are discussed.		
Literature:	1. Feynman/Leighton/Sands, Feynman Vorlesungen über Physik, Band III: Quantenmechanik, Oldenburg Wissenschaftsverlag 2009 (Neuauflage), ISBN-10: 348658989X, ISBN-13: 978-3486589894. 2. Joos, G., Fricke, B., Schäfer, K., Lehrbuch der Theoretischen Physik, AU- LA - Verlag Wiesbaden, ISBN-10: 3891044623, ISBN-13: 978- 3891044629. 3. Fliessbach, T., Quantenmechanik: Lehrbuch zur Theoretischen Physik III, Spektrum-Akademischer Verlag 2008 (5. Auflage), ISBN-10: 3827420202, ISBN-13: 978-3827420206. 4. Fliessbach, T., Statistische Physik: Lehrbuch zur Theoretischen Physik IV, Spektrum-Akademischer Verlag 2010 (5. Auflage), ISBN-10: 3827425271, ISBN-13: 978-3827425270. 5. Reichl, L.E., A Modern Course in Statistical Physics, Verlag J. Wiley. Diu, Guthmann, C., Lederer, D., Roulet, B., Grundlagen der Statistischen Physik, Verlag Walter de Gruyter, ISBN 3-11-013593-0		
Workload:	**60** hours of courses **90** hours preparation and wrap-up of courses, exam preparation		

Provider:	02 Faculty Engineering Sciences
Lecturers team (roles):	Prof. Dr. rer. nat. Steffen Weißmantel (Lecturer, content manager, examiner) Prof. Dr. rer. nat. habil. Alexander Horn (Lecturer, content manager, examiner)
Module unit forms and examinations:	see module structure below

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Quantum Mechanics / Statistical Physics	2	2	0	0		Mw/120	5

2903 Modeling / Simulation

Module name:	**Modeling / Simulation**	Classroom language:	German, English
Module number:	2903	Degree:	M.Sc.
Module code:	02-MOSIM	Frequency:	yearly
Obligation/Elective:	Mandatory	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	1
Training objectives:	The module imparts methodological and technical competence for modelling and simulation of physical processes. Students are enabled to model physical processes and technologies using selected examples and to program them with the help of suitable software. In particular the assumptions are to be discussed critically. The simulation is carried out using suitable mathematical methods. Students are enabled to independently apply the program systems MATLAB and COMSOL and to use them in simulations of physical processes.		
Teaching contents:	Modelling of physical processes: modelling, assumptions, neglect, selection of a mathematical procedure Simulation: Programming of the model, execution of test calculations, presentation and discussion of the results Application of simulation and modelling software to handle complex processes.		
Learning methods:	Methodology of the seminar should be both the mediation of material by means of concrete procedures and techniques, as well as an appropriate theory-based presentation and discussion of the problems. Presence teaching is structured in knowledge modules CBT (Computer based training) and LBD (Learning by Doing) consolidate the practical application.		
Literature	1. Grupp F.: MATLAB für Ingenieure Grundlagen und Programmbeispiele. Oldenburg Verlag München 2. Bode, H.: MATLAB in der Regelungstechnik. B.G. Teubner Stuttgart 3. Taubert K., Wiedl W.: MATLAB. Universität Hamburg 4. Benker, H.: Mathematik mit MATLAB, Eine Einführung für Ingenieure und Naturwissenschaftler, Springer Verlag Heidelberg		
Workload:	**60** hours of courses **90** hours preparation and wrap-up of courses, exam preparation		
Provider:	02 Faculty Engineering Sciences		
Lecturers team (roles):	Prof. Dr. rer. nat. habil. Alexander Horn (Lecturer, content manager, examiner) M.Sc. Markus Olbrich (Lecturer, content manager, examiner)		
Module unit forms and examinations:	see below		

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Modeling / Simulation	2	0	2	0		Mop/PT	5

2905 Radiation Physics / Optics

Module name:	**Radiation Physics / Optics**	Classroom language:	German, English
Module number:	2905	Degree:	M.Sc.
Module code:	02-SPHYO-18	Frequency:	yearly
Obligation/Elective:	Compulsory Elective	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	1
Training objectives:	Building on the knowledge of physics and optics acquired in the bachelor's programme, students, in particular graduates of the classical engineering programmes, gain access to the knowledge in the field of generation and propagation of electromagnetic waves and the interactions of this radiation with matter, which is a prerequisite for the master's programme. They understand the quantum mechanical principles of the emission and absorption process. They are able to describe the wave-optical phenomena (interference, diffraction, polarization) during the propagation of laser beams qualitatively and quantitatively. This is a build-up module.		
Teaching contents:	Maxwell's equations, dipole radiation, Planck's radiation law, wave-particle duality, atomic models, quantum numbers and spectroscopic notation of atoms, L-S coupling Electromagnetic radiation, properties and effect of laser beams, optics: propagation of light, Fermatsch's principle, reflection, refraction, paraxial beams, imaging with lenses and lens systems, Huygens Fresnel's principle, interference, diffraction, polarization, dispersion, absorption.		
Learning methods:	The teaching content is presented in the lectures, followed by the students in self-study and deepened by solving tasks in the seminar. In particular, the fundamentals of electromagnetic radiation, laser radiation and optics required for laser technology are presented.		
Literature:	1. Hering, E., Martin R., Stohrer M.: Physik für Ingenieure. VDI-Verlag Düsseldorf 2. Paus H.: Physik in Experimenten und Beispielen. Carl Hanser Verlag München Kneubühl/Sigrist Laser, Teubner Studienbücher Physik, Wiesbaden 3. Donges, A., Physikalische Grundlagen der Lasertechnik, Hüthig Verlag, Heidelberg Silvast, W.T., Laser Fundamentals, Cambridge University Press, Cambridge Eichler/Müller: Lasertechnik in der Medizin, Springer 4. Pedrotti, Pedrotti, Bausch, Schmidt, Optik für Ingenieure, Springerverlag Berlin Heidelberg, 2002 Klein, Furtak, "Optik", Springerverlag Berlin Heidelberg 1988, 5. Hecht, "Optik", Addison-Wesley Publishing Company		
Workload:	**60** hours of courses **90** hours preparation and wrap-up of courses, exam preparation		
Provider:	02 Faculty Engineering Sciences		
Lecturers team (roles):	Prof. Dr. rer. nat. Bernhard Steiger (Lecturer, content manager, examiner) Prof. Dr. rer. nat. habil. Alexander Horn (Lecturer, content manager, examiner)		
Module unit forms and examinations:	see module structure below		

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Radiation Physics / Optics	2	2	0	0		Mo/30	5

2906 Laser Physics

Module name:	**Laser Physics**	Classroom language:	German, English
Module number:	2906	Degree:	M.Sc.
Module code:	02-LAPHY	Frequency:	yearly
Obligation/Compulsory Elective:	Compulsory Elective	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	1
Training objectives:	The students know and understand the physical principles and working principles of the laser, the different types of lasers, the mathematical description of laser radiation and laser beam propagation as well as the physical working principles of peripheral components. The students acquire the necessary knowledge for the use of laser radiation for a wide range of technologies.		
Teaching contents:	Electromagnetic radiation as well as properties and effects of laser beams; Fundamentals of laser radiation theory - Spontaneous and induced emission, balance equations, 1st and 2nd order of magnitude Laser conditions and operating principle of the laser; Stable and unstable optical resonators, stability criteria; Longitudinal and transverse mode selection; Suitable term schemes for lasers; Laser types; Description and characteristics of laser radiation; Transformation of a Gaussian laser beam through a thin lens; Generation of short and ultrashort laser pulses by means of active and passive Q-switching and mode coupling; Characterization of pulsed laser beams; Generation of second and third harmonics.		
Learning methods:	The teaching content is presented in the lectures, followed by the students in self-study and deepened by solving tasks in the seminar. The possible applications of the acquired knowledge and concrete examples of the practical use of the laser are also discussed and demonstration experiments are demonstrated.		
Literature:	1. Kneubühl, F.K., Sigrist, M.W.: Laser, Vieweg + Teubner Verlag 2008 (7. Auflage) ISBN 978-3-8351-0145-6 2. Eichler, J.: Laser - Bauformen, Strahlführung, Anwendungen; Springerverlag, Berlin, 2006, ISBN 3540301493 3. Hügel, H.: Laser in der Fertigung - Strahlquellen, Systeme, Fertigungsverfahren; Verlag Vieweg und Teubner, ISBN 978-3835100053 4. Graf, T.: Laser: Grundlagen der Laserstrahlquellen, Verlag Vieweg und Teubner, 2009, ISBN 3834807702		
Workload:	**60** hours of courses **90** hours preparation and wrap-up of courses, exam preparation		
Provider:	02 Faculty Engineering Sciences		
Lecturers team (roles):	Prof. Dr. rer. nat. Steffen Weißmantel (Lecturer, content manager, examiner) M.Sc. Peter Lickschat (Lecturer, examiner)		
Module unit forms and examinations:	see below		

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Laser Physics	3	1	0	0		Mw/90	5

2907 Digital Technology

Module name:	**Digital Technology**	Classroom language:	German
Module number:	2907	Degree:	M.Sc.
Module code:	03-DIGI	Frequency:	yearly
Obligation/Compulsory Elective:	Compulsory Elective	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	1
Training objectives:	By imparting basic knowledge and methods of digital technology, the ability to describe, select, analyse, and design digital circuits is to be acquired. With practical exercises the student shall acquire the ability and skills for dimensioning, programming, construction, analysis and testing of digital circuits.		
Teaching contents:	Binary logic (logic states and levels, definition of switching times, basic logic functions, log. Basic logic gates, Boolean algebra, setting up and optimizing log. functions); Circuit families (overview, characteristics, static and dynamic behaviour of switching networks); Combinatorial circuits; Sequential circuits; Programmable logic circuits; Modelling and computer-aided design of digital systems; Minimisation of state machines; Design, function and characteristics of D/A and A/D converters; Logic analysis.		
Learning methods:	The lecture teaches the theoretical basics from the construction to the design of digital circuits. In the seminar the theoretical calculations and design methods are trained and consolidated by means of exercises. Computer-aided methods will be used. In the practical course, skills are taught by examining and realizing digital circuits.		
Literature:	1. Maier, H.: Grundlagen der Digitaltechnik, VDE Verlag 2018 2. Meuth, H.: Digitaltechnik, VDE Verlag 2017		
Workload:	**75** hours of lectures **75** hours of preparation and wrap-up of courses, exam preparation		
Provider:	03 Faculty Applied Computer Sciences & Biosciences		
Lecturers team (roles):	Dr.-Ing. Jörg Krupke (Lecturer) Prof. Dr.-Ing. Wilfried Schmalwasser (Content manager)		
Module unit forms and examinations:			

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Digital Technology	2	2	1	0		Mw/90	5

2908 Digital Image Processing

Module name:	**Digital Image Processing**	Classroom language:	German
Module number:	2908	Degree:	M.Sc.
Module code:	03-DBV3	Frequency:	yearly
Obligation/Compulsory Elective:	Compulsory Elective	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	1
Training objectives:	The module imparts profound core competences for digital image processing, which enable students to use procedures in a targeted manner and to competently participate in the solution of complex tasks in digital image processing. Emphasis is placed on the use of foreign-language literature and teamwork when working on more complex tasks. Technical and professional competence is promoted by the tasks to be solved.		
Teaching contents:	• Terms and definitions, image models; • Topological, geometric, statistical properties of images; • Image enhancement; • Segmentation method; • Filters (high pass, low pass, band pass); • Edge operators; • Hough transform, parameter transformation; • Ranking procedure; • Morphological operations; • Object detection; • Fourier transform; • Transformations in spectral space; • Folding, inverse folding; • Image compression		
Learning methods:	In this lecture terms, notations and methods of digital image processing are taught. Practical tasks of image processing are analysed, and solutions are prepared. By means of provided software the students solve standard tasks of digital image processing supervised and independently. An evaluation follows.		
Literature:	1. Tönnies, K. D.: Grundlagen der Bildverarbeitung. Pearson Studium, 2005 2. Zamperoni, P.: Methoden der digitalen Bildsignalverarbeitung, Vieweg, Braunschweig, 1991 3. Gonzales, R.C.: Wintz, P.: Digital Image Processing. Addison-Wesley, 1987 4. Steinbrecher, R.: Bildverarbeitung in der Praxis, Oldenbourg, 1993 5. Pavlidis, T.: Algorithms for Graphics and Image Processing, Springer, 1982 6. Jähne, B.: Digitale Bildverarbeitung, Springer, 1991 7. Wahl, F. M.: Digitale Bildverarbeitung, Springer, 1984 8. Pratt, W. K.: Digital Image Processing, John Wiley & Sons, 1978 9. Handels, H.: Medizinische Bildverarbeitung, B.G. Teubner, 2000		
Workload:	**60** hours of lectures **90** hours of preparation and wrap-up of courses, exam preparation		
Provider:	03 Faculty Applied Computer Sciences & Biosciences		
Lecturers team (roles):	Prof. Dr. rer. nat. habil. Thomas Haenselmann (Content manager)		
Module unit forms and examinations:	see below		

Module unit forms and examinations:

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Digital Image Processing	2	0	2	0		Mw/90	5

2909 Marketing

Module name:	**Marketing**	Classroom language:	German
Module number:	2909	Degree:	M.Sc.
Module code:	04-MARK-08	Frequency:	yearly
Obligation/Compulsory Elective:	Compulsory Elective	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	1
Training objectives:	The starting point for the module is the market and customer orientation of the entire company. As a specific professional competence, the students learn that through the differentiated processing of different customer segments with the instruments of the marketing mix (performance, communication, price and conditions and distribution) on the basis of relevant marketing strategies (company-related, business area-related, market participant related strategies), SHI are built up and maintained and thus the company goals are realized. On a superordinate level, the use of various instruments of the social sciences (e.g. empirical social research, forecasting techniques, scoring models, etc.) and instruments of other sub-disciplines of business administration (e.g. capital budgeting, organization and controlling) strengthens performance competence through recognition and application-oriented reflection of correlations. Through the presentation and discussion of case studies, the social competence and self-competence of the students is increased.		
Teaching contents:	• Basics of marketing - management • Environmental analysis and forecasting • Marketing objectives • Marketing strategies • Marketing instruments • Marketing organisation and controlling		
Learning methods:	The lecture Marketing (3 SWS) presents the above-mentioned contents of marketing in a seminaristic way, supported by slides and other media (video) and illustrates them by relevant practical examples. In the exercise Marketing (1 SWS), exercises and case studies, which students work on in groups, are presented and discussed. The material is repeated and deepened with summaries and repeat questions after each chapter. The students deal with the material in a practice-oriented way using case studies.		
Literature:	1. Bruhn, M., Marketingübungen. Basiswissen, Aufgaben, Lösungen. Selbstständiges Lerntraining für Studium und Beruf., aktuelle Auflage 2. Meffert, H. / Bruhn, M., Marketing Fallstudien. Fallbeispiele - Aufgaben - Lösungen, Wiesbaden aktuelle Auflage 3. Meffert, Heribert, Marketing Arbeitsbuch. Aufgaben - Fallstudien - Lösungen, Wiesbaden, aktuelle Auflage 4. Vollert, K. Grundlagen des strategischen Marketing, Bayreuth, aktuelle Auflage Vollert, K. Marketing. Eine Einführung in die marktorientierte Unternehmensführung, Bayreuth, aktuelle Auflage 5. Homburg, C.: Grundlagen des Marketingmanagements, Wiesbaden, neueste Auflag Kotler, P. u. a.: Marketing-Management, München u. a. (neueste Auflage) 6. Kotler, P. u. a.: Grundlagen des Marketing, München u. a. neueste Auflage 7. Meffert, H. u. a.: Marketing. Einführung in die Absatzpolitik, Wiesbaden, neueste Auflage		
Workload:	**60** hours of lectures **90** hours of preparation and wrap-up of courses, exam preparation		
Provider:	04 Faculty Industrial Engineering		
Lecturers team (roles):	Prof. PhD Roland Vielwerth (Lecturer) Prof. Dr. rer. pol. Klaus Vollert (Lecturer, Content manager)		
Module unit forms and examinations:	see below		

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Marketing	3	1	0	0		Mw/90	5

2904 Laser Device Technology

Module name:	**Laser Device Technology**	Classroom language:	German, English
Module number:	2904	Degree:	M.Sc.
Module code:	02-LASGT	Frequency:	yearly
Obligation/Compulsory Elective:	Compulsory Elective	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	1
Training objectives:	Based on the modules Laser Material Processing and Instrument Engineering of the bachelor's degree program in Laser Technology, the student acquires competences in constructive aspects of the component to be processed with the laser as well as in laser beam analysis. They are able to characterize laser beams comprehensively. He has applied and deepened his theoretical knowledge in practical training. He can characterize selected components of laser devices from the point of view of laser design and development and compare and evaluate the latest laser concepts that have been realized. In particular, students have acquired knowledge in the field of development of laser diodes and diode lasers and their use as pump laser source or stand-alone laser. They are able to evaluate and apply laser process control as a quality assurance method during laser processing in production.		
Teaching contents:	• Laser internship: laser beam diagnosis • Fiber laser Construction appropriate for laser (Weld, reaping, soldering) • Economic considerations (project work) • Laser diodes and high-capacity diode lasers • Diode-pumped solid-state lasers (rod lasers, slab lasers, disk lasers) • Fiber lasers - practical design, functionality, properties • Gas lasers for material processing • Comparison of the individual laser draughts • Problems of power supply for diode lasers • Diode-pumped solid-state laser - constructive aspects • Laser process control • Laser training period: Laser-beam diagnosis, fiber laser		
Learning methods:	The contents of the courses are presented in the lectures and are constantly discussed with the students in the manner of a seminaristic teaching. The possible applications of the acquired knowledge in practice are also discussed. The students are required to rework the content of the course in self-study. Within the scope of a project work in groups, the discussion of economic aspects of laser application will be prepared.		
Literature	1. Meschede, D.: Optik, Licht und Laser, Vieweg und Teubner 1999, 2005, 2008, ISBN 978-3-8351-0143-2. 2. Iffländer, Reinhard: Festkörperlaser zur Materialbearbeitung Berlin, Heidelberg, Springer Verlag (Laser in Technik und Forschung) ISBN 3-540-52150-X (Berlin) 3. Helmut Hügel, Thomas Graf: Laser in der Fertigung, Zweite neu bearbeitete Auflage, Wiesbaden, Springer Verlag 2009		
Workload:	**60** hours of lectures **90** hours of preparation and wrap-up of courses, exam preparation		
Provider:	02 Faculty Engineering Sciences		
Lecturers team (roles):	Prof. Dr.-Ing. André Streek (Lecturer, content manager, examiner)		
Module unit forms and examinations:	see below		

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Laser Device Technology	2	2	0	0	LA	Mw/120	5

2927 Technical thermodynamics for 3D printing

Module name:	**Technical thermodynamics for 3D printing**	Classroom language:	German, English
Module number:	2927	Degree:	M.Sc.
Module code:	02-TT3D-21	Frequency:	yearly
Obligation/Compulsory Elective:	Compulsory Elective	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	1
Training objectives:	By means of classical thermodynamics the energetic states of homogeneous systems can be described very well. In 3D printing, however, heterogeneous mixtures often occur with partially simultaneous presence of different phases. These require a precise mathematical consideration in order to analyse the energetic turnover and to define the requirements for the process. A desired microstructure of a component to be manufactured using additives can only be produced if the energy to be introduced into the process is adapted to requirements, based on thermodynamic balancing or the power to be introduced with due consideration of energy transport processes. The learned models and methods help to define the various free parameters in additive manufacturing. This not only facilitates the pre-selection of suitable materials / material pairings and feedstock properties, but also makes it possible to make statements about the microstructure of 3D printed components without empirical parameter determination. The student learns the methodology of energetic transport and thermodynamic state descriptions for additive construction processes based on heterogeneous bulk materials. They will be able to carry out their own calculations and mathematical analyses for the energy requirements of the process and derive optimal process parameters from these.		
Teaching contents:	Methodology: • Models for energetic balancing of the structure of various 3D printing processes. • Derivation of applicable mathematical models for the thermodynamic state description of mixing systems e.g. powders and their calculation by means of digital arithmetic units. • Mathematical methods for the description of energetic flows in heterogeneous systems. • Heat transport in powdery substances. Analysis: ➢ Energy and power accounting of laser-based additive generative processes with different powder and material properties.		
Learning methods:	The course contents are presented in seminaristically designed lectures using multimedia techniques. The deepening and supplementation of the acquired basic knowledge takes place through seminars as well as through independent studies based on the lecture notes provided. Task scripts are also used to carry out and follow up the teaching units. Advantages and disadvantages of different approaches are weighed up. Based on given tasks, the student learns to independently solve problems.		
Literature	1. Günter Cerbe (Autor), Gernot Wilhelms (Autor) Technische Thermodynamik: Theoretische Grundlagen und praktische Anwendungen, August 2017 2. Christoph Strunk Moderne Thermodynamik: [Set Moderne Thermodynamik Bd. 1+2] (De Gruyter Studium) Januar 2018		
Workload	**60** hours of lectures **90** hours of preparation and wrap-up of courses, exam preparation		
Provider	02 Faculty Engineering Sciences		
Lecturers team (roles):	Prof. Dr.-Ing. André Streek (Lecturer, content manager, examiner) Prof. Dr. rer. nat. habil. Alexander Horn (Lecturer, content manager, examiner)		
Module unit forms and examinations:	see below		

Module structure	L	S	P	T	PEP	EP	CP
Technical thermodynamics for 3D printing	3	1	0	0		Mo/30	5

2931 Technical Biophysics

Module name:	**Technical Biophysics**	Classroom language:	German, English
Module number:	2931	Degree:	M.Sc.
Module code:	02-TBP-21	Frequency:	yearly
Obligation/Compulsory Elective:	Compulsory Elective	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	1

Training objectives:	The technical biophysics module focuses on the theoretical and technical implementation of biophysical models. The students learn to reproduce the in-depth biophysical knowledge will also be able to technically implement complex computer models and to adapt them to the problems and questions of biophysics of biomolecules. The students analyse independent biophysical problems of biomolecules, derive and implement solutions by combining seminar and practical training in the flipped classroom model. By attending the module, the students can not only practice this way of working, but also present it to a professional audience. The latter is part of the examination.
Teaching contents:	The aim is not only to accelerate the industrial analysis of microscopic structures but also to develop suitable methods for this purpose. This requires methodological and technical skills in current biophysics, which are listed below: • MD simulations (Gromacs and VMD) • Monte Carlo simulations of photonic and diffusive processes (C++) • Image analysis with ImageJ (Java) • Visualization of biomolecules with pymol Data Science: Biophysical data analysis with Python and in browser based Jupyter notebooks.
Learning methods:	The biophysical methods will be presented in the lectures by means of examples and applied in practice in seminars and exercises. The teaching content is presented in the lectures and the students are actively involved in the lecture by asking specific questions. The content of the lecture is worked through by the students themselves, i.e. the lecture notes are compared with the lecture script as well as the specialist literature (see recommended literature). Questions arising in the process may be discussed with the lecturers in all formats (L, S), but primarily in the seminars/exercises. The seminar and the practical course are used in combination. Tasks are first discussed in the seminar and solution strategies are developed together with the students. Thereafter, the students solve the presented problems as a practical application using examples from the technical literature chosen by them independently. The lecturer supports the students only in the selection of the problem. The solutions are presented in the colloquium as a lecture.
Literature:	1. Cotterill: Biophysik; Wiley-VCH 2. Sackmann, Merkel: Lehrbuch der Biophysik; Wiley-VCH 3. Cantor, Schimmel: Biophysical Chemistry, Part I - III, W.H. Freeman and Company, New York 4. Howard: Mechanics of Motorproteins and the Cytoskeleton; Sinauer 5. Sackmann, Merkel: Lehrbuch der Biophysik; Wiley-VCH
Workload:	**60** hours of lectures **90** hours of preparation and wrap-up of courses, exam preparation
Provider:	02 Faculty Engineering Sciences
Lecturers team (roles):	Prof. Dr. rer. nat. Richard Börner (Lecturer, content manager, examiner)
Module unit forms and examinations:	see below

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Technical Biophysics	2	1	1	0		Mop/C30	5

2914 Physical Coating Technologies

Module name:	**Physical Coating Technologies**	Classroom language:	German, English
Module number:	2914	Degree:	M.Sc.
Module Code	02-PHBTL-18	Frequency:	yearly
Obligation/Compulsory Elective:	Mandatory	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	2

Training objectives:	In this module students learn the basics of modern, physically influenced vacuum processes for layer deposition and surface modification and understand how to demonstrate their advantageous use by means of application examples. Thus, the students gain the competence to assess the possibilities of using thin films as functional layers and/or for surface modification as well as to select suitable manufacturing processes for the production of special films for various applications.
Teaching contents:	The basics of generating and characterizing vacuums are explained and an introduction to the fundamentals of plasma physics is given. The different types of gas discharge and the generation of ion beams are covered. In the context of vacuum coating processes, the PVD (physical vapor deposition) processes are introduced and distinguished from the CVD (chemical vapor deposition) processes. These include evaporation and sputtering processes, the mechanisms of action and their influence on the properties of deposited layers. The application of laser radiation for evaporation or ablation as well as for influencing the layer properties is included. The material is supplemented by numerous practical examples from the fields of materials engineering and wear, optics, electronics and storage media as well as medical technology.
Learning methods:	The teaching content is presented in lectures and worked on by the students. In the seminars, tasks are set whose solutions are dealt with by the students; the proposed solutions are discussed in the seminar considering their advantages and disadvantages. In some practical experiments, coatings and/or surface modifications and the complicated technological influences on the processes are illustrated.
Literature:	1. Frey, H., Kienel, G., Behringer, U.: Dünnschichttechnologie, VDI - Verlag 1993, ISBN-10: 3184006700, ISBN-13: 978-3184006709 2. Bach, F.W., Möhwald, K., Laarmann, A., Wenz, T.: Moderne Beschichtungsverfahren, Wiley VCH - Verlag 2004 (2. Auflage), ISBN-10: 3527309772, ISBN-13: 978-3527309771 3. Bunshah, R.F.: Handbook of Hard Coatings: Deposition Technolgies, Properties and Applications, William Andrew Inc. 2000, ISBN-10: 0815514387, ISBN-13: 978-0815514381
Workload:	**60** hours of lectures **90** hours of preparation and wrap-up of courses, exam preparation
Provider:	02 Faculty Engineering Sciences
Lecturers team (roles):	Prof. Dr. rer. nat. Steffen Weißmantel (Lecturer, content manager, examiner)
Module unit forms and examinations:	

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Physical Coating Technologies	2	1	1	0		Mw/90	5

2912 Physical Analytics

Module name:	**Physical Analytics**	Classroom language:	German, English
Module number:	2912	Degree:	M.Sc.
Module code:	02-PHYAN-18	Frequency:	yearly
Obligation/Compulsory Elective:	Mandatory	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	2
Training objectives:	Students acquire knowledge of the fundamentals, principles and applications of essential physical analytical methods, based on the modules "Structure of Matter" and "Fundamentals of Solid-State Physics". The students know the physical and experimental basics of important physical analysis methods and have gained a deep understanding of the different methods with the help of necessary mathematical apparatus. They have the necessary factual knowledge for the application of the presented material. Students acquire in-depth competence in the use of the methods for the elucidation of structure and properties, especially of solids.		
Teaching contents:	• Physical basics of analytical methods; • Solid state analysis with X-rays and electron beams - X-ray and electron diffraction, scanning and transmission electron microscopy, electron spectroscopy, microanalysis methods; • Solid state analysis with ion beams - Rutherford backscattering and secondary ion mass spectroscopy; • Scanning tunneling and scanning force microscopy, including derived methods; • Fundamentals and applications of infrared and Raman spectroscopy as well as UV-VIS spectroscopy; • Nuclear magnetic resonance and electron spin resonance spectroscopy		
Learning methods:	The teaching content is presented in the lectures, followed by the students in self-study and deepened by solving tasks in the seminar. The possible applications of the acquired knowledge in practice will also be discussed.		
Literature:	1. Weißmantel, C., Hamann, C.: Grundlagen der Festkörperphysik, J. H. Barth Verlag Heidelberg 1995, ISBN 3-335-00421-3. 2. Demtröder, W., Laserspektroskopie 1: Grundlagen, Springer Verlag 2011 (6. Auflage), ISBN-10: 3642213057, ISBN-13: 978-3642213052. 3. Demtröder, W., Laserspektroskopie 2: Experimentelle Techniken, Springer Verlag 2013 (6. Auflage), ISBN-10: 3642214460, ISBN-13: 978- 3642214462. 4. Demtröder, W., Molekülphysik: Theoretische Grundlagen und experimentelle Methoden, Oldenbourg Wissenschaftsverlag 2003 (1. Auflage), ISBN-10: 3486249746, ISBN-13: 978-3486249743. 5. Göpel/Ziegler, Struktur der Materie: Grundlagen, Mikroskopie und Spektroskopie, Teubner Verlag 1994, ISBN-10: 3815421101 ISBN-13: 978-3815421109.		
Workload:	**60** hours of lectures **90** hours of preparation and wrap-up of courses, exam preparation		
Provider:	02 Faculty Engineering Sciences		
Lecturers team (roles):	Prof. Dr. rer. nat. Steffen Weißmantel (Lecturer, content manager, examiner)		
Module unit forms and examinations:	see below		

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Physical Analytics	3	1	0	0		Mo/30	5

2920 Research and Development Project I

Module name:	**Research and Development Project I**	Classroom language:	German, English
Module number:	2920	Degree:	M.Sc.
Module code:	02-FOEM1	Frequency:	yearly
Obligation/Compulsory Elective:	Mandatory	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	2
Training objectives:	In this module, students acquire methodological and technical competence for solving complex technical problems between physical principles and their engineering implementation. They extend their social competence by working on tasks in cooperation with many participants. They analyse and solve scientifically project tasks and topics from companies in the region or from externally funded projects of the university. They usually carry out their work in the companies or in the laboratory. In this module, the students are supported by a project seminar held by the responsible professor.		
Teaching contents:	Writing scientific papers or studies in the chosen specialisation		
Learning methods:	Independent scientific work in the chosen field of specialisation, study of literature, work in the laboratory or in a company, working on research topics, writing scientific papers		
Literature:	Independent literature selection		
Workload:	**120** hours of lectures **180** hours of preparation and wrap-up of courses, exam preparation		
Provider:	03 Faculty Applied Computer Sciences & Biosciences		
Lecturers team (roles):	Prof. Dr.-Ing. André Streek (Lecturer, content manager, examiner) Prof. Dr.-Ing. Udo Löschner (Lecturer, content manager, examiner) Prof. Dr. rer. nat. Bernhard Steiger (Lecturer, content manager, examiner) Prof. Dr. rer. nat. Steffen Weißmantel (Lecturer, content manager, examiner) Prof. Dr. rer. nat. habil. Alexander Horn (Lecturer, content manager, examiner) Prof. Dr. rer. nat. Richard Börner (Lecturer, content manager, examiner)		
Module unit forms and examinations:			

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Research and Development Project I	0	1	7	0		Mop/PT	10

2917 Components of Laser Technology

Module name:	**Components of Laser Technology**	Classroom language:	German, English
Module number:	2917	Degree:	M.Sc.
Module code:	02-KOLAS	Frequency:	yearly
Obligation/Compulsory Elective:	Compulsory Elective	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	2
Training objectives:	This module provides broad knowledge on selected components of laser technology based on principles of laser physics, laser technology and optical basic knowledge. Based on their acquired practical skills, they can suggest how to use the corresponding components in complex systems to solve different tasks. They are able to understand the functionality of elements and the underlying effects for • Fast laser beam switching (AOM, EOM, pocket cell) • Modification of the polarization state • Frequency conversion (SHG, THG, 3- and 4-wave mixing) and being able to classify and combine them		
Teaching contents:	• Optical beam switches (electro-optical and acoustic-optical principle) • Introduction to nonlinear optics and frequency conversion • Frequency doubling, frequency tripling • Three-wave mixing (sum frequency and difference frequency generation, optical parametric processes) • Four-wave mixing		
Learning methods:	The contents are conveyed in seminar-like tuition and have to be deepened by self-studying. The focus is on the direct relation of the teaching content to practical application. The lecture material will be presented partly by means of PowerPoint and illustrated by content-relevant image and/or video material.		
Literature:	1. Laser Jürgen Eichler, Hans Joachim Eichler Bauformen, Strahlführung, Anwendungen Springer Verlag ISBN: 978-3-540-30149-3 2. Optik, Licht und Laser D. Meschede Vieweg+Teubner Verlag, 3. durchges. Aufl. 2008 ISBN-10: 3835101439 3. Lasertechnik Grundlagen und Anwendungen Helmbrecht Bauer Würzburg: Vogel,1991 (Kamprath-Reihe) ISBN: 3-8023-0437-3 4. Optik für Ingenieure: Grundlagen F. Pedrotti, L. Pedrotti, W. Bausch, H. Schmidt Springer Verlag, 4. bearb. Aufl. 2008 ISBN: 3540734716 5. Bauelemente der Optik: Taschenbuch der technischen Optik H. Naumann, G. Schröder Fachbuchverlag Leipzig, 6. Auflage (22. Oktober 1992) ISBN: 3446170367 6. Grundlagen der Photonik B. Saleh, M. Teich Wiley-VCH Verlag Weinheim (1. Auflage 2008) ISBN: 978-3-527-40677-7		

Workload:	**60** hours of lectures **90** hours of preparation and wrap-up of courses, exam preparation
Provider:	02 Faculty Engineering Sciences
Lecturers team (roles):	Prof. Dr.-Ing. Udo Löschner (Lecturer, content manager, examiner) Prof. Dr. rer. nat. Bernhard Steiger (Lecturer, content manager, examiner)
Module unit forms and examinations:	see below

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Components of Laser Technology	2	2	0	0		Mo/30	5

2916 Physics of Laser-Matter Interaction

Module name:	**Physics of Laser-Matter Interaction**	Classroom language:	German, English
Module number:	2916	Degree:	M.Sc.
Module code:	02-PHLMW-18	Frequency:	yearly
Obligation/Compulsory Elective:	Compulsory Elective	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	2

Training objectives:	After completion of the module, students are able to understand and apply the experimental and theoretical principles of the physics of the laser radiation – material - interaction. They intensively deal with the optical properties of solids and the phenomena occurring during the interaction of laser radiation or photons with solids as well as the mathematical apparatus for their theoretical description. Through the acquired in-depth understanding of the individual phenomena, students will understand the complex correlations in the interaction of laser radiation – material interaction and hence will be able to apply this knowledge to technically relevant laser processes.
Teaching contents:	Optical properties of solids - Basics of classical theory; Fresnel coefficients, dispersion curves of metals, semiconductors as well as molecular and ion crystals and their interpretation. Fundamentals of nonlinear crystal optics - Fresnel equations and optical axes, crystal structure and optical characteristics, nonlinear polarization and generating of optical harmonics, phase matching in anisotropic crystals. Interaction of laser radiation with metals, semiconductors and insulators - absorption, heating and melting, evaporation or ablation with plasma formation. Interaction of ultra-short pulsed laser radiations of high intensity with solids - absorption via single and multi-photon processes, excitation of plasmons, two-temperature model, material ablation by ablation and structure formation on surfaces, pulse duration dependence and electron-phonon coupling time.
Learning methods:	The teaching contents will be presented in form of lectures, followed by self-study and deepened by solving tasks in the seminar. The possible applications of the acquired knowledge in practice will also be discussed.
Literature:	1. Weißmantel, C., Hamann, C.: Grundlagen der Festkörperphysik, J. H. Barth Verlag Heidelberg 1995 (Neuauflage), ISBN 3-335-00421-3 2. Kittel. C.: Einführung in die Festkörperphysik, Oldenbourg Wissenschaftsverlag 2005 (Neuauflage), ISBN-10: 3486577239, ISBN-13: 978-3486577235. 3. Bäuerle, D.: Laser Processing and Chemistry, Springer-Verlag 1986, 1996, ISBN 3-540-17147-9 4. Pedrotti, F et.al.: Optik für Ingenieure, Springer-Verlag 2002, 2005, 2008, ISBN 978-3-540-73471-0 5. Sobol, E.N.: Phase Transformations and Ablation in Laser-Treated Solids, John Wiley and Sons 1995, ISBN 0-471-59899-2 6. Meschede, D.: Optik, Licht und Laser, Vieweg und Teubner 1999, 2005, 2008, ISBN 978-3-8351-0143-2
Workload:	**60** hours of lectures **90** hours of preparation and wrap-up of courses, exam preparation
Provider:	02 Faculty Engineering Sciences
Lecturers team (roles):	Prof. Dr. rer. nat. habil. Alexander Horn (Lecturer, content manager, examiner)
Module unit forms and examinations:	

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Physics of Laser-Matter Interaction	3	1	0	0		Mo/30	5

2928 Simulation Methods in Generative Manufacturing

Module name:	**Simulation Methods in Generative Manufacturing**	Classroom language:	German, English
Module number:	2928	Degree:	M.Sc.
Module code:	02-SMGF-21	Frequency:	yearly
Obligation/Compulsory Elective:	Compulsory Elective	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	2
Training objectives:	New simulation methods in additive generative manufacturing are the subject of current research. Frequently, finite element modifiers are used to analyze a substantially thermal imprinted energy input and subsequent dissipation into the shapeless source material. However, commercially available simulation tools are hardly suitable for additive manufacturing because the case of constantly changing geometry is ignored. In addition, the latent energies are difficult to detect and describe when bonding new material to the existing microstructure and the associated energy flow transitions. Consequently, simulation modules must be developed for a realistic thermal simulation in additive manufacturing. In additive generative manufacturing, radiation sources are often used as energy- supplying elements for complex structure formation. Especially in the case of porous feedstocks, as is the case with powder bed-based 3D printing processes, the properties of the primary optical dissipation of the radiant energy must also be taken into account in order to obtain realistic descriptions of the subsequently thermally assisted build-up process. Although wave-optical calculation models can be used to describe all cases of the resulting radiation superposition in the feedstocks. However, these usually do not allow a direct derivation of the energetic dissipation through loss of intensity and are also associated with an inadequate computational effort. By contrast, the ray tracing method provides a solid tool for describing radiation transitions into a powdered medium and for spatially positioning and arranging the absorbed radiation or energy components in the feedstock. The student gets to know the methodology of the own creation of simulations for additive building processes. He will be able to develop and visualize his own simulations based on object-oriented programming languages.		
Teaching contents:	Simulation methodology: • Basic mathematical models of dissipation and radiation optics and their description as well as conversion into digital arithmetic units. • Methods of matrix operations for the simulation of energetic flows with variable convolution kernels. • Methods for the description and discretization of real microstructures (spatially and temporally). Creating a simulation: • Object-oriented creation of simulations e.g. in Matlab • Visual preparation and presentation of the simulation results		
Learning methods:	The course content will be delivered in seminar-style lectures mediated by multimedia techniques. The deepening and completion of the acquired basic knowledge takes place through seminars as well as by means of the provided lecture scripts by own independent studies. Task scripts also serve to carry out and follow up the lessons. Advantages and disadvantages of different approaches are weighed. Based on given tasks, the student learns to independently solve problems.		
Literature:	1. MATLAB und Mathematik kompetent einsetzen: Eine Einführung für Ingenieure und Naturwissenschaftler, Stefan Adam, 2017, Wiley 2. Objektorientierte Programmierung mit MATLAB, Ulrich Stein, 2016, Fachbuchverlag Leipzig im Carl Hanser Verlag 3. Simulation physikalischer Systeme: Computational Physics mit MATLAB, Wolfgang Schweizer, 2016, Verlag Walter De Gruyter Inc.		

Workload:	**60** hours of lectures **90** hours of preparation and wrap-up of courses, exam preparation
Provider:	02 Faculty Engineering Sciences
Lecturers team (roles):	Prof. Dr.-Ing. André Streek (Lecturer, content manager, examiner)
Module unit forms and examinations:	

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Simulation Methods in Generative Manufacturing	2	1	1	0	WS	Mo/30	5

2932 Molecular and Cellular Biophysics

Module name:	**Molecular and Cellular Biophysics**	Classroom language:	German, English
Module number:	2932	Degree:	M.Sc.
Module code:	02-MZBP-21	Frequency:	yearly
Obligation/Compulsory Elective:	Compulsory Elective	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	2
Training objectives:	The Molecular and Cellular Biophysics module focuses on in-depth biophysical and physical-biochemical relationships and knowledge in the fields of thermodynamics and kinetics of biomolecules as well as structural biology, especially of nucleic acids and proteins, which are relevant for engineers (Laser Technology - Advanced Biophotonics). The research area works interdisciplinary at the interface of biology, biochemistry and physics and investigates fundamental questions related to biology, medical and pharmacological research and its applications. Based on the basic knowledge of biophysics, molecular physics, biochemistry and physics from the bachelor's programme, students acquire a deeper knowledge of biophysical relationships. This means that students will be able to describe complex interrelationships of biophysical laws not only mathematically and physically correct but also to adapt them to new problems (e.g. unknown RNA or protein structures). Lecture: Students acquire specific knowledge and are not only capable of reproducing the presented correlations correctly, but also formulate them mathematically, solve them and interpret the result biophysically correct and check it critically. The scientific publications from internationally renowned journals (PNAS, JPC, JACS, applied chemistry, etc), which are to be worked on by the students according to the flipped classroom principle, enable the students to present, interpret and critically examine specialist knowledge in English. Seminar: Upon completion of the seminar/exercise module, students will be able to independently develop meaningful solutions and strategies for complex biophysical problems based on the knowledge acquired in the lecture, to formulate and solve them mathematically correct and to interpret the result or its solution physically correct. In general: Students acquire technical and methodological competence and are therefore able to critically evaluate scientific facts and statements (e.g. in publications) as well as to independently rewrite scientific contexts.		
Teaching contents:	• Polymer physics of biomolecules - Folding of biomolecules (RNA, proteins) • Thermodynamics of proteins • Thermodynamics of nucleic acids • Kinetics of biological macromolecules - The interaction of different biomolecules and their ligands. • Forces of biological macromolecules • Physics of bacteria and cells		
Learning methods:	The biophysical laws of the teaching content are discussed with regard to their technical application using selected examples. The biophysical way of thinking and working, both in experimental and theoretical biophysics, will be - presented in lectures, and - discussed in seminars/ in exercises. The teaching content is presented in the lectures and the students are actively involved in the lecture by asking specific questions. The teaching content of the lecture is independently revised by the students, i.e. the lecture notes are compared with the lecture script as well as the specialist literature (see recommended literature). Questions arising in the process can be discussed with the lecturers in all formats (L, S), but primarily in the seminars/exercises. Based on given tasks, students shall learn how to solve biophysical problems and tasks independently. In the seminar the solutions will be discussed, whereby in the discussion all details, such as initial and boundary conditions as well as simplifications will be discussed again in order to draw attention to the essentials. If necessary, different solutions are shown and their advantages and disadvantages are weighed up.		

Literature:	1. Nölting: Protein folding kinetics, Springer 2. Russel: Biophysics of RNA folding, Springer 3. Hinderdorfer, van Oijen, Handbook of Single-Molecule Biophysics, Springer 4. Börner R: Lecture manuscript Biophysics 2 is available on the intranet and on OPAL.
Workload:	**60** hours of lectures **90** hours of preparation and wrap-up of courses, exam preparation
Provider:	02 Faculty Engineering Sciences
Lecturers team (roles):	Prof. Dr. rer. nat. Richard Börner (Lecturer, content manager, examiner)
Module unit forms and examinations:	see below

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Molecular and Cellular Biophysics	3	1	0	0		Mw/120	5

2921 Project Management

Module name:	**Project Management**	Classroom language:	German, English
Module number:	2921	Degree:	*M.Sc.*
Module code:	04-PRMAN-20	Frequency:	yearly
Obligation/Compulsory Elective:	Mandatory	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	3
Training objectives:	Upon completion of this module, students master future requirements of the increasing complexity of economic activity, which is characterized by interdisciplinary and cross-departmental cooperation in projects with limited resources and low budgets. Students will be enabled to develop methodological and social skills in project management and to transfer them to their own project work. They will learn to define project goals, to manage efficient project organizations and to successfully organize their cooperation in cross-functional project teams. In addition, the students will have practical experience in generating goal-oriented project structures, schedules, resources, as well as cost and risk management plans. They will also be able to apply basic aspects of task-adequate project management methods.		
Teaching contents:	The lecture and the corresponding seminar deal with the contextualization of classical, agile and hybrid project management regarding change and innovation processes of the economy. They also aim at transferring knowledge about specific project management aspects, such as design, planning, leading and finalization of projects, risk management and among others Scrum. These theoretical aspects are presented through comprehensive information, graphics, texts, exercises and practical examples in order to support subsequent concrete application by the students. The above-mentioned elements will afterwards be applied in practice by means of a specific project. This project will be managed in such a way that the students independently plan, implement and evaluate a variety of task-adequate project management processes and methods in the format of an "idea camp". Through this structured project implementation, students generate an overall strategy that leads to mastering the complexity of projects. The prototypes created during the project are presented by the students at the end of the project and module.		
Learning methods:	This module is designed in such a way that project-based learning takes place with a focus on the practical application of knowledge. During the lecture, the lecturer explicitly treats the contents theoretically, so that a discussion of theories/models is possible. These theoretical aspects are presented through comprehensive information, graphics, texts, exercises and practical examples. Supplementary literature sources are intended to support the learning process. In the seminars an experiential space with limited resources and a defined goal is created for the students to become effective. The elements covered in the lectures are applied in practice on the basis of a specific project. This project will be managed in such a way that the students will independently plan, implement and evaluate a variety of task-adequate project management processes and methods in the format of an "idea camp". During this practical phase, students work in teams on a complex project that combines among others elements of computer science, prototyping and/or engineering sciences. The students use an iterative approach during the implementation of the project. Through continuous feedback from the teachers and self-evaluation within the teams, adjustments and optimizations should be implemented quickly.		
Literature:	1. DEPARTMENT OF DEFENSE. Risk, issue and opportunity management guide for defense acquisition programs. Washington, D.C. 2017, U.S. DoD. http://acqnotes.com/wp-content/uploads/2017/07/DoD-Risk-Issue-and-Opportunity-Management-Guide-Jan-2017.pdf 2. FELKAI, Roland, BEIDERWIEDEN, Arndt. Projektmanagement für technische Projekte: Ein prozessorientierter Leitfaden für Studium und Beruf, 3. Auflage. Wiesbaden 2015, Springer Vieweg Verlag. 3. KAISER, Ronny, PÜSCHEL, Georg, GÖTZ, Sebastian, KAHLE, Katrin und AßMANN, Uwe. Von der Software-Dissertation zum Lean Startup. In: Lecture Notes in Informatics - Software Engineering and Management, P-239, S. 470-483. Bonn 2015, Gesellschaft für Informatik https://subs.emis.de/LNI/Proceedings/Proceedings239/470.pdf 4. KUSAY-MERKLE, Ursula. Agiles Projektmanagement im Berufsalltag - Für mittlere		

	und kleine Projekte. Berlin, Heidelberg, 2018, Springer Gabler. 5. KUSTER, Jürg. Handbuch Projektmanagement Agil - Klassisch - Hybrid, 4. Auflage. Berlin, Heidelberg 2019, Springer Gabler. 6. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION. Risk Management Handbook. Washington, D.C. 2011, NASA. https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20120000033.pdf 7. OLFERT, Klaus. Projektmanagement, 11. Auflage. Herne 2019, NWB Verlag. 8. PATZAK Gerold, RATTAY, Günter. Projektmanagement: Projekte, Projektportfolios und projektorientierte Unternehmen, 7. Auflage. Wien 2018, Linde Verlag.
Workload:	**75** hours of lectures **75** hours of preparation and wrap-up of courses, exam preparation
Provider:	04 Faculty Industrial Engineering
Lecturers team (roles):	Prof. Dr. rer. nat. Frank Schumann (Lecturer, content manager) M.Sc. Tomás Adolfo Cabrera Lancheros (Lecturer, content manager)
Module unit forms and examinations:	see below

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Project Management	2	3	0	0	P/15	Mop/RP	5

2922 Optics Design / Micro Optics

Module name:	**Optics Design / Micro Optics**	Classroom language:	German, English
Module number:	2922	Degree:	M.Sc.
Module code:	02-ODEMI	Frequency:	yearly
Obligation/Compulsory Elective:	Mandatory	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	3
Training objectives:	The module conveys expertise and methodological competence to all students at the Master programme Laser technology, primarily specializing on background of modern micro optics and the development of optical components, respectively. Students are supposed to gain knowledge about methods as well as techniques concerning the development and fabrication of optical components, clusters and complex systems. A further objective deals with the special demands on optoelectronical components with regard to miniaturisation.		
Teaching contents:	Mainly, the objective of teaching is to understand basic operational principles of optoelectronical components, gain hands-on-experience using development software to calculate the propagation of electromagnetic waves as well as to introduce the setup and principle of complex optical systems, microoptical devices, wave guides and wave guide systems, materials for microoptical purposes and manufacturing methods in microoptics.		
Learning methods:	The content is presented in lectures and processed by the students in subsequent work. In the seminars special approaches are discussed more in detail. Discussions give way to analyse certain problems more precisely, helping to enable the essential by the disregard of second assumptions and boundary conditions.		
Literature:	1. Pedrotti, Pedrotti, Bausch, Schmidt, Optik für Ingenieure, Springerverlag Berlin Heidelberg, 2002 2. Schröter, "Technische Optik", Vogel Buchverlag, Würzburg Bergmann / Schäfer, "Lehrbuch der Experimentalphysik", Band 8 "Optik", Walter de Gruyter, N.Y. 3. Ebeling, Integrierte Optoelektronik, Springerverlag Berlin Heidelberg, 1992 4. Hunsperger, Integrated Optics: Theory and Technology, Springer Verlag Berlin Heidelberg, 1991		
Workload:	**75** hours of lectures **75** hours of preparation and wrap-up of courses, exam preparation		
Provider:	02 Faculty Engineering Sciences		
Lecturers team (roles):	M.Sc. Falko Jahn (Lecturer, examiner) Prof. Dr. rer. nat. Bernhard Steiger (Lecturer, content manager, examiner)		
Module unit forms and examinations:			

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Optics Design / Micro Optics	3	2	0	0		Mo/45	5

2936 Research and Development Project II

Module name:	**Research and Development Project II**	Classroom language:	German, English
Module number:	2936	Degree:	M.Sc.
Module code:	02-FEPPT-21	Frequency:	yearly
Obligation/Compulsory Elective:	Mandatory	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	
Training objectives:	With this module, the students acquire methodological and technical competence to solve complex technical tasks between physical bases and their engineering implementation. Their social competency is expanded by working together with many participants, researching topics from companies in the region or from scientific projects at the university. As a rule, the students will work in the company or the laboratory and will be supported in this module by a project seminar of the accountable professor. The students will be prepared directly for the master thesis.		
Teaching contents:	Creation of scientific papers or studies on the chosen specialisation		
Learning methods:	Independent scientific work in the chosen field of specialisation, literature studies, work in laboratories or in companies, working on research topics, writing of scientific papers		
Literature:	Independent literature selection		
Workload:	**240** hours of lectures **60** hours of preparation and wrap-up of courses, exam preparation		
Provider:	02 Faculty Engineering Sciences		
Lecturers team (roles):	Prof. Dr.-Ing. André Streek (Lecturer, content manager, examiner) Prof. Dr.-Ing. Udo Löschner (Lecturer, content manager, examiner) Prof. Dr. rer. nat. Bernhard Steiger (Lecturer, content manager, examiner) Prof. Dr. rer. nat. Steffen Weißmantel (Lecturer, content manager, examiner) Prof. Dr. rer. nat. habil. Alexander Horn (Lecturer, content manager, examiner) Prof. Dr. rer. nat. Richard Börner (Lecturer, content manager, examiner)		
Module unit forms and examinations:			

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Research and Development Project II	0	0	7	1			10
Project Report	0	0	7	0		EP4op/PT	
Tutorial	0	0	0	1		EP4o/30	

2923 Micro- and Nanotechnologies

Module name:	**Micro- and Nanotechnologies**	Classroom language:	German, English
Module number:	2923	Degree:	M.Sc.
Module code:	02-MINAT	Frequency:	yearly
Obligation/Compulsory Elective:	Compulsory Elective	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	3
Training objectives:	The aim of this module is to provide students with the basics of modern, physically described micro- and nanotechnology processes and to demonstrate their advantageous application for the creation of new products using selected examples. In this way, students gain the competence to assess modern micro- and nanotechnology processes and to select and further develop them for specific applications.		
Teaching contents:	Areas and dimensions of microtechnology, manufacturing technologies of microtechnology, conventional manufacturing processes and methods of semiconductor technology in microtechnology, LIGA technology, laser-based micro technologies, micro precision engineering, coating technologies, functional and construction materials of micro technology, application examples: Sensors, actuators and micro-optical components, micro-structured functional surfaces and layers, fields and dimensions of nanotech, top-down and bottom-up strategies in nanotechnology, manufacturing technologies of nanotechnology, nanochemical processes, sol-gel processes, nanomaterials, production, properties and applications of fullerenes Nanorods, nanofibres, nanofibre composites and nanocompensates, aerogle, nanostructured functional surfaces and layers, ultra-thin functional layers, nanoporous layers, self-organised nanostructures, functional nanostructures, molecular architectures, quantum effects in nanostructures, measurement and analysis of nanostructures.		
Learning methods:	The teaching content is presented in lectures, is reviewed by the students in self-study and is deepened by solving tasks in the seminar. In particular, the possible applications of the methods and concrete examples for practical use are discussed. Selected practical experiments will further consolidate the teaching content and provide experimental know-how for the application of the technologies.		
Literature:	1. Ehrfeld, W. Handbuch Mikrotechnik, Fachbuchverlag Leipzig 2. Ilfrich, T., Kuhnert, G.S., Nano + Mikro I bis IV, Entwicklung der Nano- und Mikrotechnologie, Verlag: Books on Demand GmbH 3. Frühauf, J., Werkstoffe der Mikrotechnik, Lehrbuch für Ingenieure, Hanser Fachbuchverlag 4. Brück, R., Angewandte Mikrotechnik, LIGA-Laser-Feinwerktechnik, Fachbuchverlag Leipzig		
Workload:	**60** hours of lectures **90** hours of preparation and wrap-up of courses, exam preparation		
Provider:	02 Faculty Engineering Sciences		
Lecturers team (roles):	Prof. Dr. rer. nat. habil. Alexander Horn (Lecturer, content manager, examiner) M.Sc. Markus Olbrich (Lecturer)		
Module unit forms and examinations:			

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Micro- and Nanotechnologies	2	1	1	0		Mw/90	5

2929 Physical and technical Instrument Development and Construction

Module name:	**Physical and technical instrument development and construction**	Classroom language:	German, English
Module number:	2929	Degree:	M.Sc.
Module code:	02-PTIG-21	Frequency:	yearly
Obligation/Compulsory Elective:	Compulsory Elective	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	3
Training objectives:	In the field of research, but also in the industrial application, implementation and further development of new high technologies, it is indispensable to convert physically measurable process variables into usable measurement and control values. In this way, physical processes can be monitored, recorded or modified or adjusted to a desired process result and, if necessary, stabilised. First, the physical measured variables for process description must be recognized, analyzed according to their behavior and converted into processable signals. For this purpose, various methods of digitalization and discretization can be applied, depending on the required precision and measuring speed. The transferred measured variables must be based on partly complex mathematical models for the measurement and control loops. According to the further processing of the data derived from the process model, the mathematical complexity, the required control cycle times and possibly necessary memory requirements, the appropriate calculators must be specifically selected. In the simplest case, these can be microcontrollers for simple data acquisition plus storage, but also complex synthesizable parallel computers in the form of FPGAs. In addition to the digitalization and solution of the mathematical functions, the manipulated variables ultimately generated must be converted back into physically usable process signals. For this purpose, corresponding driver stages must be adapted or, if necessary, developed. Students will be able to derive physical measurement variables from a process model and to feed these into a digital system by appropriate discretization. Furthermore, they learn to transfer mathematical correlations into digital arithmetic operations, to calculate resource-optimized and to optimize the calculation speed. A further focus is on minimizing the data to be stored. These can often be significantly reduced by transformation without losing their process-technological useful content (e.g. Fourier transformation). The basic design of electronic circuits for instrument and device construction will also be taught.		
Teaching contents:	• Digitization and discretization of analog signals. • Development and validation of mathematical models for process control and regulation • Transfer of mathematical description into digital arithmetic units. • Methods of programming and synthesis • Design and layout analog-to-digital converter • Design and layout of driver stages for various transmission types and protocols		
Learning methods:	The teaching content is conveyed in seminar-style lectures using multimedia techniques. The deepening and supplementation of the acquired basic knowledge takes place through seminars as well as through independent studies based on the lecture scripts provided. Task scripts are also used to carry out and follow up the teaching units. Advantages and disadvantages of different approaches are weighed up. The student learns how to solve problems independently based on given tasks. A practical part enables the student to implement the acquired knowledge in explicit process control tasks in hardware.		

Literature:	1. Heimo Gaicher, Patrick Gaicher • AVR Mikrocontroller - Programmierung in C: Eigene Projekte selbst entwickeln und verstehen Taschenbuch - 8. Januar 2016 2. Winfried Gehrke und Marco Winzker • Signalverarbeitung: Analoge und Digitale Signale, Systeme und Filter (German Edition)18. April 2011 von Martin Meyer • FPGAs für Maker: Eine praktische Einführung in programmierbare Logik 29. September 2016 von Cord Elias • Digitaltechnik: Grundlagen, VHDL, FPGAs, Mikrocontroller (Springer-Lehrbuch) 27. Dezember 2016
Workload:	**60** hours of lectures **90** hours of preparation and wrap-up of courses, exam preparation
Provider:	02 Faculty Engineering Sciences
Lecturers team (roles):	Prof. Dr.-Ing. André Streek (Lecturer, content manager, examiner)
Module unit forms and examinations:	

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Physical and technical instrument development and construction	1	1	2	0			5
Partial Examination 1						EP4op/PT	
Partial Examination 2						EP4o/30	

2930 Current Developments / Threat Analysis

Module name:	**Current Developments / Threat Analysis**	Classroom language:	German, English
Module number:	2930	Degree:	M.Sc.
Module code:	02-AEGA-21	Frequency:	yearly
Obligation/Compulsory Elective:	Compulsory Elective	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	3
Training objectives:	Students acquire knowledge about selected special new areas of laser technology, which up to now have largely only been used in research. They gain a good balance between theoretical background knowledge and practical application or implementation. Students will understand both the technical requirements of laser devices and the potential, special characteristics and limitations of the processes. This module enables students to deepen their knowledge base in laser technology and to transfer and apply this knowledge to other related or new areas in research and development. In addition, in-depth knowledge for the expert preparation of risk assessments on laser processing systems will be imparted.		
Teaching contents:	• Simulation and experimental investigation of a laser process exemplified by laser bending • Ray-optical calculations: geometrical optics, wave optics, rigorous method • New laser technologies: laser micro sintering, laser processing using fs laser radiation, laser processing inside transparent materials • High-rate laser processing: high-rate-suited laser sources (fiber laser, high repetition rate ultrashort pulse laser), high-rate laser equipment (beam delivery, beam shaping, fast beam deflection systems, beam switches, motion systems, electric control), high-rate laser processes (cutting, welding, micro structuring, micro sintering) rules and principles to conduct a risk assessment, calculations of exposure limit values (ELV) • Laser induced harmful waste and hazardous substances at workplaces as examples and exercises to perform a risk assessment		
Learning methods:	The knowledge will be imparted in a seminar-like tuition and follows practical problems and recent scientific findings in laser research. The students will be introduced systematically to new laser material processing technologies, required laser machinery as well as safety and risk aspects. The lecture material will be presented using PowerPoint. Extensive image and video material illustrate real laser processes and technologies impressively.		

Literature:	1. Strahlwerkzeug Laser Helmut Hügel Stuttgart Teubner -Studienbücher Verlag 1992 ISBN 3-519-06134-1 2. Laser in der Fertigung Helmut Hügel, Thomas Graf Strahlquellen, Systeme, Fertigungsverfahren Vieweg+Teubner GWV Fachverlage GmbH Wiesbaden, 2009 ISBN 978-3-8351-0005-3 3. Laser Jürgen Eichler, Hans Joachim Eichler Bauformen, Strahlführung, Anwendungen Springer Verlag ISBN 978-3-540-30149-3 4. Lasermesstechnik, Diagnostik der Kurzzeitphysik Manfred Hugenschmidt Springer Verlag ISBN 978-3-540-29920-2 5. Lasertechnik Grundlagen und Anwendungen Helmbrecht Bauer Würzburg: Vogel,1991 (Kamprath-Reihe) ISBN 3-8023-0437-3 6. Lasertechnik Dr. Hanskarl Treiber Frech-Verlag Stuttgart ISBN 3-7724-5403-8 7. Materialbearbeitung mit Lasern Dieter Bimberg Grundlagen und Anwendungen Ehningen bei Böblingen: Expert-Verl. 1991 ISBN 3-8169-0335-5 8. Schutz vor optischer Strahlung Ernst Sutter (2002) 9. Praxis-Handbuch optische Strahlung, Gesetzesgrundlagen, praktische Umsetzung und betriebliche Hilfen Hans-Dieter Reidenbach, Martin Brose, Günter Ott, Harald Siekmann (2012) 10. Leitfaden für Laserschutzbeauftragte - Ausbildung und Praxis Claudia Schneeweiss, Jürgen Eichler, Martin Brose (2017) 11. Directive 2006/25/EC - artificial optical radiation 12. Non-binding guide to good practice for implementing Directive 2006/25/EC "artificial optical radiation" 13. Verordnung zum Schutz der Beschäftigten vor Gefährdungen durch künstliche optische Strahlung (Arbeitsschutzverordnung zu künstlicher optischer Strahlung - OStrV) 14. Technische Regel zur Arbeitsschutzverordnung zu künstlicher optischer Strahlung - TROS Laserstrahlung
Workload:	120 hours of lectures 30 hours of preparation and wrap-up of courses, exam preparation
Provider:	02 Faculty Engineering Sciences
Lecturers team (roles):	Prof. Dr.-Ing. Udo Löschner (Lecturer, content manager, examiner) Dr. phil. Jörg Schille (Lecturer)
Module unit forms and examinations:	see below

Module structure	L	S	P	T	PEP	EP	CP
Current Developments / Threat Analysis	2	2	0	0			5
Current Developments	2	1	0	0		EP4o/30	
Threat Analysis	0	1	0	0		EP4w/90	

2933 Biophotonics/Ultra-short Measurement Technology/Applications

Module name:	**Biophotonics / Ultra-short Measurement Technology/ Applications**	Classroom language:	German, English
Module number:	2933	Degree:	M.Sc.
Module code:	02-BPUMA-21	Frequency:	yearly
Obligation/Compulsory Elective:	Compulsory Elective	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	3
Training objectives:	The module Biophotonics/ultra-short measurement techniques/applications contains in-depth biophotonic correlations and knowledge in the fields of fluorescence microscopy and the effect of ultrashort pulsed lasers on organic matter relevant for engineers (Master Laser Technology - Advanced Biophotonics). The research area works interdisciplinary at the interface of biology and physics and investigates fundamental questions related to biology, medical and pharmacological research and its applications. Based on the basic knowledge of biophotnics and the interaction of photons with organic matter from the bachelor's degree, students acquire a deeper knowledge of biophotonic interactions. Thus, the students will be able to describe complex interrelationships of biophotonic laws not only mathematically and physically correct but also to adapt them to new problems. **Lecture:** Students acquire specific technical knowledge and are not only able to reproduce the presented contexts correctly, but also to formulate them mathematically, solve them and to interpret and critically review the result scientifically correct. Through the scientific publications from internationally renowned journals (Nature, Science, Scientific reports, Review of scientific instruments etc.), which are to be processed by the students according to the flipped classroom principle, the students are able to present, interpret and critically question specialist knowledge in English. **Seminar:** After attending the modules seminar/exercise, the students are able to independently develop meaningful solutions and strategies for complex biophotonic problems based on the acquired knowledge from the lecture. Furthermore, the students will be able to formulate and solve them mathematically correct and interpret the result or its solution physically correct. **Practical course:** Aim of the module is that the students apply the theoretical knowledge from the lecture and seminars in advanced experiments. After attending the module lectures, the students are enabled to independently test highly demanding biophotonic facts, to perform the necessary biophotonic measurement procedures, as well as to conduct the measurement value analysis. **In general:** The students are not only able to critically evaluate scientific facts and statements (e.g. in publications) on the basis of the acquired technical and methodological competence, but are also capable of independently checking scientific connections methodically and experimentally.		
Teaching contents:	• Advanced biophotonic measurement techniques and methods to study the structure and function of biomolecules • Generation and application of ultrashort pulsed radiation • Pump & Probe Methods • 2-photon microscopy • Lifetime measurements of electronic states in fluorophores • Advanced single molecule FRET and FCS methods • Technical realization (microscope construction) and mathematical analysis (single photon trajectories, correlation, FFT, single molecule videos, image reconstruction, image analysis) for kinetics analysis and data processing within fluorescence spectroscopy and microscopy • Superresolution techniques (STED etc. compared to Cryo EM etc.) • (X-ray structure analysis & crystallography of biomolecules) Internship with increased time expenditure (á 8 -16 h): • FCS on lipid vesicles • Single molecule FRET on DNA hairpin		

Learning methods:	The biophysical laws of the teaching content are discussed with regard to their technical application using selected examples. The biophysical way of thinking and working, both in experimental and theoretical biophysics, will be • presented in lectures, and • discussed in seminars/ in exercises. The teaching content is presented in the lectures and the students are actively involved in the lecture by asking specific questions. The teaching content of the lecture is independently revised by the students, i.e. the lecture notes are compared with the lecture script as well as the specialist literature (see recommended literature). Questions arising in the process may be discussed with the lecturers in all formats (L, S), but primarily in the seminars/exercises. Based on given tasks, students shall learn how to solve biophysical problems and tasks independently. In the seminar the solutions will be discussed, whereby in the discussion all details, such as initial and boundary conditions as well as simplifications will be discussed again in order to draw attention to the essentials. If necessary, different solutions are shown and their advantages and disadvantages are weighed up. In the practical course, experimental skills are acquired, the recording of measured values and their logging is learned, the measured values are analysed, and the results and measurement errors are discussed quantitatively and qualitatively.
Literature:	5. Pedrotti, F et.al.: Optik für Ingenieure, Springer-Verlag 2002, 2005, 2008, ISBN 978-3-540-73471-0. 6. Meschede, D.: Optik, Licht und Laser, Vieweg und Teubner 1999, 2005, 2008, ISBN 978-3-8351-0143-2. 7. Bäuerle, D.: Laser Processing and Chemistry, Springer-Verlag 1986, 1996, ISBN 3-540-17147-9. 8. Lakowitz: Principles of fluorescence spectroscopy, Springer 9. Keiser: Biophotonics; Springer 10. Börner R: Lecture manuscript Biophotonics 5 is made available on the Intranet and on OPAL
Workload:	**60** hours of lectures **90** hours of preparation and wrap-up of courses, exam preparation
Provider:	02 Faculty Engineering Sciences
Lecturers team (roles):	Prof. Dr. rer. nat. habil. Alexander Horn (Lecturer, content manager, examiner) Prof. Dr. rer. nat. Richard Börner (Lecturer, content manager, examiner)
Module unit forms and examinations:	

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Biophotonics / Ultra-short Measurement Technology/ Applications	2	1	1	0		Mo/30	5

2935 Master Project

Module name:	**Master Project**	Classroom language:	German, English
Module number:	2935	Degree:	M.Sc.
Module code:	02-MLTPT-21	Frequency:	yearly
Obligation/Compulsory Elective:	Mandatory	Duration:	1
Course of study:	Laser Technology / Physical Technology	Standard Semester:	4
Training objectives:	With this final, independent scientific work, students will be qualified for the Master of Laser Technology/Physical Engineering. They will apply the theoretical and practical knowledge and skills acquired so far as well as comprehensive social competences and provide proof of their scientific qualification. The students complete the master's thesis in a company, another institution or at the university. In the concluding colloquium, they demonstrate their ability to present the results achieved and to engage in professional debate.		
Teaching contents:	Complex scientific task in the field of physical engineering: • Clarification of the topic in coordination with the supervisors of the master project; • Presentation of the boundary conditions and the objective for the Master thesis, research to determine the current state of knowledge; • Definition of necessary concepts; • Analysis of the causal relationships of the processed topic; • Presentation, selection and application of methods for dealing with the topic, summaries and findings of each edited main item; • Findings of the master's thesis, recommendations for the company, outlook for further topics		
Learning methods:	• Colloquium for the presentation of intermediate results; • Independent scientific work, possibly within a team or abroad; • Qualification of scientific writing; • Colloquium for presentation and discussion of the results		
Literature:	Project related literature research by the students		
Workload:	**60** hours of lectures **840** hours of preparation and wrap-up of courses, exam preparation		
Provider:	02 Faculty Engineering Sciences		
Lecturers team (roles):	Prof. Dr.-Ing. André Streek (Lecturer, content manager, examiner) Prof. Dr.-Ing. Udo Löschner (Lecturer, content manager, examiner) Prof. Dr. rer. nat. Bernhard Steiger (Lecturer, content manager, examiner) Prof. Dr. rer. nat. Steffen Weißmantel (Lecturer, content manager, examiner) Prof. Dr. rer. nat. habil. Alexander Horn (Lecturer, content manager, examiner) Prof. Dr. rer. nat. Richard Börner (Lecturer, content manager, examiner)		
Module unit forms and examinations:			

Module structure	*L*	*S*	*P*	*T*	*PEP*	*EP*	*CP*
Master Project	0	0	0	2			30
Master Thesis	0	0	0	2		MT	
Master Colloquium						EP4op/C60	