EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

Module Description
Master of Science in Biomedical Technologies

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1. Outline of the Program

The Biomedical Technologies master's program responds to the ever-growing need for qualified specialists within biomedical and technical field. The aim of the Master's course is to qualify for a research-related professional activity in this field. It has been designed to provide a broad base of knowledge and the opportunity to specialize in the field of Bioimaging, Biomedical Engineering or NanoBioAnalytics.

The Master's program in Biomedical Technology is a consecutive, research-oriented program, which leads to a Master of Science (M. Sc.) degree. It lasts two academic years and includes a total of 120 ECTS.

The two-year curriculum is divided into two main parts:

In the first year the students are concentrating on deepening knowledge and advanced laboratory research training, acquiring broad competences in the field of biomedical technologies, including specific knowledge in the fields of bioimaging, nanotechnology and biomedical engineering. Students can also choose from a wide catalog of elective modules allowing the student to tailor the program to their individual interests.
In the second year two Practical work experiences and Master Thesis Research Project form a major component of the program and entails one year of full-time practical work in the laboratory on three different research projects. In that way the graduates of the master's program train analytical thinking and judgment as well as practical research skills and knowledge.

The teaching of "soft skills" such as communication, presentation techniques and project management (e.g. module MEDTECH Innovation), which are an integral part of many modules, also plays an important role. In addition to deepening their technical and methodological skills, the students also develop their social and communication skills with Teamwork and Presentation Techniques as well as Consideration of social and ecological aspects (e.g. module Ethical and Social Aspects of Biomedical Technologies) so that they can apply different working and communication styles. In addition to the written master's thesis an oral presentation has to be completed in front of the experts, in which the graduates must represent the results of their research.

Objectives of the Program

Graduates of the Biomedical Technologies M.Sc. are qualified and well prepared for professional careers in the field of academic research or in the industry. They have comprehensive theoretical and practical expertise in different biomedical technologies and laboratory techniques and methods.
The course is to impart a profound knowledge of regulatory affairs in the field of medical devices from patenting to approval including mandatory quality control measures.
According to the chosen specializations (two out of three possible) graduates have in-depth expertise either in the field nanotechnology for medical applications including soft matter and polymer physics, mechanics of cells and tissues, physics of the cytoskeleton, cellular forces, motor proteins, methods in nanobiophysics, high resolution microscopy techniques, micro- and nano-fluidics, lab-on-a-chip technology and/or clinical and preclinical imaging including MRT, PET, CT, SPECT and optical

imaging and/or biomedical engineering including tissue engineering, biomaterials, reactor technology, operational procedures, design and use of clinical trials.

Graduates of the Master's program are able to plan and perform independent experiments to answer scientific questions ranging from molecular biology to biochemical composition of the materials. They have the expertise to analyze, interpret and statistically evaluate obtained results and to present them in from of scientific community.

Language requirements:

English is the main language of instruction and examination including master's thesis and oral presentation. The required level of English is C1. Knowledge of German is not obligatory for the degree program but will make everyday life in Tübingen and socialization easier. Few elective courses are offered in German as well.

Entry Requirements:

Admission to the Program may be granted to a person who have passed the B.A. examination in the subjects of Medical Technologies or Biomedical Technologies with a grade of 3.0 or better and can document 180 ECTS credit points or who
can document a comparable Bachelor's-level degree with a grade of 3.0 or better and 180 ECTS credit points from an institution of higher education.
It is expected that the applicants have a basic knowledge in the following areas:

- in Natural Sciences including Biology, Chemistry, Mathematics and Physics,
- in Medicine incl. Anatomy, Cell Biology, Physiology, Pathology and Biochemistry,
- in Technical Training including Informatics, Mechanics and Electrotechnology
- in Medical Technology including Implantology, Non-Invasive Imaging and Nanoanalytics

2. Curriculum

2.1 Overview by Study Progress

2.2 Overview by Study Modules

The program for *Biomedical Technologies* consists of the following modules:

No	Module Name	ECTS
	Mandatory courses	
M1	***Biomedical Technologies in Diagnostic and Therapy***	6
M2	***Laboratory Techniques and Methods***	3
M3	***Regulatory Affairs of Medical Devices***	3
M4	***Clinical cases and Consequences for Medical Devices***	6
	Specialization areas *2 out of 3 of the following specialization areas each with lecture, seminar and labwork with 15 ECTS in total have to be chosen*	
S1	***Bioimaging***	15
S1V	*Bioimaging – Lecture and Seminar*	6
S1P	*Bioimaging – Labwork*	9
S1PWE	*Bioimaging – Practical work experience**	15
S2	***NanoBioAnalytics***	15
S2V	*NanoBioAnalytics – Lecture and Seminar*	6
S2P	*NanoBioAnalytics – Labwork*	9
S2PWE	*NanoBioAnalytics – Practical work experience**	15
S3	***Biomedical Engineering***	15
S3V	*Biomedical Engineering – Lecture and Seminar*	6
S3P	*Biomedical Engineering – Labwork*	9
S3PWE	*Biomedical Engineering – Practical work experience**	15
	Elective courses *Modules comprising 12 ECTS in total have to be chosen*	
AS4.1	***Bioimaging – Lecture and Seminar only***	6
E2	***NanoBioAnalytics – Lecture and Seminar only***	6
E3	***Biomedical Engineering– Lecture and Seminar only***	6
E4ST	***Aktorik in der Gerätetechnik***	6
E6ST	***Interface-Design***	6
E7ST	***Grundlagen der Keramik und Verbundwerkstoffe***	6

E10ST	***Optische Systeme in der Medizintechnik***	6
BM8	***Biostatistics***	6
E13	***Ethical and Social Aspects of Biomedical Technologies***	3
E14	***MEDTEC Innovation***	9
E15	**MRI-applications for neuroscientific and clinical research**	6
E16	***Medical Technology Aspects of Cardio-Vascular Medicine***	3
E1	***NanoBioPhysics and scanning probe microscopy***	3
BM14	***Python course***	6
E17	***Biostatistics of Clinical Studies***	3
MT	***Master Thesis****	30
	**Can also be completed in industry or abroad and have to be performed within the selected specialization areas!*	

6. Module Descriptions

Number: M1	**Title:** *Biomedical Technologies in Diagnostic and Therapy*			**Nature:** compulsory
Credit points	6 CP			
Work load **- contact hours (SWS)** **- self study**	Total: 180 h contact hours: 60 h (4 SWS per semester) self-study (preparation for exams included): 120 h			
Duration	1 semester			
Time schedule	The module is offered only in the winter term.			
Language	English			
Number of participants	Minimum: 5			
Structure /Teaching methods	lecture (4 SWS)			
Contents	The course provides important and up-to-date knowledge of different biomedical technologies: Heart-lung machine, artificial respiration, anaesthetic technique, computer-assisted surgery, electromedical technique, electronic implants, rehabilitation technology, biocompatible prosthesis, biomedical laser applications			
Objectives	After completion of this module, students will be able to understand the state-of-the-art technologies, modern methodologies and open questions in selected fields of biomedical technologies. The students know a selection of relevant biomedical technologies and can analyse compare the advantages and disadvantages. The students are able to evaluate biomedical technologies and know the different requirements for the use of biomedical technologies			
Requirements for credit points / exams and grading scheme (where appropriate, weighting)	course	assessment	Grading scheme	weighting
	Biomedical Technologies in Diagnostic and Therapy	Written examination	1-5	6 ECTS
Applicability	M.Sc. in Biomedical Technologies (mandatory course) and M.Sc. Medizintechnik, Universität Stuttgart (elective course)			
Recommended semester	1st Semester			
Participation requirements				
Person responsible	Dr. Alfio Milazzo			
Literature / Teaching materials	Texts and books will be announced at the beginning of term.			

Number: M 2	Title: *Laboratory Techniques and Methods*	Nature: compulsory
Credit points	3 CP	
Work load **- contact hours (SWS)** **- self study**	Total: 90 h contact hours: 30 h (2 SWS per semester) self-study (preparation for exams included): 60 h	
Duration	1 semester	
Time schedule	The module is offered once per year in the winter term.	
Language	English	
Number of participants	Minimum: 5	
Structure /Teaching methods	lecture (2 SWS)	
Contents	The course provides important and up-to-date knowledge of different basic and state-of-the-art laboratory techniques. These techniques include general good scientific practice and statistical analysis, providing the base for every scientific work. Specific techniques covered in this program include, but are not limited to cell culture, xNA isolation, live cell imaging using advanced microscopic and spectroscopic techniques, lab-on-a-chip approaches and molecular interactions. <u>Thematic focus:</u> - molecular biology, cell culture, DNA, RNA and protein isolation, molecular interactions, surface refinement, opt. spectroscopy, microsystems engineering, lab-on-a-chip, live cell imaging, FACS, electron microscopy - research methodologies, experimental design - good scientific practice	
Objectives	After completion of this module, students will be able to understand the theory behind the different reviewed laboratory techniques and methods. Additionally, students will be able to plan experiments to answer scientific questions (ranging from molecular biology to biochemical composition of materials) by identifying and choosing suitable analytical methods. Additionally, students will gain the expertise to analyze, interpret and statistically evaluate data and results obtained from the taught methods under good scientific practice aspects.	

Requirements for credit points/exams and grading scheme (where appropriate, weighting)	course	assessment	Grading scheme	weighting
	Laboratory Techniques and Methods	Written exam	1-5	3 ECTS

Applicability	M.Sc. in Biomedical Technologies (mandatory course) and M.Sc. in Medizinische Strahlenwissenschaften/Medical Radiation Sciences (elective course) and M.Sc. Medizintechnik, Universität Stuttgart (elective course)
Recommended semester	1st semester
Participation requirements	
person responsible	Prof. Dr. Schenke-Layland, Katja

Number: M3	**Title:** *Regulatory Affairs of Medical Devices*			**Nature** compulsory
credit points	3 CP			
work load **- contact hours (SWS)** **- self study**	Total: 90 h contact hours: blended learning online and presence 30 h (2 SWS per semester) self-study (preparation for exams included): 60 h			
Duration	1 semester			
Time schedule	The module is offered only in the summer term.			
Language	English			
Number of participants	Minimum: 5			
Structure /Teaching methods	- live online lectures which will be updated regularly - 1 compulsory online questionnaire for every lecture - presence seminar 1x per month - total 2 SWS Lectures will be held live online, and lecture materials are made available to the students in ILIAS. It is the student's individual responsibility to study the subject. Lectures will be updated as soon as new laws and requirements arise. Progress will be monitored via compulsory online questionnaires (1 questionnaire per lecture, 3-5 multiple choice questions per lecture), which need to be completed within 1 week after the lecture. Questionnaires will be graded in the standard grading scheme (1-5). Missed questionnaires will be graded with 5. Additional seminars will be held to summarize lecture topics and clarify questions. Students will need to prepare single presentations or team presentations on the subject of the course that will be graded.			
Contents	<u>Thematic focus:</u> - regulatory affairs, patents, quality control, audits, startups - quality, risk and project management - incorporation of industry-based lectures The course provides important and up-to-date knowledge regarding regulatory affairs in the field of medical devices. The students will learn about the implemented mandatory safety strategies that ensure high quality materials and products in both academia and industry. These include, yet are not limited to, regulatory affairs, patenting and auditing. Additionally, measures to maintain quality will be highlighted by experts from academia and industry, including quality control and management. As universities are encouraging students to found spin-offs, students will gain insights on the objectives, hurdles and opportunities of creating their own startups from knowledgeable experts.			
Objectives	After the course, students will be able to - classify medical devices in corresponding regulations - recapitulate requirements for medical device to be patented and approved - describe the life cycle of a medical device from patenting to approval including mandatory quality control measures - recapitulate methods to ensure quality in an academic and industrial context			
Requirements for credit points / exams and grading scheme	course	Assessment consists of following parts	Grading scheme	weighting

(where appropriate, weighting)	Regulatory Affairs of Medical Devices	Online questionnaires Seminar presentation	1-5 1-5	1.5 ECTS (50%) 1.5 ECTS (50%)
	All grades from the online questionnaires throughout the semester will be averaged and count 50% of the overall grade.			
Applicability	M.Sc. in Biomedical Technologies (mandatory course) and M.Sc. in Medizinische Strahlenwissenschaften/ Medical Radiation Sciences (elective course)			
Recommended semester	2nd semester			
Participation requirements	B.Sc. degree			
Person responsible	Schenke-Layland, Katja, Prof. Dr. katja.schenke-layland@uni-tuebingen.de			
Literature / Teaching materials	Texts and books will be announced at the beginning of term.			

<table>
<tr><th>Number:
M4</th><th colspan="4">Title:
Clinical Cases and Consequences for Medical Devices</th><th>Nature
compulsory</th></tr>
<tr><td>Credit points</td><td colspan="5">6 CP</td></tr>
<tr><td>Work load
- contact hours (SWS)
- self study</td><td colspan="5">Total: 180 h
contact hours: 60 h (4 SWS)
self-study (preparation for exams included): 120 h</td></tr>
<tr><td>Duration</td><td colspan="5">1 semester</td></tr>
<tr><td>Time schedule</td><td colspan="5">The module is offered once a year in summer term</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Number of participants</td><td colspan="5">Minimum: 5</td></tr>
<tr><td>Structure /Teaching methods</td><td colspan="5">Hands-On Seminar (4 SWS)</td></tr>
<tr><td>Contents</td><td colspan="5"><u>Thematic focus:</u>
The course provides up-to-date knowledge of different clinical cases (e.g., brain diseases), diagnostic and therapeutic procedures (e.g., neuromodulation), the potential, limitations and future perspectives of medical technology devices.</td></tr>
<tr><td>Objectives</td><td colspan="5">After completing the module, students will have
- knowledge of the symptoms, pathophysiology, demographics and epidemiology of different clinical cases,
- an understanding of different diagnostic and therapeutic procedures,
- the ability to assess the potential and limitation of pharmacological and non-pharmacological interventions,
- knowledge of the state-of-the-art of medical technology devices and the skill to evaluate them from a clinical perspective,
- an understanding of unresolved therapeutic challenges and the ability to develop ideas and strategies to overcome them,
- the ability to anticipate future trends and perspectives in medical technology.</td></tr>
<tr><td rowspan="2">Requirements for credit points / exams and grading scheme (where appropriate, weighting)</td><td>course</td><td>exam</td><td>Grading scheme</td><td colspan="2">weighting</td></tr>
<tr><td>Clinical Cases and Consequences for Medical Devices</td><td>Written exam</td><td>1-5</td><td colspan="2">6 ECTS</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. in Biomedical Technologies (mandatory course) and M.Sc. in Medizinische Strahlenwissenschaften/ Medical Radiation Sciences (elective course), M.Sc. Neuroscience, GTC (elective course), M.Sc. Cognitive Science (elective course)</td></tr>
<tr><td>Recommended semester</td><td colspan="5">2nd semester</td></tr>
<tr><td>Participation requirements</td><td colspan="5">B.Sc. degree</td></tr>
<tr><td>Person responsible</td><td colspan="5">Gharabaghi, Alireza, Prof. Dr. med.</td></tr>
<tr><td>Literature / Teaching materials</td><td colspan="5">Texts and books will be announced at the beginning of term.
There is no general script.</td></tr>
</table>

<table>
<tr><th>Number:
S1V/AS4.1.</th><th colspan="3">Title:
Bioimaging – Lecture and Seminar</th><th>Nature:
specialization</th></tr>
<tr><td>Credit points</td><td colspan="4">6 CP</td></tr>
<tr><td>Work load
- contact hours (SWS)
- self study</td><td colspan="4">Total: 180 h
contact hours: 56 h
self-study (preparation for exams included): 124 h</td></tr>
<tr><td>Duration</td><td colspan="4">1 semester</td></tr>
<tr><td>Time schedule</td><td colspan="4">The module is offered once a year in the first half of the winter term as block course</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Number of participants</td><td colspan="4">Seminar: max.: 20
Lecture: max.: 40</td></tr>
<tr><td>Structure /Teaching methods</td><td colspan="4">lecture and seminar (4 SWS)</td></tr>
<tr><td>Contents</td><td colspan="4"><u>Thematic focus:</u>
- Image Correction
- Functional MRI
- Hyperpolarized MRI
- Principles of Combined PET/MR Imaging
- Basics of Image Reconstruction
- Imaging and Metabolomics (MRI, NMR)
- Advanced Tracer development and production
- MR Angiography
- Research in Radiochemistry
- Pharmacological Modelling</td></tr>
<tr><td>Objectives</td><td colspan="4">After attending this module, students gain:
- theoretical knowledge of the functional and methodical basics of MRT, PET, CT, SPECT and optical imaging.
- basic knowledge about radioactivity and the possibilities to protect themselves from radiation.
- basic knowledge of human and rodent anatomy, taking into account §30 LHG.
- knowledge of how to set up experiments in the fields of neurological, oncological, immunological and metabolic imaging
- knowledge of the different software tools for the analysis of the image material in the clinic and preclinical</td></tr>
<tr><td rowspan="2">Requirements for credit points / exams and grading scheme (where appropriate, weighting)</td><td>course</td><td>Assessment
Consists of two parts</td><td>Grading scheme</td><td>weighting</td></tr>
<tr><td>Lecture/Seminar</td><td>Written/oral examination</td><td>1-5</td><td></td></tr>
<tr><td>Applicability</td><td colspan="4">M.Sc. in Biomedical Technologies (specialization and elective course) and M.Sc. in Medizinische Strahlenwissenschaften/ Medical Radiation Sciences (elective course) and elective course for students of M.Sc. Medical Engineering Univ. of Stuttgart), takes place together with AS4.1. The module Completion is required for a module S1PWE</td></tr>
<tr><td>Recommended semester</td><td colspan="4">1st semester</td></tr>
</table>

Participation requirements	B.Sc. degree
Person responsible	Calaminus, Carsten, Dr. rer. nat. Carsten.calaminus@med.uni-tuebingen.de
Literature / Teaching materials	Texts and books will be announced at the beginning of term.

<table>
<tr><th>Number:
S1P</th><th colspan="3">Title:
Bioimaging – Labwork</th><th>Nature:
specialization</th></tr>
<tr><td>Credit points</td><td colspan="4">9 CP</td></tr>
<tr><td>Work load
- contact hours (SWS)
- self study</td><td colspan="4">Total: 270 h
contact hours: 90 h
self-study (preparation for exams included): 180 h</td></tr>
<tr><td>Duration</td><td colspan="4">1 Semester</td></tr>
<tr><td>Time schedule</td><td colspan="4">The module is offered once a year in the winter term as block course.</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Number of participants</td><td colspan="4">Maximum: 16
Minimum: 3</td></tr>
<tr><td>Structure /Teaching methods</td><td colspan="4">Practical Training (6 SWS)</td></tr>
<tr><td>Contents</td><td colspan="4"><u>Thematic focus:</u>
- Clinical application of PET and MRI, PET/MR application, imaging of special diseases
- Clinical application of CT and US, deeper insight into clinical topics
- Physics and technologies used in the nuclear medicine
- Image acquisition methods in preclinical imaging (MRI, OI, PET, SPECT/CT): design for special experiments in clinic and preclinical setup and scanning of rodents
- Clinical and Preclinical Application and Drawbacks of different MRI sequences
- Research in Radiochemistry
- Advanced Tracer development and production</td></tr>
<tr><td>Objectives</td><td colspan="4">After attending this module, students:
- gain the knowledge how to prepare patients and animals for the measurements and, depending on the desired outcome, to pay attention to the special requirements of the respective scan parameters.
- were part of practical demonstrations in preclinical imaging including some small hands-on experiences.
- learn animal handling procedures in preclinical imaging according to the animal welfare act and §30 LHG. All animal experiments are approved by the ethical committee and the local authorities in Tübingen.
- gain practical competences in detector physics
- are able to analyze images in clinical and preclinical studies.</td></tr>
<tr><td rowspan="2">Requirements for credit points / exams and grading scheme (where appropriate, weighting)</td><td>course</td><td>assessment</td><td>Grading scheme</td><td>weighting</td></tr>
<tr><td>Labwork</td><td>Portfolio consisting out of 6 Protocols, evaluated equally</td><td>1-5</td><td>9 ECTS</td></tr>
<tr><td>Applicability</td><td colspan="4">M.Sc. in Biomedical Technologies (specialization course), takes place together with AS4.1. The module Completion is required for a module S1PWE</td></tr>
<tr><td>Recommended semester</td><td colspan="4">1st semester</td></tr>
</table>

Participation requirements	B.Sc. degree
Person responsible	Calaminus, Carsten, Dr. rer. nat. Carsten.calaminus@med.uni-tuebingen.de
Literature / Teaching materials	Texts and books will be announced at the beginning of term.

<table>
<tr><th>Number:
S1PWE</th><th colspan="3">Title:
Bioimaging – Practical work experience</th><th>Nature:
specialization</th></tr>
<tr><td>Credit points</td><td colspan="4">15 CP</td></tr>
<tr><td>Work load
- contact hours (SWS)
- self study</td><td colspan="4">Total: 450 h = 15 ECTS</td></tr>
<tr><td>Duration</td><td colspan="4">min. 6 weeks full-time and max. 6 months,
The recommended time in the industry is 3 months</td></tr>
<tr><td>Time schedule</td><td colspan="4">Individual schedule</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Number of participants</td><td colspan="4">Maximum: 16
Minimum: 1</td></tr>
<tr><td>Structure /teaching methods</td><td colspan="4">Practical Training</td></tr>
<tr><td>Contents</td><td colspan="4">The Labwork contains a special topic which the student has to work on in theory and practice under the supervision of a scientist or medical doctor.</td></tr>
<tr><td>Objectives</td><td colspan="4">After the Labwork, the students are able to:
- develop their research skills to an independent level.
- read and understand publications about the scientific background of the project.
- write an electronic lab book.
- work on their own under the supervision of the scientist/medical doctor in charge.
- plan and perform their own first bioimaging experiments without supervision
- finish their project, write a protocol as well as to give a talk about the performed work in front of a scientific community.</td></tr>
<tr><td rowspan="2">Requirements for credit points / exams and grading scheme (where appropriate, weighting)</td><td>course</td><td>assessment</td><td>Grading scheme</td><td>weighting</td></tr>
<tr><td>Practical Training</td><td>Written report about the internship (10-15 pages, Arial 12, single-spaced)</td><td>1-5</td><td>15 ECTS</td></tr>
<tr><td>Applicability</td><td colspan="4">M.Sc. in Biomedical Technologies (specialization course), recommended for master´s thesis in bioimaging</td></tr>
<tr><td>Recommended semester</td><td colspan="4">3rd semester</td></tr>
<tr><td>Participation requirements</td><td colspan="4">B.Sc. degree, passed semester 1 and 2, and successful completion of modules S1V and S1P</td></tr>
<tr><td>Person responsible</td><td colspan="4">Calaminus, Carsten, Dr. rer. nat.
Carsten.calaminus@med.uni-tuebingen.de</td></tr>
<tr><td>Literature / Teaching materials</td><td colspan="4"></td></tr>
</table>

<table>
<tr><th>Number:
S2V or E2</th><th colspan="3">Title:
NanoBioAnalytics – Lecture and Seminar</th><th>Nature:
specialization</th></tr>
<tr><td>Credit points</td><td colspan="4">6 CP</td></tr>
<tr><td>Work load
- contact hours (SWS)
- self study</td><td colspan="4">Total: 180 h
contact hours: 60 h
self-study (preparation for exams included): 120 h</td></tr>
<tr><td>Duration</td><td colspan="4">1 semester</td></tr>
<tr><td>Time schedule</td><td colspan="4">The module is offered twice a year in winter and summer term</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Number of participants</td><td colspan="4">Lecture: Maximum: 24; Minimum: 3
Seminar: Maximum: 12; Minimum: 3</td></tr>
<tr><td>Structure /teaching methods</td><td colspan="4">NanoBioAnalytics Lecture (2 SWS) and
NanoBioAnalytics Seminar (2 SWS)</td></tr>
<tr><td>Contents</td><td colspan="4"><u>Thematic focus:</u>
- Introduction to nanophysics, fundamentals of nanotechnology, statistical physics, soft matter and polymer physics, mechanics of cells and tissues, physics of the cytoskeleton, cellular forces, motor proteins, methods in nanobiophysics, high resolution microscopy techniques, micro- and nanofluidics, lab-on-a-chip technology
- Discussion of current research topics in the field of nanotechnology and nanoanalytics for medical applications
- Student prepare and present seminar talks with 30 minutes duration about selected topic and discuss them afterwards</td></tr>
<tr><td>Objectives</td><td colspan="4">The module conveys the basics and in-depth knowledge of nanoanalytics and biophysics. After attending the module, students
- understand the basic phenomena, terms and concepts of nanoanalytics and biophysics
- can solve simple problems in the field of nanoanalytics and biophysics
- understand the connections between the various aspects of nanoanalytics and biophysics
- have the knowledge to critically discuss current fields of biomedical research
- can compare and evaluate different nanoanalytical tools for different applications and sample types
- have the competence to independently study a scientific research topic and present it in the form of an oral seminar talk
- have the competence to critically read, review, and discuss scientific studies and results
- have the competence to plan and schedule the preparation of their presentation
- are able to communicate in an understandable way about the above-mentioned technical content
- have experience with testing different styles, techniques, and media for oral presentations</td></tr>
<tr><td rowspan="2">Requirements for credit points / exams and grading scheme (where appropriate, weighting)</td><td>course</td><td>assessment</td><td>Grading scheme</td><td>weighting</td></tr>
<tr><td>NanoBioAnalytics Lecture</td><td>Written Examination</td><td>1-5</td><td>50%</td></tr>
</table>

	NanoBioAnalytics Seminar	Oral presentation (30 min presentation + 15 min discussion)	1-5	50%
Applicability	M.Sc. in Biomedical Technologies (specialization and elective course) and M.Sc. in Medizinische Strahlenwissenschaften/ Medical Radiation Sciences (elective course) and elective course for students of M.Sc. Medical Engineering Univ. of Stuttgart			
Recommended semester	1st or 2nd semester			
Participation requirements	B.Sc. degree			
Person responsible	Schäffer, Tilman, Prof., Dr. rer. nat.			
Teaching staff	Rheinlaender, Johannes, PD, Dr. rer. nat.			
Literature / Teaching materials	Literature will be announced at the beginning of term.			

<table>
<tr><th>Number:
S2P</th><th colspan="3">Title:
NanoBioAnalytics I – Labwork</th><th>Nature:
specialization</th></tr>
<tr><td>Credit points</td><td colspan="4">9 CP</td></tr>
<tr><td>Work load
- contact hours (SWS)
- self study</td><td colspan="4">Total: 270 h
contact hours: 90 h
self-study (preparation for exams included): 180 h</td></tr>
<tr><td>Duration</td><td colspan="4">1 semester</td></tr>
<tr><td>Time schedule</td><td colspan="4">The module is offered twice a year in winter and summer term</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Number of participants</td><td colspan="4">Maximum: 12
Minimum: 3</td></tr>
<tr><td>Structure /Teaching methods</td><td colspan="4">Practical Training (6 SWS)</td></tr>
<tr><td>Contents</td><td colspan="4"><u>Thematic focus:</u>
Planning, execution, analysis and discussion of practical experiments:
- optical lithography
- light microscopy
- electron microscopy
- scanning probe microscopy
- neurotransmitter detection
- scattering techniques
- protein crystallization</td></tr>
<tr><td>Objectives</td><td colspan="4">The module conveys basic experimental techniques in nanoanalytics and biophysics. After attending the module, students
- are familiar with practical work with selected experimental methods in nanoanalytics / interfaces
- can test and reflect on their skills in self-conducted experiments
- understand the basic phenomena, terms and concepts of the above-mentioned topics and are familiar with relevant experiments
- know about the advantages and disadvantages as well as the limits of the self-conducted experiments
- have competences in acquiring and analyzing empirical scientific data</td></tr>
<tr><td rowspan="2">Requirements for credit points / exams and grading scheme (where appropriate, weighting)</td><td>course</td><td>assessment</td><td>Grading scheme</td><td>weighting</td></tr>
<tr><td>Practical Training</td><td>Portfolio of written protocols of self-conducted experiments, incl. introduction, basics, results, discussion, error analysis.</td><td>1-5</td><td>9 ECTS</td></tr>
<tr><td>Applicability</td><td colspan="4">M.Sc. in Biomedical Technologies (specialization course), required for module S2PWE</td></tr>
<tr><td>Recommended semester</td><td colspan="4">1st or 2nd semester</td></tr>
<tr><td>Participation requirements</td><td colspan="4">B.Sc. degree</td></tr>
</table>

Person responsible	Schäffer, Tilman, Prof., Dr. rer. nat.
Teaching staff	Rheinlaender, Johannes, PD, Dr. rer. nat.
Literature / Teaching materials	Literature will be announced at the beginning of term.

Number: S2PWE	**Title:** *NanoBioAnalytics – Practical work experience*			**nature:** specialization
Credit points	15 CP			
Work load **- contact hours (SWS)** **- self study**	Total: 450 h contact hours: 300 h self-study (preparation for exams included): 150 h			
Duration of the module	1 semester, min. 6 weeks full-time and max. 6 months, The recommended time in the industry is three months			
Time schedule	Every semester			
Language	English			
Number of participants	Maximum: 8 Minimum: 1			
Structure /Teaching methods	Practical Training			
Contents	The Labwork contains a special topic that the student has to work on in theory and practice under the supervision of a scientist or medical doctor.			
Objectives	Independent practical familiarization with experimental methods in the planned area of the Master's thesis. After attending the module, students - are familiar with independent practical work with selected experimental methods in nanoanalytics / interfaces - can test and reflect on their skills in self-conducted experiments - understand the basic phenomena, terms and concepts of the special topic and are familiar with relevant experimental methods and approaches - know the current state of research and can question it critically - understand the connections between the various aspects of the special topic - know the theoretical explanatory approaches of the special topic and can apply them to different practical problems - know about the advantages and disadvantages as well as the limits of the self-conducted experiments - have competences in acquiring and analyzing empirical scientific data - have experience in drawing up a written report			
Requirements for credit points / exams and grading scheme (where appropriate, weighting)	course	exam	Grading scheme	weighting
	Practical Training	Written report about the internship (10-15 pages, Arial 12, single-spaced)	1-5	15 ECTS
Applicability	M.Sc. in Biomedical Technologies (specialization course),			
Recommended semester	3rd semester			

Participation requirements	B.Sc. degree and successful completion of modules S2V and S2P
Person responsible	Schäffer, Tilman, Prof., Dr. rer. nat.
Teaching staff	Rheinlaender, Johannes, PD, Dr. rer. nat.
Literature / Teaching materials	Literature will be announced at the beginning of term.

<table>
<tr><th>Number:
S3V</th><th colspan="3">Title:
Biomedical Engineering – Lecture and Seminar</th><th>Nature:
specialization</th></tr>
<tr><td>Credit points</td><td colspan="4">6 CP</td></tr>
<tr><td>Work load
- contact hours (SWS)
- self study</td><td colspan="4">Total: 180 h
contact hours: 60 h
self-study (preparation for exams included): 120 h</td></tr>
<tr><td>Duration</td><td colspan="4">1 semester</td></tr>
<tr><td>Time schedule</td><td colspan="4">The module is offered once per year in the summer term as block course</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Number of participants</td><td colspan="4">Lecture: max.: 50
Seminar: max.: 20</td></tr>
<tr><td>Structure /teaching methods</td><td colspan="4">lectures and seminars (4 SWS)</td></tr>
<tr><td>Contents</td><td colspan="4"><u>Thematic focus:</u>
- Tissue engineering: cell biology, biomaterials, extracellular matrix (ECM), micropatterning
- Implants: ATMPs, cell-/material interface, host response, biostability, biocompatibility
- Bioengineered in vitro models: Spheroid, transwell models, hydrogels and bioprinting, organoids, organ-on-chip and multi-organ-chips</td></tr>
<tr><td>Objectives</td><td colspan="4">Students
- Get fundamental overview over in vitro models as alternatives to animal models from the development to regulatory acceptance and use, with their advantages, limitations, and applications
- Gain insight in the most recently established technologies and basics of microfabrication and additive fabrication
- Gain knowledge of ECM (focus on collagen and elastic fibres), properties of biomaterials, cell-ECM interactions
- Understand the coupling and interaction between technical implants and tissue, material and bio-compatibility, rejection, knowledge about the passivation of surfaces and technical body parts of all kinds, principles of sensory and motor function</td></tr>
<tr><td rowspan="3">Requirements for credit points / exams and grading scheme (where appropriate, weighting)</td><td>course</td><td>assessment</td><td>Grading scheme</td><td>weighting</td></tr>
<tr><td>Lecture</td><td>Written/oral exam</td><td>1-5</td><td>50%</td></tr>
<tr><td>Seminar</td><td>Oral presentation (30 min presentation + 15 min discussion)</td><td>1-5</td><td>50%</td></tr>
<tr><td>Applicability</td><td colspan="4">M.Sc. in Biomedical Technologies (specialization and elective course) and M.Sc. in Medizinische Strahlenwissenschaften/ Medical Radiation Sciences (elective course) and elective course for students of M.Sc. Medical Engineering Univ. of Stuttgart), required for module S3PWE</td></tr>
</table>

Recommended semester	2nd semester
Participation requirements	Successful completion of a Bachelor degree in Medical Technologies, or equivalent
Person responsible	Loskill, Peter, Prof., Dr. rer. nat. Peter.Loskill@uni-tuebingen.de
Literature / Teaching materials	Texts and books will be announced at the beginning of term.

Number: S3P	**Title:** *Biomedical Engineering – Labwork*			**Nature:** specialization
Credit points	9 CP			
Work load **- contact hours (SWS)** **- self study**	Total: 270 h contact hours: 90 h self-study (preparation for exams included): 180 h			
Duration	1 semester			
Time schedule	The module is offered once per year in the summer term			
Language	English			
Number of participants	Maximum: 16 Minimum: 3			
Structure /teaching methods	Practical Training			
Contents	<u>Thematic focus:</u> - Tissue engineering: cell biology, biomaterials, extracellular matrix (ECM), micropatterning - Implants: ATMPs, cell-/material interface, host response, biostability, biocompatibility - Bioengineered in vitro models: Spheroid, transwell models, organ-on-chip			
Objectives	Students have in-depth knowledge in tissue engineering including cell and tissue culture techniques, properties of biomaterials, cell and tissue analysis for characterization, bioreactor technology, creating reports They have expertise in design and use of electronic implants (e.g. hearing implants, visual implants,) and characterization of implant surfaces as well as bioengineered in vitro models including 3D cell culture techniques, microfabrication, advanced analysis tools and sensor integration			
Requirements for credit points / exams and grading scheme (where appropriate, weighting)	course	assessment	Grading scheme	weighting
	Practical Training	Portfolio of Experimental protocols	1-5	9 ECTS
Applicability	M.Sc. in Biomedical Technologies (specialization course), required for module S3PWE			
Recommended semester	2nd semester			
Participation requirements	Successful completion of a Bachelor degree in medical technologies, or equivalent.			
Person responsible	Loskill, Peter, Prof., Dr. rer. nat. Peter.Loskill@uni-tuebingen.de			
Literature / Teaching materials	Texts and books will be announced at the beginning of term			

<table>
<tr><th>Number:
S3PWE</th><th colspan="3">Title:
Biomedical Engineering – Practical work experience</th><th>Nature:
specialization</th></tr>
<tr><td>Credit points</td><td colspan="4">15 CP</td></tr>
<tr><td>Work load
- contact hours (SWS)
- self study</td><td colspan="4">Total: 450 h</td></tr>
<tr><td>Duration</td><td colspan="4">Min. 6 weeks full-time and max. 6 months
Recommended length in the industry is 3 months</td></tr>
<tr><td>Time schedule</td><td colspan="4">Individual schedule</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Number of participants</td><td colspan="4">Maximum: 16
Minimum: 1</td></tr>
<tr><td>Structure/Teaching methods</td><td colspan="4">Practical Training (10 SWS)</td></tr>
<tr><td>Contents</td><td colspan="4"><u>Thematic focus:</u>
- Tissue engineering: cell biology, biomaterials, extracellular matrix (ECM), micropatterning
- Implants: ATMPs, cell-/material interface, host response, biostability, biocompatibility
- Bioengineered in vitro models: Spheroid, transwell models, hydrogels and bioprinting, organoids, organ-on-chip and multi-organ-chips</td></tr>
<tr><td>Objectives</td><td colspan="4">Students have comprehensive experience with state-of-the-art research covering at least one of the thematic foci of the Biomedical Engineering specialization module. This includes in-depth literature proficiency, theoretical and conceptual knowledge as well as hands-on experience.
They have expertise in reading and composing protocols, writing a laboratory notebook and scientific reporting.</td></tr>
<tr><td rowspan="2">Requirements for credit points / exams and grading scheme (where appropriate, weighting)</td><td>course</td><td>Assessment</td><td>Grading scheme</td><td>weighting</td></tr>
<tr><td>Practical Training</td><td>Written report about the internship (10-15 pages, Arial 12)</td><td>1-5</td><td>15 ECTS</td></tr>
<tr><td>Applicability</td><td colspan="4">M.Sc. in Biomedical Technologies (specialization course), recommended for master´s thesis in biomedical engineering.</td></tr>
<tr><td>Recommended semester</td><td colspan="4">3rd semester</td></tr>
<tr><td>Participation requirements</td><td colspan="4">Successful completion of a Bachelor degree in medical technologies, or equivalent, successful completion of module S3V and S3P</td></tr>
<tr><td>Person responsible</td><td colspan="4">Loskill, Peter, Prof., Dr. rer. nat.
Peter.Loskill@uni-tuebingen.de</td></tr>
<tr><td>Literature/Teaching materials</td><td colspan="4">Texts and books will be announced at the beginning of term</td></tr>
</table>

<table>
<tr><td>module number:
E4ST</td><td colspan="3">title of the module:
Aktorik in der Gerätetechnik; Konstruktion, Berechnung und Anwendung mechatronischer Komponenten</td><td>nature of the module:
elective course</td></tr>
<tr><td>credit points</td><td colspan="4">6 CP</td></tr>
<tr><td>work load
- contact hours (SWS)
- self study</td><td colspan="4">Total: 180 h
contact hours: 42 h
self-study (preparation for exams included): 138 h</td></tr>
<tr><td>duration of the module</td><td colspan="4">2nd semester</td></tr>
<tr><td>time schedule (winter/summer term)</td><td colspan="4">The module is offered each semester at the University of Stuttgart</td></tr>
<tr><td>language (English/German)</td><td colspan="4">German</td></tr>
<tr><td>maximum/minimum number of participants</td><td colspan="4">Maximum: 20</td></tr>
<tr><td>module structure /teaching methods</td><td colspan="4">Lecture, practical training.</td></tr>
<tr><td>contents</td><td colspan="4">Behandelt werden feinwerktechnische Antriebe unterschiedlicher Wirkprinzipe mit den Schwerpunkten:
- Magnettechnik/-technologie (Werkstoffe, Verfahren, konstruktive Auslegung, Magnetisierung)
- Elektromagnetische Antriebe (rotatorische und lineare Schritt-motoren; Berechnung, Gestaltung, Anwendung)
- Elektrodynamische Antriebe (rotatorische und lineare Gleichstrom-kleinstmotoren; Berechnung, Gestaltung, Anwendung)
- Piezoelektrische, magnetostriktive und andere unkonventionelle Aktorik (neue Werkstoffe in mechatronischen Komponenten, Berechnung, Gestaltung, Anwendung)
- Beispiele zur Realisierung mechatronischer Lösungen in der Gerätetechnik. Beispielhafte Vertiefung in zugehörigen Übungen und Praktika (Spezialisierungsfachpraktika und APMB).</td></tr>
<tr><td>objectives</td><td colspan="4">Die Studierenden kennen die Grundlagen der Magnettechnik und -technologie (Werkstoffe, Verfahren, konstruktive Auslegung, Magnetisierung). Die Studierenden können elektromagnetische Antriebe
(rotatorische und lineare Schrittmotoren) vereinfacht berechnen, gestalten und auslegen. Die Studierenden können elektrodynamische Antriebe (rotatorische und lineare Gleichstromkleinstmotoren) vereinfacht berechnen, gestalten und auslegen. Die Studierenden kennen piezoelektrische, magnetostriktive und andere unkonventionelle Aktorik.</td></tr>
<tr><td rowspan="2">Requirements for credit points / exams and grading scheme (where appropriate, weighting)</td><td>course</td><td>exam</td><td>Grading scheme</td><td>weighting</td></tr>
<tr><td>Lecture</td><td>Oral exam (ca. 40 min)</td><td>1-5</td><td>6 ECTS</td></tr>
<tr><td>applicability</td><td colspan="4">M.Sc. in Biomedical Technologies (elective course)</td></tr>
<tr><td>recommended semester</td><td colspan="4">1st or 2nd semester</td></tr>
<tr><td>participation requirements</td><td colspan="4">B.Sc. degree in Medical Technologies</td></tr>
</table>

person responsible for the module	Schinköthe, Wolfgang, Prof., Dr.-Ing.
literature / teaching materials	Literature will be distributed before start of lecture.

<table>
<tr><th>Number:
E6ST</th><th colspan="3">Title:
Interface-Design</th><th>Nature:
elective course</th></tr>
<tr><td>Credit points</td><td colspan="4">6 CP</td></tr>
<tr><td>Work load
- contact hours (SWS)
- self study</td><td colspan="4">Total: 180 h
contact hours: 42 h
self-study (preparation for exams included): 138 h</td></tr>
<tr><td>Duration</td><td colspan="4">1 semester</td></tr>
<tr><td>Time schedule</td><td colspan="4">The module is offered in the summer term only at the University of Stuttgart</td></tr>
<tr><td>Language</td><td colspan="4">German</td></tr>
<tr><td>Number of participants</td><td colspan="4">Maximum: 20</td></tr>
<tr><td>Structure /teaching methods</td><td colspan="4">Lecture, practical training, seminar</td></tr>
<tr><td>Contents</td><td colspan="4">Darstellung des interdisziplinären Interface-Design als Vertiefung zum Technischen Design mit Fokussierung auf alle relevanten Mensch-Maschine- Interaktionen. Beschreibung aller notwendigen Begriffe und Grundlagen zur Interfacegestaltung. Ausführliche Vorstellung der Methoden zur Integration der Makro-, Mikro- und Informationsergonomie in den gegenwärtigen Entwicklungsprozess. Darauf aufbauend werden Werkzeuge, wie Usability-Tests und Workflow-Analyse, intensiv beschrieben und deren Bewertungen und Ergebnisse diskutiert. Es werden zahlreiche realisierte Beispiele aus der Praxis als Fallbeispiele vorgestellt und behandelt.</td></tr>
<tr><td>Objectives</td><td colspan="4">Das Modul vermittelt Grundlagen und Vertiefungen zum Interfacedesign.
Studierende besitzen nach dem Besuch des Moduls
- das Wissen über die wesentlichen Grundlagen des Interfacedesigns als Bestandteil der methodischen Entwicklung und zur Vertiefung des Technischen Designs,
- die Kenntnis über wesentliche Interaktionsprinzipien zur Wahrnehmung, Kognition und Betätigung und Benutzung,
- die Fähigkeit wichtige Methoden zur Gestaltung der Mensch-Maschine-Schnittstelle anzuwenden, Lösungen zu realisieren und zu präsentieren,
- die Fertigkeiten zur Planung und Durchführung von Usability-Tests mit Probanden,
- grundlegende Kenntnisse zu Kriterien und Bewertung von Anzeigern und Stellteilen über die X Kompatibilitäten,
- ein detailliertes Verständnis von Makro- und Mikro-Informationsergonomie und deren Integration in die Planungs-, Konzept-, Entwurfs- und Ausarbeitungsphase,
- die Fähigkeit zur Durchführung und Auswertung einer Workflow-Analyse als Querschnittsfunktion,
- die Fähigkeit effiziente Bedienstrategien zu beurteilen,
- das Wissen über Auswirkungen und zukünftige Trends der Interfacegestaltung.</td></tr>
<tr><td rowspan="2">Requirements for credit points / exams and grading scheme (where appropriate, weighting)</td><td>course</td><td>assessment</td><td>Grading scheme</td><td>weighting</td></tr>
<tr><td>Lecture</td><td>Written exam</td><td>1-5</td><td>6 ECTS</td></tr>
</table>

Applicability	M.Sc. in Biomedical Technologies (elective course)
Recommended semester	2nd semester
Participation requirements	B.Sc. degree in Medical Technologies or eqivalent
Person responsible	Maier, Thomas, Univ.-Prof., Dr.-Ing.
Teaching staff	Maier, Thomas, Univ.-Prof., Dr.-Ing. Schmid, Peter, M. Sc.
Literature / Teaching materials	Literature will be distributed before start of lecture.

Number: E7ST	**Title:** *Grundlagen der Keramik und Verbundwerkstoffe*	**Nature:** elective course
Credit points	6 CP	
Work load **- contact hours (SWS)** **- self study**	Total: 180 h contact hours: 42 h self-study (preparation for exams included): 138 h	
Duration	2 semesters	
Time schedule	The module is offered once per year at the University of Stuttgart	
Language	German	
Number of participants	Maximum: 20	
Structure /teaching methods	Lecture	
Contents	Dieses Modul hat die werkstoff- und fertigungstechnischen Grundlagen keramischer Materialien zum Inhalt. Darüber hinaus werden konstruktive Konzepte und die werkstoffspezifische Bruchmechanik berücksichtigt. Es werden keramische Materialien und deren Eigenschaften erläutert. Keramische werden gegen metallische Werkstoffe abgegrenzt. Anhand von ingenieurstechnischen Beispielen aus der industriellen Praxis werden die Einsatzgebiete und -grenzen von keramischen Werkstoffen aufgezeigt. Den Schwerpunkt bilden die Formgebungsverfahren von Massivkeramiken. Die theoretischen Inhalte werden durch Praktika vertieft und verdeutlicht. Stichpunkte: - Grundlagen von Festkörpern im Allgemeinen und der Keramik. - Einteilung der Keramik nach anwendungstechnischen und stofflichen Kriterien, Trennung in Oxid-/ Nichtoxidkeramiken und Struktur-/ Funktionskeramiken. - Abgrenzung Keramik zu Metallen. - Grundregeln der Strukturmechanik, Bauteilgestaltung und Bauteilprüfung. - Klassische Herstellungsverfahren vom Rohstoff bis zum keramischen Endprodukt. - Formgebungsverfahren, wie das Axialpressen, Heißpressen, Kalt-, Heißisostatpressen, Schlicker- , Spritz-, Foliengießen und Extrudieren keramischer Massen. - Füge- und Verbindungstechnik. - Sintertheorie und Ofentechnik. - Industrielle Anwendungen (Überblick und Fallbeispiele).	
Objectives	Die Studenten können: - Merkmale und Eigenheiten keramischer Werkstoffe unterscheiden, beschreiben und beurteilen. - Belastungsfälle und Versagensmechanismen verstehen und analysieren. - werkstoffspezifische Unterschiede zwischen metallischen und keramischen Werkstoffen wiedergeben und erklären. - Technologien zur Verstärkung von Werkstoffen sowie die wirkenden Mechanismen benennen, vergleichen und erklären. - Verfahren und Prozesse zur Herstellung von massivkeramischen Werkstoffen benennen, erklären, bewerten, gegenüberstellen, auswählen und anwenden.	

	- Herstellungsprozesse hinsichtlich der technischen und wirtschaftlichen Herausforderungen bewerten und anwendungsbezogen auswählen. - in Produktentwicklung und Konstruktion geeignete Verfahren und Stoffsysteme identifizieren, planen und auswählen. - Werkstoff- und Bauteilcharakterisierung erklären, bewerten, planen und anwenden.			
Requirements for credit points / exams and grading scheme (where appropriate, weighting)	course	exam	Grading scheme	weighting
	Lecture	Written exam	1-5	6 ECTS
Applicability	M.Sc. in Biomedical Technologies (elective course)			
Recommended semester	1st and 2nd semester			
Participation requirements	B.Sc. degree in Medical Technologies			
Person responsible	Kern, Frank, apl. Prof., Dr. rer. nat.			
Teaching staff	Kern, Frank, apl. Prof., Dr. rer. nat.			
Literature / Teaching materials	Literature will be distributed before start of lecture.			

<table>
<tr><th>Number:
E10ST</th><th colspan="4">Title:
Optische Systeme in der Medizintechnik</th><th>Nature:
Elective course</th></tr>
<tr><td>Credit points</td><td colspan="5">6 CP</td></tr>
<tr><td>Work load
- contact hours (SWS)
- self study</td><td colspan="5">Total: 180h
contact hours: 42h
self-study (preparation for exams included): 138h</td></tr>
<tr><td>Duration</td><td colspan="5">1 semester</td></tr>
<tr><td>Time schedule</td><td colspan="5">The module is offered only in the summer term at the University of Stuttgart</td></tr>
<tr><td>Language</td><td colspan="5">German</td></tr>
<tr><td>Number of participants</td><td colspan="5">Maximum: 20</td></tr>
<tr><td>Structure /Teaching methods</td><td colspan="5">Lecture, practical training</td></tr>
<tr><td>Contents</td><td colspan="5">Basic optical system design and optical system parameters.
Basic architecture of optical systems used in medicine (microscope, surgical microscope, endoscope, ophthalmic systems)
Modern microscopy methods (structured illumination, confocal, fluorescence).
Optics of the human eye and ophthalmic systems.
Lasers in medical diagnostics and therapy.
Spectroscopic and hyperspectral methods and systems.
3-D optical metrology.
Basic properties of detectors.</td></tr>
<tr><td>Objectives</td><td colspan="5">The students know how to calculate basic optical quantities within simple optical systems
The students are familiar with
- the optical setup of microscopes, endoscopes, and ophthalmic systems
- spectral systems and their application
- the properties of the human eye
- properties of laser beams
- polarization
The students have an overview
- over state-of-the-art microscopic methods in order to enhance resolution and/or contrast
- laser systems and their application in medicine
- important properties of optical detectors</td></tr>
<tr><td rowspan="2">Requirements for credit points / exams and grading scheme (where appropriate, weighting)</td><td>course</td><td colspan="2">exam</td><td>Grading scheme</td><td>weighting</td></tr>
<tr><td>Lecture</td><td colspan="2">Written exam</td><td>1-5</td><td>6 ECTS</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. in Biomedical Technologies (elective course)</td></tr>
<tr><td>Recommended semester</td><td colspan="5">1st or 2nd semester</td></tr>
<tr><td>Participation requirements</td><td colspan="5">B.Sc. degree in Medical Technologies</td></tr>
<tr><td>Person responsible</td><td colspan="5">Herkommer, Alois, Univ.-Prof., Dr.</td></tr>
<tr><td>Literature /Teaching materials</td><td colspan="5">Literature will be distributed before start of lecture.
Additional recommended books:
- Gross H.: Handbook of optical systems Vol. 1-4
- Hecht, E.: Optik (Optics)
- Kühlke D.: Optik</td></tr>
</table>

<table>
<tr><th>Number:
BM8</th><th>Title:
Biostatistcs</th><th>Nature:
Elective course</th></tr>
<tr><td>Credit points</td><td colspan="2">6 CP</td></tr>
<tr><td>Work load
- contact hours (SWS)
- self study</td><td colspan="2">Total: 180 h
contact hours: 90 h
self-study (preparation for exams included): 90hours</td></tr>
<tr><td>Duration</td><td colspan="2">Statistics 1: one week block course
ANOVA: one week block course</td></tr>
<tr><td>Time schedule</td><td colspan="2">Annual</td></tr>
<tr><td>Language</td><td colspan="2">English</td></tr>
<tr><td>Number of participants</td><td colspan="2">Lecture: no limit
Tutorial: max. 28 participants</td></tr>
<tr><td>Structure/ Teaching methods</td><td colspan="2">Statistics 1: Lecture 1 (2 SWS), Tutorial (1 SWS) (elective, English)3 ECTS
Anova: Lecture 1 (2 SWS), Tutorial (1 SWS) (elective, English) 3 ECTS</td></tr>
<tr><td>Contents</td><td colspan="2">Statistics 1:
Scales, Descriptive Statistics (Graphics, Tables, Parameters), Correlation and Regression, Diagnostic Tests, Confidenceintervals, Kaplan Meier Analysis of Survival Data
Examples and Principles of statistical tests, Tests for independent samples, Tests for dependent Samples, Assessment of Normal Distribution, one factorial analysis of variance, Multiple Testing, Principles of sample size estimation
Anova:
One factorial analysis of variance, analysis of covariance, two factorial analysis of variance without interaction, two factorial analysis of variance with interaction, two factorial analysis of variance with one between and one within factor, multiple comparisons, mixed models and generalized estimating equations</td></tr>
<tr><td>Objectives</td><td colspan="2">The students can develop statistical modelling and analysis of experiments, interventional and observational clinical studies and of epidemiological studies. They can interpret the results. The students have knowledge of statistical analysis (descriptive, confirmatory, regression, multivariate) and they can decide which method is the most adequate in a specific study.</td></tr>
<tr><td rowspan="2">Requirements for credit points / exams and grading scheme (where appropriate, weighting)</td><td>Course</td><td>Assessment</td><td>Grading Scheme</td><td>Weighting</td></tr>
<tr><td>Statistics 1
Analysis of Variance</td><td>Written exam
Daily Exercise Sheets</td><td>1-5</td><td>3 ECTS
3 ECTS</td></tr>
<tr><td>Applicability</td><td colspan="2">M.Sc Biomedical Technology and M.Sc Medizinische Strahlenwissenschaften</td></tr>
<tr><td>Recommended semester</td><td colspan="2">1st Semester</td></tr>
<tr><td>Participation requirements</td><td colspan="2">The knowledge of the Course Statistics 1 is required to attend the ANOVA</td></tr>
<tr><td>Person responsible</td><td colspan="2">Martus, Peter, Prof. Dr. rer. nat.
Peter.martus@med.uni-tuebingen.de</td></tr>
</table>

Literature/ Teaching materials	To be announced at the beginning of the term

<table>
<tr><th>Number:
E13</th><th colspan="3">Title:
Ethical and Social Aspects of Biomedical Technologies</th><th>Nature:
Elective course</th></tr>
<tr><td>Credit points</td><td colspan="4">3 CP</td></tr>
<tr><td>Work load
- contact hours (SWS)
- self study</td><td colspan="4">Total: 90 h
contact hours: 30 h
self-study (preparation for exams included): 60 h</td></tr>
<tr><td>Duration</td><td colspan="4">1 semester</td></tr>
<tr><td>Time schedule</td><td colspan="4">The module is offered once per year in the winter term</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Number of participants</td><td colspan="4">Maximum: 20
Minimum: 6</td></tr>
<tr><td>Structure /Teaching methods</td><td colspan="4">Seminar (2 SWS)</td></tr>
<tr><td>Contents</td><td colspan="4">Basics:
- What makes and innovation a good innovation?
- What are ethical and social aspects of biomedical technologies?
- How to deal with those aspects?
Joint case study of a particular biomedical technology:
- What is the case?
- How can we detect ethical and social aspects of the case?
- How to deal with those aspects?
Individual case studies of the technologies the students develop in their master thesis:
- Which ethical and social aspects has my own work?
- How can I deal with them?</td></tr>
<tr><td>Objectives</td><td colspan="4">- The students reflect their criteria for good innovations and get to know the debates about responsible, sustainable innovation.
- The students get an idea of what ethical and social questions are. They become familiar with ethical and social scientific research on biomedical technologies.
- The students are empowered to detect and to discuss ethical and social aspects of the technologies they develop. They get to know tools which support ethical and social reflections.</td></tr>
<tr><td rowspan="2">Requirements for credit points / exams and grading scheme (where appropriate, weighting)</td><td>course</td><td>assessment</td><td>Grading scheme</td><td>weighting</td></tr>
<tr><td>Seminar</td><td>Presentation during Seminar and writing of a reflection paper</td><td>1-5</td><td>3 ECTS</td></tr>
<tr><td>Applicability</td><td colspan="4">M.Sc. in Biomedical Technologies (elective course)</td></tr>
<tr><td>Recommended semester</td><td colspan="4">1st semester</td></tr>
<tr><td>Participation requirements</td><td colspan="4"></td></tr>
</table>

Person responsible	Dr. Mone Spindler, IZEW
Teaching staff	Dr. Mone Spindler, IZEW
Literature/Teaching materials	Literature will be announced at the beginning of term.

<table>
<tr><th>Number:
E14</th><th colspan="3">Title:
MEDTEC Innovation</th><th>Nature:
Elective course</th></tr>
<tr><td>Credit points</td><td colspan="4">9 CP</td></tr>
<tr><td>Work load
- contact hours (SWS)
- self study</td><td colspan="4">Total: 180 h
Contact hours:60 h
Self-study: 120h</td></tr>
<tr><td>Duration</td><td colspan="4">2 semesters</td></tr>
<tr><td>Time schedule</td><td colspan="4">The module is offered once per year in the winter and summer term</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Number of participants</td><td colspan="4">Maximum: 12</td></tr>
<tr><td>Structure /teaching methods</td><td colspan="4">Lecture / Seminar combination (2 SWS in Winter Term and 2 SWS in Summer Term)</td></tr>
<tr><td>Contents</td><td colspan="4"><u>Thematic focus:</u>
- The module deals with the development process of a medical device from the industry perspective. The students will be undergoing an innovation process from primary identification of clinical unmet needs to concept generation to a functional demonstrator. During this process several steps such as self-assessment, needs finding, idea generation, IP and market analysis, as well as the physical process of drafting a design and building a demonstrator will be included.</td></tr>
<tr><td>Objectives</td><td colspan="4">Students
- Are familiar with the field of innovation management
- have fundamental knowledge about the importance of a structured process, challenging situations during the process and the application of ancillary tools
- have expertise in important methods and processes along the definition of a project towards feasibility and fabrication of a demonstrator.</td></tr>
<tr><td rowspan="2">Requirements for credit points / exams and grading scheme (where appropriate, weighting)</td><td>course</td><td>assessment</td><td>Grading scheme</td><td>weighting</td></tr>
<tr><td>Lecture / Seminar</td><td>Presentation Concept and Demonstrator</td><td>1-5</td><td>9 ECTS</td></tr>
<tr><td>Applicability</td><td colspan="4">M.Sc. in Biomedical Technologies (elective course)</td></tr>
<tr><td>Recommended semester</td><td colspan="4">1st and 2nd semester</td></tr>
<tr><td>Participation requirements</td><td colspan="4">B.Sc. degree</td></tr>
<tr><td>Person responsible</td><td colspan="4">Wahl, Siegfried, Prof. Dr. rer. nat.</td></tr>
<tr><td>Literature/Teaching materials</td><td colspan="4">Literature will be announced at the beginning of term.</td></tr>
</table>

<table>
<tr><th>Number:
BM21</th><th colspan="3">Title:
MRI-applications for neuroscientific and clinical research</th><th>Nature:
Elective course</th></tr>
<tr><td>Creditpoints</td><td colspan="4">6 CP</td></tr>
<tr><td>Work load
- contact hours (SWS)
- self study</td><td colspan="4">Total: 90h
Contact hours:30 h
Self-study: 60h</td></tr>
<tr><td>Duration</td><td colspan="4">1 semester</td></tr>
<tr><td>Time schedule</td><td colspan="4">The module is offered only in summer term</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Number of participants</td><td colspan="4">Maximum: 12</td></tr>
<tr><td>Structure/Teaching methods</td><td colspan="4">Lecture and seminar</td></tr>
<tr><td>Contents</td><td colspan="4">MRI has widely increased our knowledge about the structure and function of the human brain. The continuous development of new technologies and methods in this field allow investigations to be carried out at an ever-increasing level of detail. In this course, established and emerging methods that allow robust and reproducible quantification of physiologic and pathologic processes will be taught.
Topics include:
- Non-invasive imaging of tissue
- MR principles
- Tissue structure and MRI of gray matter regions
- White matter (WM) microstructure and diffusion weighting (DWI)
- Mapping long-range connections, brain plasticity and neurodegeneration using DWI
- MRI of WM using non-diffusion techniques
- Mapping brain function, structure: connectome networks and radiomics
- How structure and function modify local magnetic susceptibility
- Contrast agents for cell-labelling and studies of the ‘glymphatic’ system
- Neurochemistry and multi-nuclear magnetic resonance spectroscopy
- MRI at high magnetic field strengths – Visit of the MRZ</td></tr>
<tr><td>Objectives</td><td colspan="4">After completion of the module students know how does connectivity analyses relate to the progression of neurodegenerative diseases. They are able to investigate the anatomical microstructure. Students can measure the function of the blood-brain-barrier. Students follow the fate of stem-cells within the anatomical microstructure by MR.</td></tr>
<tr><td rowspan="2">Requirements for credit points / exams and grading scheme (where appropriate, weighting)</td><td>Lecture / Seminar</td><td>assessment</td><td>Grading scheme</td><td>weighting</td></tr>
<tr><td>M.Sc. in Biomedical Technologies
(elective course)</td><td>Final report
8-15 pages</td><td>Passed/failed</td><td>6 ECTS</td></tr>
<tr><td>Recommended semester</td><td colspan="4">2nd semester</td></tr>
<tr><td>Participation requirements</td><td colspan="4">B.Sc. degree</td></tr>
<tr><td>Person responsible</td><td colspan="4">Dr. Gisela Hagberg
gisela.hagberg@tuebingen.mpg.de
gisela.hagberg@med.uni-tuebingen.de</td></tr>
<tr><td>Literature/Teaching materials</td><td colspan="4">Literature will be announced at the beginning of term.</td></tr>
</table>

Number: E16	**Titel:** *Medical Technology Aspects of Cardio-Vascular Medicine*			**Nature:** Elective course
Credit points	3 CP			
Work load **- contact hours (SWS)** **- self study**	Total: 90 h contact hours: 20 h self-study (preparation for exams included): 70 h			
Duration	One-Week Block Course			
Time schedule	The module is offered once per year in the winter term			
Language	English			
Number of participants	Maximum: 12 Minimum: 7			
Structure/Teaching methods	Hands-On Seminar			
Contents	- Heart: Basics of Anatomy - Heart Disease - Heart Failure - Technical Products: Cardiac Implants, Cannulas, etc. - Technical challenges and solutions			
Objectives	- The students can explain and describe the basic anatomy, physiology and pathology of a heart - The students know a selection of relevant medical technology products and can compare the advantages and disadvantages. - The students are able to evaluate the medical technology products. - The students know the different requirements for the use of medical technology products			
Requirements for credit points / exams and grading scheme (where appropriate, weighting)	course	exam	Grading scheme	weighting
	Seminar	Written examination	1-5	3 ECTS
Applicability	M.Sc. in Biomedical Technologies (elective course)			
Recommended semester	1st semester			
Participation requirements	B.Sc. degree			
Person responsible	Prof. Dr. Tobias Walker			
Teaching staff				
Literature / Teaching materials	Literature will be announced at the beginning of term.			

<table>
<tr><th>Number:
E 1</th><th colspan="4">Title:
NanoBioPhysics and scanning probe microscopy</th><th>Nature:
Elective course</th></tr>
<tr><td>Credit points</td><td colspan="5">3 CP</td></tr>
<tr><td>Work load
- contact hours (SWS)
- self study</td><td colspan="5">Total: 90 h
contact hours: 30 h
self-study (preparation for exams included): 60h</td></tr>
<tr><td>Duration</td><td colspan="5">1 semester</td></tr>
<tr><td>Time schedule</td><td colspan="5">The module is offered once per year in the summer term</td></tr>
<tr><td>Language</td><td colspan="5">German or English</td></tr>
<tr><td>Number of participants</td><td colspan="5">Maximum: 20</td></tr>
<tr><td>Structure/Teaching methods</td><td colspan="5">Lecture (2 SWS)</td></tr>
<tr><td>Contents</td><td colspan="5"><u>Thematic focus:</u>
- Interactions on the nanoscale, measurement of inter- and intramolecular forces, contact models, technology of scanning probe microscopy, mechanical oscillations of nanostructures such as cantilevers, static and dynamic imaging modes, atomic force microscopy.</td></tr>
<tr><td>Objectives</td><td colspan="5">The module conveys the basics and in-depth knowledge of NanoBioPhysics and Scanning Probe Microscopy. After attending the module, students
- have become familiar with a young field of nanobio-science
- have acquired fundamental knowledge about the area of NanoBioPhysics
- have learned interdisciplinary methods and applications of scanning probe microscopy
- understand the basic phenomena, terms and concepts of NanoBioPhysics and Scanning Probe Microscopy
- can solve simple problems in the field of NanoBioPhysics and Scanning Probe Microscopy
- understand the connections between the various aspects of NanoBioPhysics and Scanning Probe Microscopy
- have acquired experience in mathematically formulating and solving simple linear differential equations</td></tr>
<tr><td rowspan="2">Requirements for credit points / exams and grading scheme (where appropriate, weighting)</td><td>course</td><td colspan="2">assessment</td><td>Grading scheme</td><td>weighting</td></tr>
<tr><td>Lecture</td><td colspan="2">Written exam
or oral exam</td><td>1-5</td><td>3 ECTS</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. in Biomedical Technologies (elective course)</td></tr>
<tr><td>Recommended semester</td><td colspan="5">2nd semester</td></tr>
<tr><td>Participation requirements</td><td colspan="5">B.Sc. degree</td></tr>
<tr><td>Person responsible</td><td colspan="5">Schäffer, Tilman, Prof., Dr. rer. nat.</td></tr>
<tr><td>Teaching staff</td><td colspan="5">Schäffer, Tilman, Prof., Dr. rer. nat.</td></tr>
<tr><td>Literature/Teaching materials</td><td colspan="5">Literature will be announced at the beginning of term.</td></tr>
</table>

<table>
<tr><th>Number:
BM14</th><th colspan="3">Title:
Python course</th><th>Nature:
compulsory</th></tr>
<tr><td>Credit points</td><td colspan="4">6 CP</td></tr>
<tr><td>Work load
- contact hours (SWS)
- self study</td><td colspan="4">Total: 180 h
60 h/4 SWS
120 h</td></tr>
<tr><td>Duration</td><td colspan="4">1 semester</td></tr>
<tr><td>Time schedule</td><td colspan="4">The module is offered once per year in the winter term</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Number of participabnts</td><td colspan="4"></td></tr>
<tr><td>Structure/Teaching methods</td><td colspan="4">Practical Training (10 SWS)</td></tr>
<tr><td>Contents</td><td colspan="4">The Python Programming Fundamentals is an immersive and comprehensive course designed to equip students with a strong foundation in Python, one of the most popular and versatile programming languages. Throughout this course, students will embark on a journey that takes them from the basics of Python syntax to advanced concepts, enabling them to become proficient Python programmers. The main covered topics are data structures, operators and control structures, functions, I/O operations, object-oriented programming and several advanced libraries for tasks such as data analysis. The course is designed for students with little or no programming background.</td></tr>
<tr><td>Objectives</td><td colspan="4">Students acquire basic knowledge of Python syntax. They develop an understanding of data structures, operators, and control structures in Python.
Students gain the ability to create and use functions in Python and gain knowledge of input and output operations in Python. They develop an understanding of object-oriented programming in Python and gain skills in using advanced libraries for tasks such as data analysis, as well as programming independently in Python to become a proficient Python programmer.</td></tr>
<tr><td rowspan="2">Requirements for credit points / exams and grading scheme (where appropriate, weighting)</td><td>course</td><td>exam</td><td>Grading scheme</td><td>weighting</td></tr>
<tr><td>seminar</td><td>Written examination</td><td>1-5</td><td>6 ECTS</td></tr>
<tr><td>Applicability</td><td colspan="4">This module is a compulsory module in the Master's program Strahlenwissenschaften/Medical Radiation Sciences, profile area "Artificial Intelligence in Med. Radiation Sciences" and an elective course for Biomedical Technologies M.Sc.</td></tr>
<tr><td>Recommended semester</td><td colspan="4">1st semester</td></tr>
<tr><td>Participation requirements</td><td colspan="4"></td></tr>
<tr><td>Person responsible</td><td colspan="4">tba</td></tr>
<tr><td>Literature/Teaching materials</td><td colspan="4">tba</td></tr>
</table>

Number: E 17	**Title:** ***Biostatistics of Clinical Studies***			**Nature:** Elective course
Credit points	3 CP			
Work load **- contact hours (SWS)** **- self study**	Total: 90 h contact hours: 45 h self-study (preparation for exams included): 90hours			
Duration	One-Week Block Course			
Time schedule	Annual			
Language	English			
Number of participants	Lecture: no limit Tutorial: max. 28 participants			
Structure/ Teaching methods	Lecture 1 (2 SWS), Tutorial (1 SWS) (elective, English) 3 ECTS			
Contents	• Statistical methods for clinicial studies • sample size estimation • sequential and adaptive designs • diagnostic studies • studies with censored data			
Objectives	The students can develop statistical modelling and analysis of experiments, interventional and observational clinical studies and of epidemiological studies. They can interpret the results. The students have knowledge of statistical analysis (descriptive, confirmatory, regression, multivariate) and they can decide which method is the most adequate in a specific study.			
Requirements for credit points / exams and grading scheme (where appropriate, weighting)	Course	Assessment	Grading Scheme	Weighting
	Tutorial	Daily Exercise Sheets	Passed or failed	3 ECTS
Applicability	M.Sc Biomedical Technology and M.Sc Medizinische Strahlenwissenschaften			
Recommended semester	1st / 2nd Semester			
Participation requirements				
Person responsible	Martus, Peter, Prof. Dr. rer. nat. Peter.martus@med.uni-tuebingen.de			
Literature/ Teaching materials	To be announced at the beginning of the term			

Number: MT	**Title:** *Master Thesis*			**Nature:** compulsory
Credit points	30 CP			
Work load **- contact hours (SWS)** **- self study**	Total: 900 h contact hours: 600 h self-study: 300 h			
Duration	6 months			
Frequency of the offer	each semester			
Language of instruction	English			
Number of participants	maximal 24			
Teaching methods	seminar (3 SWS), practical work (40 SWS)			
Content	depending on the project			
Qualification goals	Students are able to study published data to get insight a research field At the end of the master thesis the students should be able to develop an own research project idea and design and perform the appropriate experiments with help of published data. They understand the general flow from the idea of an experiment via the experimental design and methodology to interpretation of the results taking sufficient and appropriate controls and published data into account They have expertise in documentation, oral and written presentation of experimental data			
Requirements for credit points / exams and grading scheme (where appropriate, weighting)	course	assessment	Grading scheme	weighting
	Master Thesis	- oral presentation - written thesis	1-5 1-5	20% 80%
Usability	M.Sc. in Biomedical Technologies			
Recommended semester	4th semester			
Prerequisite to attend the activities	Successful completion of two Specializations.			
Person responsible	The head of the examination committee			
Teacher	Various teachers of the faculty of Medicine, faculty of Science and Biomedical Technologies Industry			
Literature/Teaching materials	will be provided by the supervisor before start of master thesis			