OTTO-VON-GUERICKE-UNIVERSITÄT MAGDEBURG

Fakultät für Maschinenbau

Modulhandbuch
für den
Masterstudiengang

Biomechanical Engineering

M-BiME

zur studiengangspezifischen
Studien- und Prüfungsordnung vom 02.03.2022

(Datum des Fakultätsratsbeschlusses)

Version: 01.10.2022

Inhaltsverzeichnis | Table of contents

1 Kurzbeschreibung des Studiengangs | Description of the study program

Name des Studiengangs:	Biomechanical Engineering	**Name of the Study program:**	Biomechanical Engineering
Art des Studiengangs:	Präsenzstudiengang (Vollzeitstudium)	**Type of Course of studies:**	Attendance course of studies (full-time study)
Abschluss:	Master of Science (M. Sc.)	**Degree:**	Master of Science (M. Sc.)
Umfang:	4 Semester	**Duration:**	4 semesters
Profil:	„stärker forschungsorientiert“	**Profile:**	„more research-oriented“

Ausbildungsergebnisse
(Fachliche Kompetenzen):

Der Masterstudiengang „Biomechanical Engineering“ ist forschungs- und methodenorientiert und fokussiert nach einem medizintechnisch orientierten oder ingenieurwissenschaftlichen Bachelorstudium inhaltlich auf die Entwicklung medizintechnischer Produkte mit der Anwendung im oder am Menschen und geht qualitativ deutlich über die Ausbildungsziele des jeweiligen Vorstudiums hinaus.

Durch sein curriculares Angebot können spezifische und Schnittstellen-Kompetenzen in den Bereichen Konstruktion und Materialwissenschaft sowie Medizin und Produktrecht herausgebildet werden, wobei die ingenieurorientierte Lösung innerhalb einer starken interdisziplinären Ausrichtung im Mittelpunkt steht. Das Studium befähigt die Studierenden, die im Studium erworbenen Kenntnisse und Fähigkeiten in theoretischen und anwendungsbezogenen Problemstellungen selbstständig, ganzheitlich und lösungsorientiert sowie interdisziplinär zu bearbeiten und in der beruflichen Praxis sowie in der weiterführenden Forschung anzuwenden. Zudem sollen die Absolventinnen und Absolventen über die allgemein zu erreichenden Ziele des Masterstudiums hinaus befähigt werden, sich in vielfältige Aufgaben einzuarbeiten, Probleme zu identifizieren und zu lösen sowie für ein technisch orientiertes, verantwortungsbewusstes Arbeiten sensibilisiert werden.

Educational Results
(professional competences):

The master degree program "Biomechanical Engineering" is research- and method-oriented and focuses on the development of medical-technical products with applications in or on humans after receiving a medical-technical or engineering bachelor's degree. It clearly deepens and intensifies the educational aims of the respective pre-studies.

By its curriculum, specific and interface competences can be developed in the areas of design and materials science as well as medicine and product law, focusing on engineering-oriented solutions within a strong interdisciplinary orientation. The program enables students to apply the knowledge and skills acquired in the course of study to theoretical and application-related problems independently, holistically and in a solution-oriented and interdisciplinary manner, and to apply them in professional practice as well as in further research. In addition, the graduates should be enabled, beyond the general aims of the master's program, to familiarize themselves with a variety of tasks, to identify and solve problems, and to be sensitized to technically oriented, responsible work.

The aim is to develop professional and methodological competences that enable a holistic view of biomedical-technical contexts based on a substantial basic knowledge and ensure that new and in-depth knowledge can be acquired quickly in the

Ziel ist es, fachliche und methodische Kompetenzen herauszubilden, die eine ganzheitliche Betrachtung von biomedizinisch-technischen Zusammenhängen basierend auf einem fundierten grundlagenorientierten Wissen ermöglichen und im Zuge eines lebenslangen Lernens gewährleisten, sich schnell neue, als auch vertiefende Kenntnisse anzueignen. In dem 4-semestrigen Masterstudiengang erwerben die Absolventen und Absolventinnen neben biomechanischen und medizintechnischen auch soziale und rechtliche Kenntnisse und bilden Kompetenzen heraus, die sie befähigen,

- über Inhalte und Probleme von biomechanischen Medizinprodukten und deren angrenzenden Disziplinen mit Fachleuten zu kommunizieren,
- Projekte durchzuführen,
- einzeln und integriert als Mitglied internationaler Gruppen zu arbeiten,
- Führungsverantwortung zu übernehmen sowie
- engagiert, zielorientiert, aufgabenbezogen und lernbereit in verschiedenen Berufsfeldern zu agieren.

Die Studierenden erlangen die Fähigkeiten, auf ihrem Fachgebiet Meinungen kritisch zu hinterfragen, anstehende Probleme wissenschaftlich strukturiert unter Berücksichtigung angrenzender Fachdisziplinen zu lösen und ihre erarbeitete Lösung vor Fachkollegen und Laien zu vertreten bzw. ihr Wissen zu vermitteln. Sie sind dazu in der Lage, ihr Fachgebiet über den aktuellen Stand der Technik hinaus kreativ weiterzuentwickeln. Auch auf der Grundlage begrenzter Informationen können die Absolventen und Absolventinnen wissenschaftlich fundierte Entscheidungen treffen und dabei gesellschaftliche und ethische Erkenntnisse berücksichtigen.

Absolventinnen und Absolventen sind qualifiziert, Problemlösungsstrategien anzuwenden, um Anforderungen des jeweiligen biomechanischen Medizinproduktbereichs abzuleiten und systematisch Lösungen zu erarbeiten.

course of lifelong learning. In the master degree program with a duration of 4 semesters, graduates acquire not only biomechanical and medical-technical knowledge, but also social and legal knowledge, and develop competences that enable them to:

- communicate with experts about the contents and problems of biomechanical medical devices and their related disciplines,
- carry out projects,
- work individually and in an integrated manner as a member of international groups,
- assume leadership responsibility and
- be committed, goal-oriented, task-oriented and willing to learn in various professional fields.

The students acquire skills to critically question opinions in their field of expertise, to solve upcoming problems in a scientifically structured manner, taking into account related disciplines, and to present their solutions to colleagues and laypersons or to communicate their knowledge. They are able to creatively develop their field of expertise beyond the current state of the art. Even on the basis of limited information, graduates are able to make scientifically substantiated decisions, taking social and ethical findings into account.

Graduates are qualified to apply problem-solving strategies to derive requirements of the respective biomechanical medical device field and to develop systemic solutions.

Ausbildungsergebnisse
(Soziale Kompetenzen):

Im Studienverlauf erhalten die Studierenden über Qualifizierungsarbeiten und ein interdisziplinäres Teamprojekt Zugang zu den vorhandenen Forschungsschwerpunkten.

Die Studierenden werden entsprechend qualifiziert, um nach dem Abschluss des Masterstudiums unterschiedliche Karrierewege einschlagen zu können:

- Einerseits soll durch die Teilhabe der Studierenden an wissenschaftlichen forschungsprojektbezogenen Arbeiten eine Qualifizierung im Bereich der Forschung und Entwicklung, aber auch im Bereich der Wissenschaft erreicht werden.
- Durch die größtenteils studierenden-individuelle Gestaltung des Studienprogramms auf Basis der beiden Vertiefungsrichtungen Exoprothetik (am Körper) und Endoprothetik (im Körper) werden andererseits Ingenieure und Ingenieurinnen für die Tätigkeit in der freien Wirtschaft ausgebildet.

Im Spannungsfeld des demografischen Wandels mit neuen veränderten Anforderungen wie z.B. Autonomie und Mobilität im Alter und der regenerativen Medizin stehen den Absolventen und Absolventinnen des Masterstudiengangs Biomechanical Engineering besonders aktuelle und nachgefragte Berufsfelder mit hervorragenden Zukunftsperspektiven zur Auswahl.

Die Absolventen und Absolventinnen sind befähigt, einerseits leitende und selbständige Tätigkeiten in der Industrie (z.B. folgende Branchen: Medizintechnik, insbesondere Entwicklung, Herstellung und Vertrieb von Medizinprodukten und deren Zuliefer- und Produktionsketten, Zertifizierungsstellen und -behörden, Patentbehörden etc.) sowohl in Anwendung und Dienstleistung als auch in der Forschung auszufüllen. Andererseits sind entsprechende Tätigkeiten in Wissenschaft und Bildungswesen möglich.

Die akademische Ausbildung mit dem Abschluss M.Sc. der Otto-von-Guericke-Universität liefert eine hinreichende Voraussetzung für weitere postgraduale Ausbildungen im Bereich der Ingenieurwissenschaften und angrenzenden Gebieten. (zum Beispiel Promotion).

Educational Results
(social competences):

In the course of their studies, students gain access to existing research foci by an interdisciplinary team project and qualifying papers.

The students are qualified accordingly in order to be able to follow different professional paths after completing the master degree program:

- By the participation of students in scientific research project-related work, a qualification in the field of research and development, but also in the field of science is to be achieved on the one hand
- By the predominantly student-individual design of the study program based on the two specializations exoprosthetics (on the body) and endoprosthetics (in the body), engineers are trained for work in the private sector on the other hand.

With respect to the demographic change and new rising challenges such as autonomy and mobility in senior life and regenerative medicine, graduates of the master degree program Biomechanical Engineering are offered wide occupational fields of recent and popular jobs with great potential.
Graduates are qualified to take on managerial and independent positions in industry (e.g. the following sectors: medical technology, especially development, production and distribution of medical products and their supply and production chains, certification bodies and authorities, patent authorities, etc.) both in application and service as well as in research. On the other hand, corresponding activities in science and education are possible.
The academic education with the degree M.Sc. of the Otto-von-Guericke University provides a sufficient prerequisite for further postgraduate education in the field of engineering and related fields, e.g. doctorate.

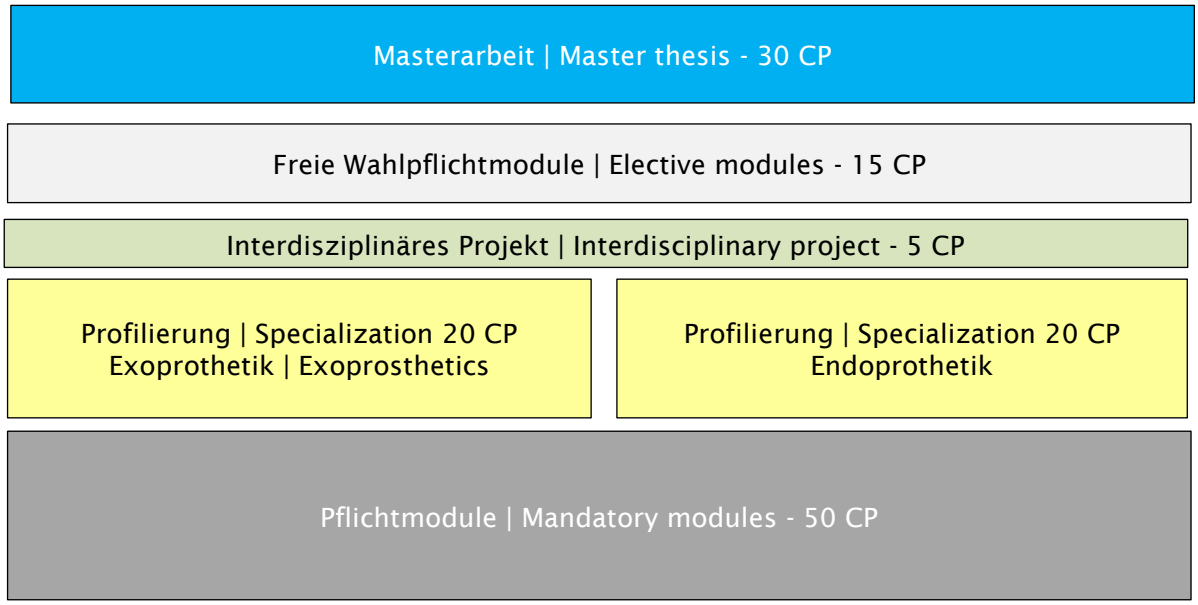
Kurzcharakteristik

Die Immatrikulation erfolgt zum Wintersemester. Der Masterstudiengang ist so konzipiert, dass das Studium einschließlich der Anfertigung der Masterarbeit mit Kolloquium in der Regelstudienzeit von vier Semestern abgeschlossen werden kann.

Der Studienaufwand wird mit Leistungspunkten (Creditpoints [CP]) beschrieben. Er beträgt insgesamt 120 CP, die sich auf den Pflicht-, Spezialisierung- und Wahlpflichtbereich sowie die Masterarbeit verteilen.
Das Arbeitspensum beträgt ca. 30 CP pro Semester.

Brief Description

Enrollment takes place in the winter semester. The master degree program is designed in such a way that the course of study, including the preparation of the master thesis with colloquium, can be completed in the standard period of study of four semesters.
The study effort is described with credit points (CP). It amounts to a total of 120 CP, which are distributed among the mandatory, specialization and elective areas as well as the master thesis.
The workload is approximately 30 CP per semester.



Prinzipieller Aufbau des Master Biomechanical Engineering
General structure of the master degree program Biomechanical Engineering

Die Abbildung zeigt schematisch den prinzipiellen Aufbau des Masters Biomechanical Engineering, bestehend aus:

- einem Pflichtbereich mit 6 Modulen zu je 5 CP
- der studierendenindividuellen Wahl einer der Profilierungen mit je 4 Modulen zu je 5 CP,
- einem interdisziplinären Projekt zu 5 CP,
- drei freien Wahlpflichtmodulen zu je 5 CP, aus dem dafür verfügbaren breiten Modulangebot
- und der abschließenden Masterarbeit.

Der Profilierungsbereich und der freie Wahlpflichtbereich ermöglichen den Studierenden, individuellen Neigungen und Interessen nachzugehen bzw. fachspezifischen Erfordernissen

The figure shows the schematic structure of the master degree program Biomechanical Engineering, consisting of:

- a mandatory area with 6 modules of 5 CP each
- the student-individual choice of one of the specializations with 4 modules of 5 CP each,
- one interdisciplinary project of 5 CP,
- three elective modules of 5 CP each, from the broad range of modules available for this purpose,
- and the final master thesis.

The specialization area and the elective area enable the students to pursue individual inclinations and interests or to take into account subject-specific requirements of the later field of activity. The mandatory and elective

des späteren Tätigkeitsfeldes Rechnung zu tragen. Der Pflicht- und Wahlpflichtbereich verteilt sich auf die ersten drei Semester. Das interdisziplinäre Projekt ist als interdisziplinäres Projekt konzipiert und wird empfohlen, im 3. Semester anzuordnen.

Das Studium schließt mit einer Abschlussarbeit, der so genannten Masterarbeit und deren Präsentation in einem Kolloquium ab. Die Abschlussarbeit soll zeigen, dass die Studierenden in der Lage sind, innerhalb einer vorgegebenen Bearbeitungszeit eine Problemstellung selbständig, wissenschaftlich und kompetent zu bearbeiten.

areas are distributed over the first three semesters. The interdisciplinary project is designed as an interdisciplinary project and is recommended to be arranged within the 3rd semester.

The program concludes with a final thesis, the master thesis, and its presentation in a scientific colloquium. The thesis should show that the students are able to work on a problem independently, scientifically and professionally within a given period of time.

2 Geltung des Modulhandbuchs | Validity of the module handbook

Das vorliegende Modulhandbuch gilt für Studierende, deren Studium sich nach der Studien- und Prüfungsordnung für den Masterstudiengang Biomechanical Engineering vom 02.03.2022 (Datum der Fakultätsratsbeschlusses) richtet.

This module handbook applies to students whose studies are based on the study and examination regulations for the master degree program in Biomechanical Engineering dated 02.03.2022 (date of the decision of the Faculty Council).

3 Pflichtbereich | Mandatory area

Die Module des Pflichtbereichs spannen den weiten Bogen und den Facettenreichtum des Biomechanical Engineering auf und bilden den Rahmen für die möglichen Spezialisierungen. Die Module liegen in den ersten 3 Semestern des Fachstudiums und sind von allen Studierenden zu absolvieren.

The modules of the mandatory area cover the broad spectrum and the many facets of biomechanical engineering and provide the context for the possible specializations. The modules are situated in the first 3 semesters of the study program and have to be completed by all students.

Regelstudienplan allgemein | General study plan

Masterstudiengang | Master degree program Biomechanical Engineering		CP	V|Ü|P [SWS]	1. Sem WiSe	2. Sem SoSe	3. Sem WiSe	4. Sem SoSe
Pflichtbereich | Mandatory area							
Anatomy for Engineering Students		5	0|3|–	R			
Biomechanical Sensors		5	2|2|–	K120			
Orthopedic Technology		5	2|2|–	K120			
Applied Biomechanics		5	2|2|–	K120			
Additive Manufacturing (in Medical Engineering)		5	2|1|–	K120			
Biomedical Materials		5 5	2|1|– 2|1|–		 K120		
Clinical Biomechanics		5	2|1|–		K120		
Medical Device Regulation and Ethics in Medicine		5 5	2|1|– 2|1|–		K90	 K90	
Profilierungsbereich | Specialization area							
Specialization Exoprosthetics	Modul 1	5			P		
	Modul 2	5			P		
	Modul 3	5				P	
	Modul 4	5				P	
Specialization Endoprosthetics	Modul 1	5			P		
	Modul 2	5			P		
	Modul 3	5				P	
	Modul 4	5				P	
Wahlpflichtbereich | Elective area							
Modul 1		5			P		
Modul 2		5				P	
Modul 3		5				P	
Projektbereich | Project area							
Interdisciplinary Project		5	–|3|–			W	
Masterarbeit mit Kolloquium | Master thesis with colloquium		30					W
Summe in CP je Semester | Total in CP per semester				30	30	30	30

Legende Prüfungsformen | Legend Forms of examination:

K – Klausur (angegebene Dauer in Minuten) | written exam (duration in minutes),

R – Referat | oral presentation,

W – Wissenschaftliches Projekt | scientific project

V|Ü|P Lecture|Exercise|Practical course

4 Profilierung / Spezialisierung | Profiling / Specialization

4.1 Profilierung Exoprothetik | Specialization Exoprosthetics

Die Exoprothetik beschäftigt sich mit medizinische Assistenzsysteme, also Unterstützungsprodukten am Körper. Dazu zählen neben orthopädischen Hilfsmitteln, die als Körperersatzstücke fungieren, auch am menschlichen Körper getragene mechanische Strukturen, sogenannte Orthesen, die die Bewegungen des Trägers unterstützen, verstärken oder erleichtern können. Der Ersatz von Gliedmaßen mit einer vollständigen oder teilweisen Wiederherstellung der ursprünglichen Funktionalitäten wie z.B. künstliche Hände mit nahezu vollständiger mechanischer Funktionalität oder Unterschenkelprothesen im Leistungssport, sind ebenfalls Bestandteile der Exoprothetik.

Studierende, die sich im Studiengang Biomechanical Engineering in Richtung der Exoprothetik spezialisieren, können unter anderem folgende Kompetenzen erlangen:

- vertiefende Kenntnis biomechanischer Bewegungsabläufe sowie deren Analyse und Modellierung/ Simulation
- Fähigkeit zur Ableitung von Voraussetzungen, Randbedingungen und Anforderungen, welche Exoprothesen im Anwendungsfall erfüllen müssen und Übertragung dieser in einen Produktentwicklungsprozess
- Konzipierung, Auslegung/Dimensionierung und Gestaltung von anforderungsgerechten medizinischen Assistenzsystemen unter Berücksichtigung aller zusammentreffenden Komponenten (biologisch, mechanisch, medizinisch, elektronisch, …)

Mit diesen Kompetenzen können die Absolventen und Absolventinnen im Berufsleben in Branchen der Medizintechnik und Ingenieurwissenschaften darunter insbesondere in Bereichen der Entwicklung, Herstellung und dem Vertrieb und Zertifizierung von Medizinprodukten anspruchsvolle und vielseitige Tätigkeiten ausüben.

Die wesentlichen Einsatzmöglichkeiten liegen in den Aufgabenbereichen Forschung, Vorentwicklung, Entwicklung, Versuch, Projektierung, Konstruktion, Inbetriebnahme, Service und Berechnung und Auslegung von medizinischen

The specialization in Exoprosthetics deals with medical assistance systems, i.e. supportive products for the human body. In addition to orthopedic aids that function as body substitutes, this also includes mechanical structures worn on the human body, so-called orthoses, which can support, reinforce or facilitate the movements of the person wearing them. The replacement of limbs with a complete or partial restoration of the original functionality, such as artificial hands with almost complete mechanical functionality or lower leg prostheses in competitive sports, are also part of exoprosthetics.

Students of the master program Biomechanical Engineering that specialize in Exoprosthetics can acquire the following competences, among others:

- in-depth knowledge of biomechanical movement processes and their analysis and modeling/ simulation
- skills to derive prerequisites, boundary conditions and requirements that exoprostheses must fulfill in the application and transfer these to a product development process
- Conceptualization, layout/dimensioning and design of medical assistance systems according to requirements considering all coinciding components and interfaces involved (biological, mechanical, medical, electronic, ...).

With these competences, the graduates will be able to perform challenging and versatile tasks and activities in their professional careers in the field of medical technology and engineering sectors, including in particular the areas of development, manufacturing, sales and quality management, such as certification of medical devices.
Main employment opportunities comprise the working fields of research, pre-development, development, testing, project planning, construction, commission, service, simulation and design of medical assistance systems. In addition to many employment opportunities in industry, interesting fields of activity can also be found at service providers, such as TÜV or other testing

Assistenzsystemen. Neben den vielfältigen Beschäftigungsmöglichkeiten in der Industrie sind auch bei Dienstleistern, wie z.B. TÜV oder anderen Prüfinstituten und Behörden und bei öffentlichen Forschungseinrichtungen (z.B. Fraunhofer- und Max-Planck-Institute) und Hochschulen interessante Tätigkeitsfelder zu finden.

institutes and authorities, and at public research institutions (e.g. Fraunhofer and Max Planck Institutes) and universities.

Moduleinordnung in den Studienablauf in der Profilierung „Exoprothetik“ |
Module integration into the course of study within the "Exoprosthetics" specialization

Masterstudiengang | Master degree program Biomechanical Engineering		CP	V|Ü|P [SWS]	1. Sem	2. Sem	3. Sem	4. Sem
				WiSe	SoSe	WiSe	SoSe
Pflichtbereich | Mandatory area							
Anatomy for Engineering Students		5	0|3|–	R			
Biomechanical Sensors		5	2|2|–	K120			
Orthopedic Technology		5	2|2|–	K120			
Applied Biomechanics		5	2|2|–	K120			
Additive Manufacturing (in Medical Engineering)		5	2|1|–	K120			
Biomedical Materials		5 5	2|1|– 2|1|–		 K120		
Clinical Biomechanics		5	2|1|–		K120		
Medical Device Regulation and Ethics in Medicine		5 5	2|1|– 2|1|–		K90	 K90	
Profilierungsbereich | Specialization area							
Specialization Exoprosthetics	Design of Mechatronic Systems	5	–|3|–		K90		
	Dynamics of Motion	5	2|2|–		K120		
	Motion Analysis	5	2|1|–			K120	
	Product Design and Drafting	5	2|2|–			K120	
Wahlpflichtbereich | Elective area							
Modul 1		5			P		
Modul 2		5				P	
Modul 3		5				P	
Projektbereich | Project area							
Interdisciplinary Project		5	–|3|–			W	
Masterarbeit mit Kolloquium | Master thesis with colloquium		30					W
Summe in CP je Semester | Total in CP per semester				30	30	30	30

Legende Prüfungsformen | Legend Forms of examination:

K – Klausur (angegebene Dauer in Minuten) | written exam (duration in minutes),

R – Referat | oral presentation,

W – Wissenschaftliches Projekt | scientific project

V|Ü|P Lecture|Exercise|Practical course

4.2 Profilierung Endoprothetik | Specialization Endoprosthetics

Die Endoprothetik beschäftigt sich mit verschiedenen Formen von Implantaten, d. h. Medizinprodukten, welche möglichst dauerhaft im Körper verbleiben und die Funktion der zu ersetzenden Komponente (Gelenk) vollständig übernehmen oder unterstützen. Dazu zählen insbesondere künstliche Knie-, Schulter- und Hüftendoprothesen.

Studierende, die sich im Studiengang Biomechanical Engineering in Richtung der Endoprothetik spezialisieren, können unter anderem folgende Kompetenzen erlangen:

- vertiefende Kenntnisse über positive und negative Wechselwirkungen zwischen Implantaten, insbesondere der verschiedenen Werkstoffe, und menschlichem Gewebe
- Verständnis der im Körper ablaufenden chemischen bzw. biologischen Reaktionen, welche bei Nutzung von Implantaten eine wichtige Bedeutung haben
- Erlernung der Fähigkeiten zur Auslegung, Auswahl und Überwachung (mit bildgebenden Verfahren) von anforderungsgerechten Implantaten

Mit diesen Kompetenzen können die Absolventen und Absolventinnen im Berufsleben in Branchen der Medizintechnik und Ingenieurwissenschaften darunter insbesondere in Bereichen der Entwicklung, Herstellung und Optimierung von Implantaten anspruchsvolle und vielseitige Tätigkeiten ausüben.

Die wesentlichen Einsatzmöglichkeiten liegen in den Aufgabenbereichen Forschung, Vorentwicklung, Entwicklung, Versuch, Projektierung, Konstruktion, Inbetriebnahme, Service und Berechnung, Auslegung und Überwachung von Medizinprodukten für den Gebrauch im menschlichen Körper. Neben den vielfältigen Beschäftigungsmöglichkeiten in der Industrie sind auch bei Dienstleistern, wie z.B. TÜV oder anderen staatlichen und unabhängigen Prüfinstituten, in Zertifizierungs- und Zulassungsbehörden und bei öffentlichen Forschungseinrichtungen (z.B. Fraunhofer- und Max-Planck-Institute) und Hochschulen interessante Tätigkeitsfelder zu finden, worunter auch gutachterliche Tätigkeiten im freiberuflichen oder Angestellten-verhältnis fallen.

Endoprosthetics deals with various forms of implants, which are medical devices that remain in the body as permanently as possible and completely take over or support the function of the component (joint) to be replaced. These include in particular artificial knee, shoulder and hip endoprostheses.

Students of the master program Biomechanical Engineering that specialize in Endoprosthetics can acquire the following competences, among others:

- in-depth knowledge of positive and negative interactions between implants, especially the various materials, and human tissue
- Understanding of the chemical and biological reaction and processes place in the human body, which are relevant for the application of implants
- Learn the skills to design, select and monitor (with imaging techniques) implants that meet the requirements

With these competences, the graduates will be able to perform demanding and versatile activities in their professional life in the medical technology and engineering sectors, especially in the areas of development, production and optimization of implants.

Main employment opportunities comprise the working fields of research, pre-development, development, testing, project planning, construction, commission, service, simulation, quality management/ monitoring of medical devices for use in the human body.

In addition to the wide range of employment opportunities in industry, interesting fields of activity can also be found at service providers, such as TÜV or other state and independent testing institutes, in certification and licensing authorities and at public research institutes (e.g. Fraunhofer and Max Planck Institutes) and universities, which also include expert activities on a freelance or salaried basis.

Moduleinordnung in den Studienablauf in der Profilierung „Endoprothetik“ |
Module integration into the course of study within the "Endoprosthetics" specialization

Masterstudiengang | Master degree program Biomechanical Engineering		CP	V|Ü|P [SWS]	1. Sem	2. Sem	3. Sem	4. Sem
				WiSe	SoSe	WiSe	SoSe
Pflichtbereich | Mandatory area							
Anatomy for Engineering Students		5	0|3|–	R			
Biomechanical Sensors		5	2|2|–	K120			
Orthopedic Technology		5	2|2|–	K120			
Applied Biomechanics		5	2|2|–	K120			
Additive Manufacturing (in Medical Engineering)		5	2|1|–	K120			
Biomedical Materials		5 5	2|1|– 2|1|–		 K120		
Clinical Biomechanics		5	2|1|–		K120		
Medical Device Regulation and Ethics in Medicine		5 5	2|1|– 2|1|–		K90	 K90	
Profilierungsbereich | Specialization area							
Specialization Endoprosthetics	Biotribological Systems	5	2|–|–		K90		
	Imaging and Visualization in Biomedical Engineering	5	2|1|–		K120		
	Biochemistry/Biomedicine	5	2|1|–			K120	
	Introduction in Tissue Engi-neering	5	2|2|–			K90	
Wahlpflichtbereich | Elective area							
Modul 1		5			P		
Modul 2		5				P	
Modul 3		5				P	
Projektbereich | Project area							
Interdisciplinary Project		5	–|3|–			W	
Masterarbeit mit Kolloquium | Master thesis with colloquium		30					W
Summe in CP je Semester | Total in CP per semester				30	30	30	30

Legende Prüfungsformen | Legend Forms of examination:

K – Klausur (angegebene Dauer in Minuten) | written exam (duration in minutes),

R – Referat | oral presentation,

W – Wissenschaftliches Projekt | scientific project

V|Ü|P Lecture|Exercise|Practical course

5 Freier Wahlpflichtbereich | Elective area

Der freie Wahlpflichtbereich ermöglicht es den Studierenden, individuellen Neigungen und Interessen nachzugehen bzw. fachspezifischen Erfordernissen des späteren Tätigkeitsfeldes Rechnung zu tragen. Im freien Wahlpflichtbereich sind Module im Umfang von mindestens 15 CP aus dem Modulangebot der nicht gewählten Spezialisierung bzw. aus der nachstehenden Auflistung zu belegen und zur Notenberechnung einzubringen.

The elective area enables students to pursue individual inclinations and interests or to take into account subject-specific requirements of the later field of activity. In the elective area, modules with an amount of at least 15 CP from the range of modules of the non-selected specialization or from the following list must be passed and included in the grade calculation.

Liste von weiteren freien Wahlpflichtmodulen | List of possible elective courses

		winter semester				Summer semester			
Categories	**CP**	V	Ü	P	PL	V	Ü	P	PL
Applied Engineering Design	5	2	2		K120				
Computational Biomechanics	5	2	2		K90				
Microscopic Methods	5					2		1	K120
Introduction Medical Science in Space	5					2	2		K90
Dental Implants and Technologies	*5*								
Immunology	*5*								
Perfusion and Cardiac Engineering	*5*								
Marketing Methods and Analysis	*5*								
History of Medicine	*5*								
Bionics	*5*								
Business Decision Making	*5*								

Kursiv-gestellte Module = angedacht

V Lecture
Ü Exercise
P Practical course
PL Forms of examination

6 Modulbeschreibungen | Module descriptions

6.1 Additive Manufacturing in Medical Engineering

Course name	Additive Manufacturing in Medical Engineering
German title	Additive Fertigung in der Medizintechnik
Teaching aims and content of the module	Teaching aims and competences to be gained: • Learn the fundamentals of Additive manufacturing of polymers, metals, and ceramics, along with those for emerging materials (e.g., nanocomposites, biomaterials) and complex architectures. • Understand the operating principles, capabilities, and limitations of state-of-the-art AM methods, including Fused Deposition Modeling, Stereolithography, Laser Sintering/Melting, Jetting, Hybrid, a.o. • Become familiar with the complete workflow of AM, including computational design tools, file formats, toolpath generation, scanning, and microstructure characterization. • Understand key design rules for parts made by AM, and compare and contrast AM processes with conventional manufacturing methods such as machining and molding in terms of rate, quality, cost, and flexibility. • Be able to identify unique requirements within the entire design-to- manufacture process and select the best AM technology and optimize its benefits. • Preserve an understanding of current methods of nondestructive inspection/testing (NDI/NDT) and AM-Standards. • Gain hands-on experience with a variety of AM machines; use these machines to fabricate example parts, post-process the parts, and study the results. • Study applications of AM across industries, including aerospace/auto- motive, biomedical devices, energy, electronics, and consumer products.

	Contents:
	• Introduction and fundamentals of Additive Manufacturing (AM)
	• AM processes & technologies, variability of materials, capabilities & limitations
	• Materials: polymers, fiber-reinforced composites, metals, ceramics, nanocomposites, biomaterials, etc.
	• Design-to-Manufacture processes and capabilities: AM-Prototyping, AM-Tooling, AM-Manufacturing, Pre-/Post-Processing
	• Applications in aerospace, automotive, biomedical, electronics, and consumer products
	• Design for AM and optimization strategies with AM
	• Workflow of pre-processing for AM:
	  ○ 3D CAD software and computational design tools
	  ○ Lattice structure design software
	  ○ Topology optimization software
	  ○ 3D Scanning and Reverse Engineering
	  ○ File formats for AM: STEP, IGES, STL, AMF, etc.
	  ○ G-code/toolpath generation, etc.
	  ○ Microstructure characterization
	• Workflow of post-processing for AM:
	  ○ Part cleaning and surface finish/sanding/waxing
	  ○ Surface coating and painting
	  ○ Preparation for tooling, etc.
	• Nondestructive Inspection/Testing (NDI/NDT) and Standards
	• AM Processes combined with conventional manufacturing methods such as

	machining, molding, tooling, etc. • AM Economics: comparison of AM processes with conventional manufacturing methods in terms of rate, quality, cost, flexibility, etc. • Supply Chain Benefits: Reduction of storage space and costs, etc. • Future trends
Type of lecture	Lectures; Seminars
Literature	Gibson, Ian; Rosen, David; Stucker, Brent: Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Second Edition. p 1-498, January 1, 2015. Publisher: Springer New York. ISBN-13: 9781493921126; DOI: 10.1007/978-1-4939-2113-3
Preconditions for attending	none
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Advanced provisions: Exercise credits Examination: Written Exam (120 min) K120
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	2 hours per week lecture, 1 hour per week exercises, 119 hours self-study
Frequency of provision	Every winter term
Duration of module	1 semester
Responsible lecturer	Prof. Dr.-Ing. Christiane Beyer, FMB-IMK

6.2 Anatomy for Engineering Students*

Course name	Anatomy for Engineering Students
German title	Grundlagen der Anatomie und Physiologie
Teaching aims and content of the module	Teaching aims and competences to be gained: - Students acquire basic knowledge of anatomy and physiology of the central and peripheral nervous system - Students acquire basic knowledge of anatomy and physiology of the locomotion system - Students acquire basic knowledge of anatomy and physiology of the cardio-vascular system - Students apply knowledge on biomechanical properties of the structures/ organs discussed in a problem-based approach - Students apply knowledge on consequences and requirements for medical devices and implants in a problem-based approach
	Contents: - Microscopic and macroscopic structures and functions of human nervous system, musculoskeletal system and cardiovascular system - Literature search on biomechanical properties and functionality of the discussed structures, and application in biomedical engineering - coursework, e.g., on properties of skeletal and smooth muscles, properties of joint structures (bone, tendon, cartilage), proprioception, movement regulation
Type of lecture	Seminar
Literature	Anatomy and Physiology books and atlases, original research articles, reviews, PubMed, open E-learning source
Preconditions for attending	None
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Examination: 50% marked coursework 50% marked multiple-choice exam
ECTS and marks	5 CP Grading according to the study and examination regulations
Efforts	3 hours per week seminar
Frequency of provision	Every winter term
Duration of module	1 semester
Responsible lecturer	Prof. Dr. med. Friedemann Awiszus, FME Orthopädische Universitätsklinik Magdeburg

*) The module will be mentioned in the planning of the lectures as “Anatomy for Engineering Students (BiMe)”

6.3 Applied Biomechanics

Course name	Applied Biomechanics
German title	Angewandte Biomechanik (?)
Teaching aims and content of the module	- Detailed knowledge concerning deformation mechanisms in solid materials - Understanding to formulate concrete boundary and initial value problems out of continuum mechanics - Detailed knowledge concerning kinematics and kinetics of motion - Knowledge concerning different solution methods for static and dynamical systems - Comprehensive understanding concerning vibration problems in biomechanical systems - Understanding of the general spatial dynamics of rigid biomechanical systems
	Contents: • Fundamentals of continuum mechanics • Fundamental balance laws • Constitutive equations for soft (e.g. tissue) and hard (e.g. bone) materials • Kinematics and kinetics of linear and angular motion • Force and energy based mechanical methods for describing dynamical systems • Basics of vibration dynamics (oscillator with 1 and 2 degrees of freedom) • Introduction of harmonic, modal and transient analyses • Coordinate systems and spatial orientation • Basics of spatial dynamics with focus on gyroscopic effects
Type of lecture	Lectures; Seminars
Literature	will be offered in the first lecture
Preconditions for attending	Recommended: Knowledge of engineering mechanics (statics, basics of strength theory and dynamics)
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Examination: Written examination K120
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	2 hours per week lecture, 2 hours per week exercises, Self-Study: Individual semester assignment that is included in the examination grade
Frequency of provision	Every winter term
Duration of module	1 semester
Responsible lecturer	Prof. Dr.-Ing. Daniel Juhre, FMB-IFME Jun.-Prof. Dr.-Ing. Elmar Woschke, FMB-IFME apl. Prof. Dr.-Ing. habil. Konstantin Naumenko, FMB-IFME

6.4 Applied Engineering Design

Course name	Applied Engineering Design
German title	Angewandte Konstruktionstechnik
Teaching aims and content of the module	Teaching aims and competences to be gained: The aim of this mandatory subject is to impart in-depth knowledge of special design issues. The lecture contents are applied and deepened in the exercises as well as through the document to be completed. This is done with the help of design tasks from the practice of Medical Engineering. Furthermore, knowledge of working in a development team is imparted. Learning objectives & competences to be acquired: • Deepening and application of design methodology • Developing the ability to apply methodical design, the basic rules of design, design principles and guidelines • Acquiring leadership and teamwork skills by working on tasks and providing evidence in teams • Applying knowledge and experience from other subject areas such as materials technology, production theory, technical mechanics, machine elements
	Contents: • Methodical design -Basic rules, design principles and guidelines • Methodical designing • Solution fields - Composite design, mechatronics, adaptronics • Building series and design kits • Methods for quality-assured product development • Cost recognition • Design exercises and a design term paper
Type of lecture	Lectures; Seminars
Literature	Engineering Design : A Systematic Approach / by Gerhard Pahl, Wolfgang Beitz, Jörg Feldhusen, Karl-Heinrich Grote ; edited by Ken Wallace, Luciienne Blessing, 3rd edition, London : Springer-Verlag London Limited, 2007. - 978-1-84628-319-2, 978-1-84628-318-5 (Druckausgabe)
Preconditions for attending	none
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Pre-examination: creating a paper Examination: Written Exam (K120) + Seminar assignment
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	2 hours per week lecture, 1 hour per week exercises, 119 hours self-study
Frequency of provision	Every winter term
Duration of module	1 semester
Responsible lecturer	Prof. Dr.-Ing. Christiane Beyer, FMB-IMK

6.5 Biochemistry/ Biomedicine

Course name	Biochemistry/ Biomedicine
German title	Biochemie/ Biomedizin
Teaching aims and content of the module	Teaching aims and competences to be gained: The aim of the module is to teach the students the basics of anatomy and physiology of the joint (bone, cartilage, muscle and ligaments). In addition, the students learn the necessary basics of biological processes of the joint cells and the extracellular matrix in order to understand the physiological processes of the healthy joint. In the further course, students are taught the pathophysiological processes of the joint (osteoarthritis, fracture healing, rheumatic diseases, osteomalacia, etc.) and the underlying mechanisms are explained based on the current state of science. Based on the understanding of the physiological processes of the healthy joint, the basics of biotribology and biomechanics are finally taught, which enables the students to evaluate the involved influencing factors of orthopaedically relevant diseases of the joint based on the basic knowledge of medicine, biology, mechanics and tribology. In the accompanying seminar, various test setups, ISO standards and basic skills for the independent development of new approaches (statistics, experimental design, influencing factors, etc.) are taught.
	Contents: Introduction to relevant biomedical cellular processes: • Cell and Metabolism: Molecular biology and biochemistry of genes, cell biology, gene regulation and metabolism. • Basics of extracellular matrix • Basics mechanosensing • Basics immunology and inflammation • Infections and pathogens
Type of lecture	Lectures; Seminars
Literature	
Preconditions for attending	none
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Written examination (K120)
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	2 hours per week lecture, 1 hours per week exercises, Self-Study
Frequency of provision	every winter term
Duration of module	1 semester
Responsible lecturer	Prof. Dr. rer.nat. Jessica Bertrand, FME-KORT Prof. Dr. rer. biol. hum. Heike Walles, FVST-ICH

6.6 Biomechanical Sensors

Course name	Biomechanical Sensors / Sensors in Biomechanics
German title	Biomechanische Sensoren
Teaching aims and content of the module	Teaching aims and competences to be gained: Sensors in biomechanics have changed and expanded the possibilities of biomechanical analysis. High-precision sensing and feedback systems are essential in medicine, sports, research, and robotics applications, and will continue to revolutionize biomechanics in the future. Increasing advances in sensor performance are leading to a steady convergence towards practical requirements. This lecture will highlight the fundamentals and advances in the development and application of biomechanical sensors at the component level and in (wearable) biomechanical systems. Students will learn the technological fundamentals of sensor systems and discuss their applicability in various application scenarios. In addition, students independently acquire an in-depth knowledge of selected biomechanical issues based on current scientific publications. After successful completion of the module, students will be able to understand and apply measurement principles with different sensors and systems. In the exercises, students are enabled to deepen their knowledge and skills, to communicate and to apply them to concrete problems.
	Contents will include: - tactile sensors - inertial measurement unit (IMU) sensors - pressure sensors - optical sensors - textile-based sensors - smartphone-based sensors for health monitoring and diagnosis
Type of lecture	Lectures; Seminars
Literature	
Preconditions for attending	none
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Attending of Exercises Examination: Written Exam (K120)
ECTS and marks	5 CP = 150 h (56 h time of attendance + 94 h autonomous work) Grading according to the examination regulations
Efforts	2 hours per week lecture, 2 hours per week exercises, Autonomous work: Post processing of lectures, reading of selected scientific papers and preparation for discussion in seminar, preparation of exam
Frequency of provision	Every winter term
Duration of module	1 semester
Responsible lecturer	Prof. Dr.-Ing. Ulrike Steinmann, FEIT-IFAT

6.7 Biomedical Materials

Course name	Biomedical Materials
German title	Werkstoffe in der Medizintechnik
Teaching aims and content of the module	Teaching aims and competences to be gained: Students will be teached an overview of technical materials that are commonly used as biomaterials as well as materials that are used for exoprosthetic applications and biomechanical applications. Theoretical basics (atomic structure, mechanical properties), Typical applications and uses in biomechanical products.
	Contents: Materials: metallic materials, glasses, ceramics, plastics. Properties: mechanical, corrosive, biocompatibility, wear, fatigue, failure.
Type of lecture	Lectures; Seminars
Literature	will be given in the first lecture
Preconditions for attending	Recommended: materials science basic knowledge
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Written examination at the end of winter term (K120)
ECTS and marks	10 CP Grading according to the examination regulations
Efforts	2 hours per week lecture, 1 hours per week exercises, Self-Study: Individual semester assignment that is included in the examination grade
Frequency of provision	Part 1: summer term, Part 2: winter term
Duration of module	2 semesters
Responsible lecturer	Prof. Dr.-Ing. habil. Thorsten Halle, FMB-IWF Additional instructors: Prof. Dr.-Ing. habil. Manja Krüger, FMB- IWF Prof. Dr. rer. nat. Michael Scheffler, FMB-IWF

6.8 Bionics in Medical Engineering

Under construction

Course name	Bionics in Medical Engineering
German title	Bionik in der Medizintechnik
Teaching aims and content of the module	Teaching aims and competences to be gained:
	Contents:
Type of lecture	Lectures; Seminars
Literature	
Preconditions for attending	
Usability of the module	according to module handbook
Prerequisites for the provi-sion of ECTS	Written examination
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	hours per week lecture, hours per week exercises, Self-Study
Frequency of provision	summer/winter term
Duration of module	1 semester
Responsible lecturer	remains to be clarified

6.9 Biotribological Systems

Course name	Biotribological Systems
German title	Biotribologische Systeme
Teaching aims and content of the module	Teaching aims and competences to be gained: • Learning the basic understanding of the biotribological systems in the human body • Learning the ability to design and optimize tribologically loaded components under the boundary conditions in the human body
	Contents: • Biotribological system • Natural joints and ligaments (function, friction, wear, damage) • Prosthesis and implants (function, friction, wear, damage) • Bio-inspired materials, coatings, surfaces and lubricants • Material interaction (surface processing and functionalization) • Test methods
Type of lecture	Lectures and project work (seminar, presentation, and documentation of the project results)
Literature	• Ostermeyer, G.-P. et al.: Multiscale Biomechanics and Tribology of inorganic and organic Systems. Springer Tracts in Mechanical Engineering, 2021 • Rao, T.V.V.L.N. et al.: Biotribology – Emerging Technologies and Applications. CRC Press, 2021 • Davim, J. P.: Biotribology. Wiley-ISTE, 2010 • Hamill, J. et al.: Biomechanical Basis of Human Movements. Wolters Kluwer | Lippincott Williams & Wilkins, 2009 • Ahmed, S.: Tribology and Characterization of Surface Coatings. John Wiley & Sons Inc., 2022 • Roy, M.: Surface Engineering for Enhanced Performance against Wear. Springer, 2013
Preconditions for attending	none
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Examination: written exam (K90)
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	2 semester hours per week lecture as well as project work, self-study (lectures and project work)
Frequency of provision	every summer term
Duration of module	1 semester
Responsible lecturer	Prof. Dr.-Ing. habil. Dirk Bartel, FMB-IMK Dr.-Ing. Joachim Döring, FME-KORT

6.10 Clinical Biomechanics

Course name	Clinical Biomechanics
German title	Klinische Biomechanik
Teaching aims and content of the module	Teaching aims and competences to be gained: Detection methods of pathophysiology, as well as treatment forms and detection methods of damage cases are taught. In the lectures, students learn about special imaging methods and their advantages and disadvantages for special applications in orthopaedics. Furthermore, different conservative forms of treatment (arthroscopy) and invasive methods (joint replacement) are explained and the technique used. The basics of cell therapy with different carrier materials and the requirements for these materials are also taught. The different types of prostheses and materials are also presented and the advantages and disadvantages of the respective design and material are explained. Finally, different types of material failure of prostheses are shown and the causes explained. In the associated seminar, different detection methods of biocompatibility and material failure are explained in parallel and carried out in the practical course.
	Contents: Introduction to imaging methods (MRT, CT), Introduction to forms of treatment, (conservative and invasive) Basics of cell therapy Introduction to prosthesis materials and design, reasons for material failure, o In vitro simulation techniques o Particle analysis and particle isolation o Material-cell interaction o Microscopy detection of implant wear and cellular reactions
Type of lecture	Lectures; Seminars
Literature	
Preconditions for attending	
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Written examination (K120)
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	2 hours per week lecture, 1 hour per week exercises, Self-Study
Frequency of provision	every summer term
Duration of module	1 semester
Responsible lecturer	Prof. Dr. rer.nat. Jessica Bertrand, FME-KORT Dr.-Ing. Joachim Döring, FME-KORT

6.11 Computational Biomechanics

Course name	Computational Biomechanics
German title	Computational Biomechanics
Teaching aims and content of the module	Teaching aims and competences to be gained: The lecture is aimed to provide the students with knowledge and skills in computational mechanics to solve engineering problems (statics, strength of materials, dynamics). The lecture provides an introduction into the mathematical modeling and the computational analysis of engineering problems. The students receive the ability to solve simplified technical problems with a reference to biomechanical and medical engineering.
	Contents: • Overview about modern computational methods in mechanics • Application in biomechanics and medical engineering • Introduction in mathematical modeling • Discretization methods: ▫ Finite difference method (FDM) ▫ Energy Methods (Ritz, Galerkin) ▫ Finite element method (FEM) • Computational analysis of selected problems in biomechanics
Type of lecture	Lectures; Seminars
Literature	
Preconditions for attending	Understanding of basic mechanisms for measure properties, testing and analytics
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Written examination (K90), individual semester assignment
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	2 hours per week lecture, 2 hours per week exercises, Self-Study: Individual semester assignment that is included in the examination grade
Frequency of provision	Every winter term
Duration of module	1 semester
Responsible lecturer	Prof. Dr.-Ing. Daniel Juhre, FMB-IFME

6.12 Dental Implants and Technologies

Under construction

Course name	Dental Implants and Technologies
German title	Dentaltechnik und dentale Implantate
Teaching aims and content of the module	Teaching aims and competences to be gained:
	Contents:
Type of lecture	Lectures; Seminars
Literature	
Preconditions for attending	
Usability of the module	according to module handbook
Prerequisites for the provi-sion of ECTS	Written examination
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	hours per week lecture, hours per week exercises, Self-Study
Frequency of provision	summer/winter term
Duration of module	1 semester
Responsible lecturer	remains to be clarified (Kaibel, Wagner, Zahl)

6.13 Design of Mechatronic Systems

Course name	Design of Mechatronic Systems
German title	Entwurf mechatronischer Systeme
Teaching aims and content of the module	Teaching aims and competences to be gained: - Grundlagen und beispielhafte Anwendung der Systementwicklung bzw. Entwicklungsmethodik mechatronischer Systeme - Grundlagen und beispielhafte Anwendung der Modellbildung und Simulation mechatronischer Systeme
	Contents: - Grundlagen der Beschreibung mechatronischer Systeme: Modellbildung mechanischer, elektronischer und informationstechnischer Komponenten - Mechatronische Funktionsgruppen am Beispiel Medizintechnik: Mobilitäts- und Rehabilitationshilfsmittel, Prothetik, Exoskelett - Zusammenwirken mechatronischer Funktionsgruppen
Type of lecture	Lectures; Seminars
Literature	
Preconditions for attending	Grundlagen Technische Mechanik, Elektrotechnik oder Mechatronik, Numerische Simulationsmethoden
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Examination: written exam (K90)
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	3 hours per week seminar, Self-Study
Frequency of provision	Every summer term
Duration of module	1 semester
Responsible lecturer	Prof. Dr.-Ing. Stephan Schmidt, FMB-IMS Dr.-Ing. Martin Schünemann, FMB-IMS

6.14 Dynamics of Motion

Course name	Dynamics of Motion
German title	Bewegungsdynamik
Teaching aims and content of the module	Teaching aims and competences to be gained: • Students acquire knowledge on modelling and simulation of dynamic systems with focus on exoprotheses • Students receive basic understanding of numerical methods to solve the underlying differential equations • Students get the ability to solve dynamic problems and analyse the overall motion due to acting forces in biomechanical context • Students acquire knowledge to solve inverse problems based on measured kinematic quantities for motion analysis
	Contents: Plane and spatial kinematics and kinetics of multibody systems (linear and angular motion) to describe the motion of exoprotheses including • kinematic models of joints • spatial orientation • forward dynamic simulation • time integration • animation of movement • consideration of elastic elements • collision detection and contact models • inverse kinematics and dynamics
Type of lecture	Lectures, Seminars
Literature	
Preconditions for attending	Understanding of basic mechanical mechanisms (statics, strength theory and dynamics) – General Mandatory Course: Applied Biomechanics
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Written examination (K120), individual semester assignment
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	2 hours per week lecture, 2 hours per week exercises, Self-Study: Individual semester assignment that is included in the examination grade
Frequency of provision	Every summer term
Duration of module	1 semester
Responsible lecturer	Jun.-Prof. Dr.-Ing. Elmar Woschke (FMB-IFME) Additional instructors: Dr.-Ing. Christian Daniel (FMB-IFME)

6.15 History of Medicine

Under constuction

Course name	History of Medicine
German title	Geschichte der Medizin
Teaching aims and content of the module	Teaching aims and competences to be gained:
	Contents:
Type of lecture	Lectures; Seminars
Literature	
Preconditions for attending	
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Written examination
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	hours per week lecture, hours per week exercises, Self-Study
Frequency of provision	summer/winter term
Duration of module	1 semester
Responsible lecturer	Prof. Dr. phil. habil. Eva Brinkschulte, FME-GET

6.16 Imaging and Visualization in Biomedical Engineering

Course name	Imaging and Visualization in Biomedical Engineering
German title	Verfahren der Biomedizinischen Bildgebung
Teaching aims and content of the module	Teaching aims and competences to be gained: Understanding the physics of different imaging approaches relevant for biomedical engineering Learning about typical implementations Pros and cons of the different methods with respect to biomedical engineering applications
	Contents: Imaging methods in 2D and 3D, including various methods like CT, dual energy and spectral X-ray absorption, phase contrast imaging, fluorescence imaging, nanoparticle imaging, Nuclear medical imaging basics, MRI, Ultrasound imaging, Microscopy
Type of lecture	Lectures; Seminar/Exercises
Literature	- Andrew Webb: Introduction to Biomedical Imaging - Peter Morris: Biomedical Imaging: Applications and Advance - Nadine Barrie Smith, Andrew Webb: Introduction to Medical Imaging: Physics, Engineering and Clinical Applications - Bushberg, Seibert, Leidholt, Boone: The essential Physics of Medical Imaging - Hendee, Russell Ritenour: Medical Imaging Physics - Olaf Dössel: Bildgebende Verfahren in der Medizin - Giussani, Hoeschen: Imaging in Nuclear Medicine
Preconditions for attending	Basic knowledge in physics and mathematics
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Attending of exercises Examination: written examination (K120)
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	2 hours per week lectures, 1 hour per week seminar, Self-Study
Frequency of provision	Every summer term
Duration of module	1 semester
Responsible lecturer	Prof. Dr.rer.nat. Christoph Hoeschen, FEIT-IMT

6.17 Immunology

Under construction

Course name	Immunology
German title	Immunologie
Teaching aims and content of the module	Teaching aims and competences to be gained:
	Contents:
Type of lecture	Lectures; Seminars
Literature	
Preconditions for attending	
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Written examination
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	hours per week lecture, hours per week exercises, Self-Study
Frequency of provision	summer/winter term
Duration of module	1 semester
Responsible lecturer	Prof. Dr. rer. nat. Andreas Müller, FME-IMKI

6.18 Interdisciplinary Project

Course name	Scientific Project
German title	Wissenschaftliches Projekt
Teaching aims and content of the module	Teaching aims and competences to be gained: The students are to complete the development of a medical device holistically under guidance and in a team. All competences acquired up to this point are to be brought in. The teams are formed overlapping from the two specialization fields.
	Contents: Collaborative work on the development of a medical device in teams, all teams are given the identical task in the form of a specification for a medical device, communicating project work, milestone presentations, etc.
Type of lecture	Lectures; Seminars, Independent working in a team
Literature	none
Preconditions for attending	recommended to be solved within the third term
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Examination: Scientific project (presentation and project documentation or scientific writing (paper))
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	Self-Study
Frequency of provision	Every winter term
Duration of module	1 semester
Responsible lecturer	Prof. Dr.-Ing. habil. Thorsten Halle, FMB-IWF

6.19 Introduction in Tissue Engineering

Course name	Introduction in Tissue Engineering
German title	Tissue Engineering
Teaching aims and content of the module	Teaching aims and competences to be gained: In the lecture, we will start with an introduction into cell biology and signaling. This knowledge is a prerequisite for the introduction into cell culture technology and principles in tissue engineering. A methodical focus will be on detection of vitality, metabolic activity, histological staining and antibody-based detection methods such as ELISA; RIA, FACS or MACS. In the second half of the course we will focus on (I) the development of (bio) materials as 3D scaffolds and, the (II) bioreactor technology in Tissue Engineering, (III) non-invasive detection methods and (IV)modeling cell material interaction for tissue engineering. Finally, we give a brief insight into the application of human 3D tissues.
	Contents: ▪Fundamentals of cell biology and cell culture technology ▪Biological methods to characterize cellular function ▪Basic principles of tissue engineering ▪3D tissue models and their application
Type of lecture	Lectures, Seminar (Tutorial)
Literature	Review article will be provided
Preconditions for attending	none
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Attending of exercises Examination: Written exam (K90)
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	2 hours per week lecture, 2 hours per week seminar, supporting tutorials
Frequency of provision	Every winter term
Duration of module	1 semester
Responsible lecturer	Prof. Dr. rer. biol. hum. Heike Walles, FVST-ICH

6.20 Introduction Medical Science in Space

Course name	Introduction to Medical Science in Space
German title	Einführung in die Medizinische Weltraumforschung
Teaching aims and content of the module	Teaching aims and competences to be gained: The course provides an introduction to the fundamentals and methods of biomedical research under microgravity conditions. For this purpose, the special properties and effects of a microgravity environment on cells, organisms and humans, which outline the possibilities for research under a unique environmental condition. Technical requirements of the different realization options for experiments in microgravity are presented and the process from project idea to implementation is taught. This will provide students an overview of the main experimental approaches to microgravity platforms as well as the design and implementation of projects in various scientific, engineering and medical fields.
	Contents: <u>Lecture:</u> ▪ History of space science (Mercury, Apollo, Vostok, MIR, Skylab etc.) ▪ Platforms for microgravity research: rotational bioreactors, drop tower, parabolic flight, sounding rockets (suborbital), satellites, space stations ▪ Human physiology under microgravity conditions (musculoskeletal system, cardiovascular system, immune system), typical diseases of astronauts, cognitive impairment, "space pharmacology", bed rest studies, human centrifuges. ▪ Perception of gravity, cell physiology under gravitational stress, genetics and epigenetics in microgravity. ▪ Application of microgravity to terrestrial problems in medicine (for example, research on cancer, cartilage, vascular system), tissue engineering under microgravity conditions. ▪ Technology development for biomedical space research: hardware requirements and tests, technical implementations. ▪ Technological challenges and strategies in human space exploration: life support systems, space greenhouses, radiation protection. <u>Seminar:</u> ▪ Milestones, current methods and technologies in medical space research.
Type of lecture	Lecture (2 SWS), seminar (2 SWS)
Literature	[1] G. Ruyters, M. Braun (Eds): „SpringerBriefs in Space Life Sciences“ (book series; currently 13 titles), Springer Verlag, ISSN: 2196-5560 [2] B. Ganse, U. Ganse: „Das kleine Handbuch für angehende Raumfahrer“, Springer Verlag, 1st edition 2017, ISBN: 978-3662544105
Preconditions for attending	Recommendation: basic knowledge in biology and physics
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Examination: Exam, K90
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	Lecture: 28h (2 SWS), seminar 28h (2 SWS), self-dependent studies: 94h
Frequency of provision	Every summer term
Duration of module	1 semester

Responsible lecturer	Prof. Dr. med. Daniela Grimm, FME-MTRM Additional Instructors: Dr. rer. nat. Markus Wehland (FME-MTRM), Dr. rer. nat. Marcus Krüger (FME-MTRM), Dr. rer. medic. Herbert Schulz (FME-MTRM), Dr. rer. nat. Kirsten Harth (FME-MTRM)

6.21 Master Thesis

Name des Moduls	Master Thesis
Deutscher Titel	Masterarbeit
Content and qualification goals of the module	Learning objectives and acquired competences: The Master's thesis should demonstrate that the student is able to work independently on a problem using scientific methods within a given period of time, as well as to analyze and critically evaluate possible approaches to solving the problem. The students are able to classify their work in the context of current research.
	Contents: Topics from all relevant disciplines of the Faculty of Mechanical Engineering with a clear reference to biomechanical issues, preferably with an orientation towards engineering-relevant issues.
Teaching forms	Self-Study, colloquium in compliance with the design guideline as well as instructions for the processing and presentation of final theses of the FMB
Requirements for the start of the mas-ter work	Proof of 70 CP from compulsory and elective courses and completed module interdisciplinary project
Prerequisite for the colloquium	Proof of all required 90 CP Presentation of two expert opinions on the Master's thesis, graded at least "sufficient"
Usability of the module	M-BiME
Prerequisites for the award of credit points	2 Expert opinions, colloquium
Credit points and grades	30 CP Grading scale according to examination regulations
Workload	independent project work, master thesis, lecture
Offering frequency	every semester
Duration of the module	5 months Issue of the topic and submission of the master's thesis on record in the examination office of the FMB
Responsible for the module	Study programme coordinator

6.22 Medical Device Regulation and Ethics in Medicine

Course name	Medical Device Regulation and Ethics in Medicine
German title	Medizinprodukterecht und Medizinethik
Teaching aims and content of the module	Teaching aims and competences to be gained: In contrast to pharmaceuticals, no worldwide uniform legally requirements are available for the approval and CE certification of medical devices. Every manufacturer is responsible to set up the process and documentation of his medical devices to get it approved according to defines OECD Guidelines and ISO norms. The regulatory affair offers an unexpectedly exciting and diverse range of tasks for all students, especially in small and medium-sized companies. In the first semester, the approval process of medical devices as whole as well as regulatory and structural requirements will be addressed. The second semester will give an overview over ethical guidelines within medicine, medical research and medical engineering.
	Contents: The ethical implications of medical research on humans are to be elaborated in lectures and seminars. This includes the history of the establishment of ethical codes in medicine since the end of the 19th century up to the current Declaration of Helsinki. Ethical competence is characterized by an understanding of normative ethics as well as ethical principles (autonomy, care, non-harm, justice). In the seminars, the different positions will be reflected on the basis of historical and current case studies, also taking into account the legal frame-work. The seminars should promote both ethical discourse and practical decision-making behaviour.
Type of lecture	Lectures; Seminars
Literature	Ethik in der Medizin. Ein Studienbuch, 5.erw.Aufl.2020; Wolfgang U. Eckart: Geschichte, Theorie und Ethik der Medizin, 9.Aufl.2021
Preconditions for attending	
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Written examination K90 for part I: Medical Device Regulation and K90 for part II: Ethics in Medicine
ECTS and marks	10 CP Grading according to the examination regulations, final grade will be calculated as equal combination of the exams part I (50 %) and part II (50 %)
Efforts	2 hours per week lecture, 1 hour per week exercises, Self-Study
Frequency of provision	Part I: summer term, Part II: winter term
Duration of module	2 semesters
Responsible lecturer	Prof. Dr.-Ing. habil. Thorsten Halle, FMB-IWF Prof. Dr. rer.nat. Jessica Bertrand, FME-KORT Marc Michel, Peter Brehm GmbH/ BVMed Prof. Dr. phil. habil. Eva Brinkschulte, FME-GET

6.23 Microscopic Methods

Under construction

Course name	Microscopic Methods
German title	Mikroskopische Methoden in der Medizintechnik
Teaching aims and content of the module	Teaching aims and competences to be gained:
	Contents:
Type of lecture	Lectures; Seminars
Literature	
Preconditions for attending	
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Written examination
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	2 hours per week lecture, 2 hours per week exercises, Self-Study
Frequency of provision	every summer term
Duration of module	1 semester
Responsible lecturer	Prof. Dr.-Ing. habil. Thorsten Halle, FMB-IWF Prof. Dr. rer.nat. Jessica Bertrand, FME-KORT Prof. Dr. rer. nat. Andreas Müller, FME-IMKI Dr. Werner Zuschratter, LIN Dipl.-Ing. Markus Wilke, FMB-IWF

6.24 Motion Analysis

Course name	Motion Analysis
German title	Funktionale Bewegungsanalyse
Teaching aims and content of the module	Teaching aims and competences to be gained: The lecture is aimed to provide the students with knowledge and skills in theoretical foundations, methods, and specific applications of motion analysis. In the exercises, students learn to apply the special procedures to selected human movements.

	Contents:
	▪ Basics of motor control
	▪ Biomechanical modelling
	▪ Statistics in motor control
	▪ Gait analysis
	▪ Procedures of motion analysis
	  ○ Optical methods
	  ○ Inertial sensors
	  ○ Dynamometry
	  ○ Electromyography
	▪ Postural control
	▪ Virtual reality in human movement science

Type of lecture	Lectures (2 SWS); Exercises (1 SWS)
Literature	
Preconditions for attending	successful completion of the modules Anatomy for Engineering Students and Applied Biomechanics is recommended
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Written examination (K120)
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	2 hours per week lecture, 1 hours per week exercises, Self-Study: individual semester assignment that is included in the examination grade
Frequency of provision	every winter term
Duration of module	1 semester
Responsible lecturer	apl. Prof. Dr. habil. Kerstin Witte, FHW-SPW

6.25 Orthopedic Technology

Course name	Orthopedic Technology
German title	Orthopädietechnik
Teaching aims and content of the module	Teaching aims and competences to be gained: The aim of the module is to teach the students the basics of anatomy and physiology of the joint (bone, cartilage, muscle and ligaments). Based on the understanding of the physiological processes of the healthy joint, the basics of biomechanics are taught, which enables the students to evaluate the involved influencing factors of orthopaedically relevant diseases of the joint based on the basic knowledge of medicine, biology, mechanics and tribology. In the accompanying seminar, various test setups, ISO standards and basic skills for the independent development of new approaches (statistics, experimental design, influencing factors, etc.) are taught.
	Contents: Introduction to human anatomy with a focus on the joint, • Basics of cell biology and physiology of joints, • Introduction to pathophysiology in orthopaedics, • basics of biotribology and biomechanics and experimental design • Forces and moments in joints • Methods of experimental design • Normative requirements in biomechanics • Detection strategies and influencing factors • Implants and materials
Type of lecture	Lectures; Seminars
Literature	
Preconditions for attending	none
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Attending of exercises Examination: written examination (K120)
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	2 hours per week lecture, 2 hours per week exercise, self-study
Frequency of provision	every winter term
Duration of module	1 semester
Responsible lecturer	Prof. Dr. med. Christoph Lohmann, FME-KORT

6.26 Perfusion and Cardiac Engineering

Under construction

Course name	Perfusion and Cardiac Engineering
German title	Durchblutung und Kardiotechnik
Teaching aims and content of the module	Teaching aims and competences to be gained:
	Contents:
Type of lecture	Lectures; Seminars
Literature	
Preconditions for attending	
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Written examination (K90)
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	hours per week lecture, hours per week exercises, Self-Study
Frequency of provision	winter/summer term
Duration of module	1 semester
Responsible lecturer	Prof. Dr. med. Jens Wippermann, FME-KCHH

6.27 Product Design and Drafting

Course name	Product Design and Drafting
German title	Produktdesign und Entwurf (PDE)
Teaching aims and content of the module	Teaching aims and competences to be gained: The course aims to promote an understanding of the role of product design in integrated product development processes and to motivate an integrative approach. The human being as user and owner of products is the benchmark. Aesthetic-ergonomic requirements derived from this are examined in particular and considered in relation to other aspects of requirements. The core objective is to enable exemplary design-oriented and integrative product design. • Sensitisation to formal aesthetic qualities and training in design skills for the visual design of complex form design problems within exercises and vouch work. • Practical processes and applications from brainstorming, design drawing, digital sketching and prototyping to the product. • Recognition of formal qualities such as form formation, form quality, form expression in connection with use requirements and their form problems such as use form, use recognition and ergonomic dimensioning of form design. • Recognition of design interrelationships of formal-aesthetic, ergonomic and technical requirements to align the product design with user needs
	Contents: • The human being as user and owner of product-use-oriented design strategies and design methods • Human-centred design requirements and usability processes (aesthetics / perception and ergonomics) • Methodological procedures and analogue and digital design tools • Integrative process model and interface design with design disciplines • In-depth exercises in the plastic design of functional objects (sketching and modelling) by linking formal aesthetic, ergonomic and technical design requirements • Own production of models to check the perceptually appropriate quality of the design
Type of lecture	Lectures; Seminars
Literature	• Design als Produktsprache; Dagmar Steffen, Form-Verlag (November 1999), ISBN: 978-3931317348. • Design Basics; Gerhard Heufler, Niggli-Verlag (November 2012), ISBN: 978-3721208290. • Design | Die 100 Prinzipien für erfolgreiche Gestaltung; Stiebner-Verlag (September 2004), ISBN: 978-3830712954.
Preconditions for attending	none
Usability of the module	according to module handbook
Prerequisites for the provision of ECTS	Examination: Written Exam (K120)
ECTS and marks	5 CP Grading according to the examination regulations
Efforts	2 hours per week lecture, 2 hours per week exercises, 108 hours self-study
Frequency of provision	Every winter term
Duration of module	1 semester

Responsible lecturer	Prof. Dr.-Ing. Christiane Beyer, FMB-IMK