Curriculum for the master's degree programme in

Biomedical Engineering

Curriculum 2016 in the version of 2021

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(Please note: The English version of this document is a courtesy translation. Only the German version is legally binding.)

On the basis of the Federal Act on the Organisation of Universities and their Studies (UG), Austrian Federal Law Gazette (BGBl.) No. 120/2002 as amended, the Senate of Graz University of Technology issues the following curriculum for the master's degree programme in Biomedical Engineering.

§ 1 General provisions

(1) The engineering sciences master's degree programme in Biomedical Engineering comprises four semesters. The total scope of the programme is 120 ECTS credit points.

(2) The master's degree programme in Biomedical Engineering is exclusively held in English according to § 71.e para. 4 UG.

(3) Graduates of this programme are awarded the university degree of "Diplom-Ingenieurin"/"Diplom-Ingenieur", abbreviated: "Dipl.-Ing." or "DI". The international equivalent of this university degree is "Master of Science", abbreviated: "MSc".

(4) Admission to the master's degree programme in Biomedical Engineering requires a subject-related bachelor's degree or another equivalent degree according to § 64 para. 5 UG. The master's programme in Biomedical Engineering is based on the bachelor's degree programme in Biomedical Engineering offered by TU Graz. Graduates of this degree programme shall be admitted to this master's degree programme without any further prerequisites.

(5) Depending on the previous education of the applicant to the programme, up to 22 ECTS credit points from the courses of the above bachelor's degree programme in Biomedical Engineering may be prescribed as part of the admission to the curriculum presented here for graduates of other bachelor's degree programmes. These prescribed courses reduce the workload outlined in the curriculum for achievements in

elective subjects or minors accordingly. A bachelor's degree programme that entitles the student to be admitted must comprise at least 180 ECTS credit points. In order to obtain an overall scope of 300 ECTS credit points for the graduate and postgraduate study programmes together, students shall not be assigned courses in the master's programme which they have already completed as part of their bachelor's degree and which were part of their qualification for the master's degree programme.

(6) The study programme is completed by writing a master's thesis and passing an examination before a committee according to § 7a below.

§ 2 Qualification profile

(1) Object of study programme

The master's degree programme is designed to be part of the overall training to become a graduate engineer in Biomedical Engineering, which provides a future-oriented, interdisciplinary education in combination with the preceding bachelor's programme. The sound, interdisciplinary basic education offered by the bachelor's programme is followed by specialisations in the fields of five elective subjects: Biomechanical Engineering, Biomedical Instrumentation and Sensors, Biomedical Imaging and Sensing, Computational Neuroscience and Health Care Engineering. The curriculum aims to provide a comparatively high degree of freedom in choosing the teaching content, and increases students' independence and initiative in the way they think, decide and act in an interdisciplinary manner.

(2) Qualification profile and skills

The master's degree programme in Biomedical Engineering is intended to enable graduates to work at the interface between technology, medicine and biology, to understand the language and content of these fields and to apply their interdisciplinary, technical expertise in cooperation and to solve problems.

Graduates of the master's degree programme in Biomedical Engineering are prepared for a variety of challenges in medical engineering and are able to familiarise themselves in a short time with all the fields of biomedical engineering better than graduates of other, less interdisciplinary master's degree programmes. Students who have successfully completed the master's degree programme in Biomedical Engineering have achieved the following objectives and acquired the following skills:

Knowledge and understanding

Graduates

- are familiar with the key theories, principles and methods of biomedical engineering;
- have deepened their knowledge in two particular fields of biomedical engineering;
- understand the working methods in these fields and are capable of applying these methods and the scientific basics for them in a practical way, and
- know the most important strategies to solve problems efficiently.

Knowledge-based application and assessment

Graduates

- have acquired the skills to apply theoretical knowledge in a practical way, both technically and scientifically;

- have developed skills for interdisciplinary analysis and assessment, and are able to formulate scientifically founded assessments and possible solutions;
- recognise ethical, social, societal and economic implications, connections and needs, and
- are able to correctly interpret the results acquired with the subject-specific methods and to continue working with these results.

Communicative, organisational and social competencies
Graduates

- are able to write scientific texts and to present results both in written form and orally;
- are able to acquire new knowledge independently, to contribute independently to research and development;
- are able to integrate themselves into a team and to assume subtasks and leadership roles independently;
- have basic knowledge of handling projects;
- have developed an awareness for the necessity of lifelong learning, and
- are capable of international, interdisciplinary cooperation.

(3) Demand for and relevance of the study programme for science and on the job market

The current sociopolitical and scientific challenges underline the importance of and future prospects for the study programme in Biomedical Engineering. The demographic development combined with the increased life expectancy is leading to a dramatically ageing population and, consequently, to an enormous increase in healthcare costs, as well as to a growing demand for new solutions to provide efficient, safe and cost-effective healthcare and for new, innovative medical products, therapies and everyday medical aids for the ageing population.

In combination with new possibilities in modelling and simulation, but particularly in computational science and engineering, telecommunications and neurosciences, molecular medicine, biomedical instruments and sensors, imaging, bioinformatics, biomechanics and tissue engineering as well as the structural, economic and methodological challenges in healthcare, very promising research potential, development potential and market potential is created.

This dynamic development is giving rise to an increased demand in business, research and development for graduates of the study programme in Biomedical Engineering. The intention is for graduates to work in research and development, business and the public sector to develop improved diagnostic and therapeutic solutions, to implement them technically, and to make them available efficiently and economically.

Through the sound, broad education of the basics, with a subsequent specialisation in one of the five focus areas offered, the conditions are created for graduates of the study programme in Biomedical Engineering to analyse interdisciplinary issues, to create new foundations, to prepare concepts and principles and to implement them for the benefit of society.

The career opportunities for graduates of this study programme are extraordinarily diverse: in industry (from start-ups to large-scale industry), for service providers and public authorities, and in science, research and teaching.

§ 3 ECTS credit points

In accordance with the European Credit Transfer and Accumulation System, the individual courses are assigned ECTS credit points that determine the relative share of the workload. The Universities Act (UG) determines the workload for one ECTS credit point to be an average of 25 full hours.

§ 4 Structure of the study programme

The master's degree programme in Biomedical Engineering consists of:

1. a **major** with **at least 50 ECTS credit points**;
2. a **minor** from a second subject-specific specialisation with at least **21 ECTS credit points**;
3. **elective courses** with a workload of **10 ECTS credit points**, which are assigned to the minor. These elective courses can be chosen from the catalogues of electives. The courses are to be selected from the list in § 5a in such a way that the total for the major, minor and elective courses without the master's degree seminar comprises at least 81 ECTS credit points. A higher number of ECTS credit points for the major and the minor reduces the required workload of the elective courses accordingly;
4. a **free-choice subject** that contains free-choice courses with a workload of **6 ECTS credit points**, and
5. a **master's thesis**. The master's thesis corresponds to **30 ECTS credit points** and must be assignable to the major or the minor according to § 4b below.

As part of the major or minor, a **master's degree seminar** with a workload of **3 ECTS credit points** must be completed. The subject to which the master's degree seminar is assigned is then allocated a further 3 ECTS credit points accordingly.

Master's degree programme in Biomedical Engineering	
Subject	**ECTS**
Major according to § 4a below	min. 53 or 50 [1]
Minor according to § 4a below (including elective courses)	min. 31 or 34 [1]
Free-choice subject according to § 5b below	6
Total workload without master's thesis	**90**
Master's thesis according to § 4b below (assigned to the major or the minor in terms of content)	30
Total for the master's degree programme in Biomedical Engineering	**120**

[1] The seminar with a workload of 3 ECTS credit points is included in the higher number of ECTS credit points.

§ 5a below contains a list of the individual courses of this master's programme and their allocation to the subjects. The semester allocation is a recommendation and ensures that the sequence of courses builds optimally on previous knowledge and that the workload of an academic year does not exceed 60 ECTS credit points.

Courses that were used to complete the bachelor's degree programme to grant admission to this programme are not part of this master's degree programme. If compulsory courses that are provided for in this curriculum were already used as part of the bachelor's degree programme described above, they are to be replaced by additional elective courses comprising the same workload (ECTS credit points).

§ 4a Choice of major, minor and elective courses

The major and minor are scientifically relevant and business-related specialisations in the field of biomedical engineering.

During the first semester of the master's degree programme, the catalogues of electives for the major and minor must be chosen. These are catalogues of electives from the list in § 5a. Each catalogue of electives contains a list of related courses, which enable an extensive specialisation in the field of biomedical engineering.The choice of a catalogue of electives listed in § 5a can be changed if the reasons are stated.

The **major** shall be selected from the *technical* catalogues of electives (catalogues c1-c5) defined in § 5a. This consists of a predefined compulsory course component and courses that can be freely chosen from the same catalogue of electives.

The **minor** can be selected from the catalogues of electives (catalogues c1-c5, b1-b2) defined in § 5a. This consists of a predefined compulsory course component and courses that can be freely chosen from the same catalogue of electives.

The diagram below provides an overview of how the major and minor can be combined. The combinations marked in black are not possible. For a combination with a number in brackets, compulsory courses that occur twice must be replaced according to the table entitled "Replacement courses" (see § 5a, page 18-19).

			Minors											
			Biomaterials	Biomolecular Analytics	Medical Electronics	Bioinstrumentation	Optical Microscopy	Biomedical Imaging	Brain-Computer Interfacing	Neural Engineering	Clinical Engineering	Cellular Electrophysiology and Sensors	Business, Law, Management and Soft Skills	Bioinformatics
			c1	c2			c3		c4		c5		b1	b2
Majors	c1	Biomechanics: Modeling and Simulation	■					(1)						
	c2	Biomedical Instrumentation and Sensors		■		■				(2)		(3)		
	c3	Biomedical Imaging and Sensing		(4)		(5)	■	■	(8)	(6)		(7)		(9)
	c4	Computational Neuroscience						(10)	■					(11)
	c5	Biomedical Device Design, Safety and Regulation			(12)	(13)								

All courses offered according to § 5a can be selected as **elective courses**.

Other courses can also be completed as part of the elective courses to improve knowledge of a foreign language (English or German) with a total scope of up to 3 ECTS credit points.

§ 4b Master's thesis

Within the master's degree programme in Biomedical Engineering, a master's thesis must be written, which must be assignable to the named major or minor.

Before a student starts work on their master's thesis, it must be registered with the Dean of Studies via the responsible dean's office. The topic, the area of expertise of the topic and the supervisor as well as the institute must be stated.

When the student begins the thesis, in the case of individual subjects pursuant to the transitional provisions (§8 below), he/she must make an informed decision together with the Dean of Studies and the supervisor of the master's thesis with regard to assigning the master's thesis to a subject.

§ 5 Course content and semester plan

Master's degree programme in Biomedical Engineering								
Subject	Course	SSt	Type of course	ECTS	Semester incl. ECTS			
					I	II	III	IV
	Master's degree seminar according to § 4 above	1.0	SP	3.0			3.0	
Total for the major and minor				81.0	30.0	27.0	27.0	
Master's thesis according to § 4b above				30.0				30.0
Free-choice subject								
	Free-choice course according to § 5b below			6.0		3.0	3.0	
Overall total				**120.0**	**30.0**	**30.0**	**30.0**	**30.0**

Abbreviations: SP: seminar project; SSt: semester hours

§ 5a Catalogues of electives

The technical catalogue of electives **c1 – Biomechanical Engineering** comprises:

- the major: **Biomechanics: Modeling and Simulation**, and
- Minor 1: **Biomaterials**.

Catalogue of electives: c1 – Biomechanical Engineering										
Course	SSt	Type of course	ECTS	Semester	Compulsory component				Notes / Recommendation	Language
					Major	Minor 1	Minor 2	Minor 3		
Prerequisites from the bachelor's degree programme in Biomedical Engineering										
Strength of Materials	3.0	VU	4.5	WS					compulsory for the major if not completed in the bachelor's programme	English
Theory of Materials / Structural Analysis										
Tissue Engineering	2.0	VO	3.0	WS	3.0	3.0				English
Theory of Materials	2.0	VU	3.0	SS						English
Biological and Bio-based Materials	2.0	VO	3.0	SS	3.0	3.0				English
Imaging Laboratory	2.0	LU	3.0	SS						English
Electron Microscopy Imaging	1.0	VO	1.5	WS						English
Bionanotechnology	2.0	VO	3.0	SS						English
Microscopy in Biotechnology	2.0	VO	4.0	WS						English
Materials Characterization II	1.33	VO	2.0	WS						English
Materials Characterization III	1.33	VO	2.0	WS						English
Physics of Modern Materials	2.0	VO	3.0	WS						English

Medical Image Analysis	2.0	VO	3.0	SS	3.0					English
Medical Image Analysis	1.0	KU	2.0	SS						English
Micromechanics	2.0	VO	3.0	WS						English
Biomaterials	2.0	VO	3.0	WS					recommended for Minor 1	English
Pathologie	2.0	VO	3.0	WS					recommended for major	German
Subtotal					9.0	6.0	0.0	0.0		
Multiscale Biomechanics										
Mechanics of Biological Tissues	2.0	VO	3.0	WS	3.0	3.0				English
Mechanics of Proteins and Cells	2.0	VO	3.0	WS	3.0					English
Subtotal					6.0	3.0	0.0	0.0		
Basics of Biomechanical Modeling and Simulation										
Continuum Mechanics	3.0	VU	4.5	WS	4.5					English
Strömungslehre und Wärmeübertragung I	4.0	VO	6.0	SS						German
Strömungslehre und Wärmeübertragung I	2.0	UE	2.0	SS						German
Strömungslehre und Wärmeübertragung II VT	2.0	VO	3.0	WS						German
Strömungslehre und Wärmeübertragung II VT	1.0	UE	2.0	WS						German
Höhere Strömungslehre und Wärmeübertragung	2.0	VO	3.0	WS						German
Thermodynamics for Biomedical Engineers	2.0	VO	3.0	WS	3.0					English
Thermodynamics for Biomedical Engineers	1.0	UE	2.0	WS	2.0					English
Höhere Thermodynamik	2.0	VO	3.0	SS						German
Höhere Thermodynamik	2.0	UE	2.0	SS						German
Subtotal					9.5	0.0	0.0	0.0		
Basics of Numerical Methods (Finite Element Method) and Applications										
Optimization for Computer Science	2.0	VO	3.0	WS	3.0					English
Optimization for Computer Science	1.0	UE	2.0	WS	2.0					English
Finite Element Method	2.0	VU	3.0	WS	3.0	3.0				English

Course	**SSt**	**Type of course**	**ECTS**	**Semester**	**Compulsory component**				**Notes / Recommendation**	**Language**
					Major	**Minor 1**	**Minor 2**	**Minor 3**		
Finite Element Method - Advanced course	2.0	VU	3.0	SS	3.0					English
Computational Biomechanics	4.0	VU	5.5	SS	5.5					English
Technische Numerik 2	2.0	VO	3.0	SS						German
Technische Numerik 2	1.0	UE	1.0	SS						German
Numerische Methoden Strömungslehre und Wärmeübertragung	3.0	VO	4.5	WS						German
Numerische Methoden in der angewandten Thermodynamik	2.0	VO	3.0	SS						German
Partielle Differentialgleichungen und Numerik	2.0	VO	3.0	SS						German

Course	SSt	Type of course	ECTS	Semester	Compulsory component				Notes / Recommendation	Language
					Major	Minor 1	Minor 2	Minor 3		
Partielle Differentialgleichungen und Numerik	1.0	UE	1.0	SS						German
Biostatistics and Experimental Design	2.0	VU	3.0	WS						German
Biomedical Sensor Systems, Laboratory	2,0	LU	3,0	SS						English
Subtotal					16.5	3.0	0.0	0.0		
Overall total for the compulsory component					**41.0**	**12.0**	**0.0**	**0.0**		

Abbreviations: KU: design exercise; LU: laboratory course; SS: summer semester; SSt: semester hours; UE: exercise; VO: lecture; VU: lecture with integrated exercises; WW: winter semester

The technical catalogue of electives **c2 – Biomedical Instrumentation and Sensors** comprises:

- the major: **Biomedical Instrumentation and Sensors**;
- Minor 1: **Biomolecular Analytics**;
- Minor 2: **Medical Electronics**, and
- Minor 3: **Bioinstrumentation**.

Catalogue of electives: c2 – Biomedical Instrumentation and Sensors										
Course	**SSt**	**Type of course**	**ECTS**	**Semester**	**Compulsory component**				**Notes / Recommendation**	**Language**
					Major	**Minor 1**	**Minor 2**	**Minor 3**		
Prerequisites from the bachelor's degree programme in Biomedical Engineering										
									none	
Signal processing										
Biosignal Processing	2.0	VO	3.0	WS	3.0					English
Biosignal Processing	2.0	UE	3.0	WS	3.0					English
Nonlinear Signal Processing	2.0	VO	3.0	SS						English
Nonlinear Signal Processing	1.0	UE	2.0	SS						English
Subtotal					6.0	0.0	0.0	0.0		
Analytics / Biosensors										
Chemical Analytics and Sensors	3.0	VO	4.5	SS	4.5	4.5		4.5		English
Molecular Diagnostics	2.0	VO	3.0	SS	3.0	3.0				English
Molecular Diagnostics	2.0	LU	2.0	SS	2.0	2.0				English
Physical Effects for Sensors	2.0	VO	3.0	SS	3.0	3.0				English
Bionanotechnology	2.0	VO	3.0	SS		3.0		3.0		English
Biomaterials	2.0	VO	3.0	WS	3.0				recommended for Minor 1	English
Subtotal					15.5	15.5	0.0	7.5		

Course	SSt	Type of course	ECTS	Semester	Compulsory component				Notes / Recommendation	Language
					Major	Minor 1	Minor 2	Minor 3		
Biomedical Instrumentation Basics										
Medical Instrumentation	2.0	VU	3.0	WS	3.0			3.0		English
Medizinische Gerätetechnik	2.0	VO	3.0	WS						German
Biomedical Sensor Systems 2	1.5	VU	2.0	SS	2.0					English
Control of Medical Instrumentation	2.0	VU	3.0	SS	3.0			3.0		English
Rehabilitation Engineering	2.0	VO	3.0	WS	3.0					English
Medical Laser Technology	2.0	VO	3.0	WS						English
Introduction to Brain-Computer Interfacing	1.0	VO	1.5	WS	1.5					English
Biomedical Sensor Systems, Laboratory	2.0	LU	3.0	SS	3.0			3.0		English
Biomedical Instrumentation Project	1.0	SP	6.0	J						English
EMC of Electronic Systems	2.0	VO	3.0	WS			3.0		recommended for major and Minor 3	English
EMC of Electronic Systems, Laboratory	1.0	LU	2.0	WS			2.0		recommended for major and Minor 3	English
Subtotal					15.5	0.0	5.0	9.0		
Instrumentation Specialization										
Biooptics	1.0	VO	1.5	WS						English
Biooptics	1.0	UE	1.5	WS						English
Nachrichtentechnik	3.0	VO	4.5	SS						German
Nachrichtentechnik	2.0	UE	3.0	SS						German
Grundlagen der Hochfrequenztechnik	2.0	VO	3.0	WS						German
Grundlagen der Hochfrequenztechnik	1.0	UE	2.0	WS						German
Energietechnik für biomedizinische TechnikerInnen	2.0	VO	3.0	SS						German
Microcontroller	1.5	VO	2.0	WS			2.0			German
Microcontroller	2.0	UE	2.0	WS			2.0			German
Practical Analog Circuit Design	2.0	UE	3.0	SS			3.0		recommended for major	English
Practical Analog Circuit Design, Laboratory	1.0	LU	1.5	SS					recommended for major and Minor 2	English
Circuit Simulation	1.0	VO	1.5	SS	1.5				recommended for Minor 3	English
Circuit Simulation	2.0	UE	3.0	SS	3.0				recommended for Minor 3	English
Subtotal					4.5	0.0	7.0	0.0		
General Skills										
Development and Design of Biomedical Devices	2.0	VO	3.0	WS			3.0			English
Predictive Healthcare Information Systems	2.0	VO	3.0	WS						English
Medizinprodukterecht	2.0	VO	3.0	SS					recommended for major, Minor 1 and Minor 3	German
Encyclopedia Business Economics	3.0	VO	4.5	SS						English

Course	SSt	Type of course	ECTS	Semester	Compulsory component				Notes / Recommendation	Language
					Major	Minor 1	Minor 2	Minor 3		
Encyclopedia Business Economics	2.0	UE	3.0	SS						English
Biostatistics and Experimental Design	2.0	VU	3.0	WS					recommended for Minor 1	English
Subtotal					0.0	0.0	3.0	0.0		
Overall total for the compulsory component					**41.5**	**15.5**	**15.0**	**16.5**		

Abbreviations: J: annually; SP: seminar project; SS: summer semester; SSt: semester hours; UE: exercise; VO: lecture; VU: lecture with integrated exercises; WW: winter semester

The technical catalogue of electives **c3 – Biomedical Imaging and Sensing** comprises:

- the major: **Biomedical Imaging and Sensing**;
- Minor 1: **Optical Microscopy**, and
- Minor 2: **Biomedical Imaging**.

Catalogue of electives: c3 – Biomedical Imaging and Sensing

Course	SSt	Type of course	ECTS	Semester	Compulsory component				Notes / Recommendation	Language
					Major	Minor 1	Minor 2	Minor 3		
Prerequisites from the bachelor's degree programme in Biomedical Engineering										
Computer Vision	2.0	VU	2.5	SS					compulsory for major and Minor 1 if not completed in the bachelor's programme	German
General Skills										
Encyclopedia Business Economics	3.0	VO	4.5	SS						English
Encyclopedia Business Economics	2.0	UE	3.0	SS						English
Medizinprodukterecht	2.0	VO	3.0	SS						German
Pathologie	2.0	VO	3.0	WS		3.0	3.0			German
Strahlenschutz in der Medizin	2.0	VO	3.0	WS						German
Subtotal					0.0	3.0	3.0	0.0		
Foundations										
Biological Control, Modeling and Simulation	2.0	VO	3.0	SS	3.0					English
Biological Control, Modeling and Simulation	2.0	UE	3.0	SS						English
Inverse Problems in Biomedical Engineering	2.0	VO	3.0	SS	3.0					English
Inverse Problems in Biomedical Engineering	2.0	UE	2.0	SS	2.0					English
Optimization for Computer Science	2.0	VO	3.0	WS						English

Course	SSt	Type of course	ECTS	Semester	Compulsory component				Notes / Recommendation	Language
					Major	Minor 1	Minor 2	Minor 3		
Optimization for Computer Science	1.0	UE	2.0	WS						English
Subtotal					8.0	0.0	0.0	0.0		
Imaging and Sensing Methods										
Magnetic Resonance in Medicine and Biology	2.0	VO	3.0	WS	3.0		3.0			English
Selected Chapters in Bioimaging	2.0	VU	3.0	SS	3.0		3.0			English
Imaging Laboratory	2.0	LU	3.0	SS	3.0					English
Biooptics	1.0	VO	1.5	WS	1.5	1.5				English
Biooptics	1.0	UE	1.5	WS		1.5				English
Microscopy	2.0	VO	3.0	WS		3.0				English
Microscopy (Lab Course)	1.0	LU	1.5	J		1.5				English
Electron Microscopy Imaging	1.0	VO	1.5	WS		1.5				English
Chemical Analytics and Sensors	3.0	VO	4.5	SS	4.5					English
Biomedical Sensor Systems, Laboratory	2.0	LU	3.0	SS						English
Biomedical Sensor Systems 2	1.5	VU	2.0	SS						English
Molecular Diagnostics	2.0	VO	3.0	SS						English
Molecular Diagnostics	2.0	LU	2.0	SS						English
Methods of Functional Brain Research	2.0	VO	3.0	SS			3.0			English
Subtotal					15.0	9.0	9.0	0.0		
Signal and Data Processing, Analysis and Management										
Biostatistics and Experimental Design	2.0	VU	3.0	WS	3.0					English
Biosignal Processing	2.0	VO	3.0	WS	3.0					English
Biosignal Processing	2.0	UE	3.0	WS	3.0					English
Nonlinear Signal Processing	2.0	VO	3.0	SS						English
Nonlinear Signal Processing	1.0	UE	2.0	SS						English
Machine Learning 2	2.0	VO	3.0	SS	3.0					English
Machine Learning 2	1.0	KU	2.0	SS						English
Non-Invasive Brain-Computer Interfaces	2.0	VO	3.0	SS						English
Non-Invasive Brain-Computer Interfaces	2.0	KU	3.0	SS						English
Subtotal					12.0	0.0	0.0	0.0		
Image Processing and Visualization										
Computergrafik	2.0	VU	2.5	SS						German
Computer Vision	2.0	VU	2.5	SS						German
Image Processing and Pattern Recognition	2.0	VO	3.0	WS	3.0	3.0				English
Image Processing and Pattern Recognition	1.0	KU	2.0	WS	2.0	2.0				English
Medical Image Analysis	2.0	VO	3.0	SS			3.0			English
Medical Image Analysis	1.0	KU	2.0	SS			2.0			English

Course	SSt	Type of course	ECTS	Semester	Compulsory component				Notes / Recommendation	Language
					Major	Minor 1	Minor 2	Minor 3		
Biomedical Visualization	2.0	VO	3.0	WS	3.0					English
Subtotal					8.0	5.0	5.0	0.0		
Overall total for the compulsory component					**43.0**	**17.0**	**17.0**	**0.0**		

Abbreviations: J: annually; KU: design exercise; LU: laboratory course; SS: summer semester; SSt: semester hours; UE: exercise; VO: lecture; VU: lecture with integrated exercises; WW: winter semester

The technical catalogue of electives **c4 – Computational Neuroscience** comprises:

- the major: **Computational Neuroscience**;
- Minor 1: **Brain-Computer Interfacing**, and
- Minor 2: **Neural Engineering**.

Catalogue of electives: c4 – Computational Neuroscience

Course	SSt	Type of course	ECTS	Semester	Compulsory component				Notes / Recommendation	Language
					Major	Minor 1	Minor 2	Minor 3		
Prerequisites from the bachelor's degree programme in Biomedical Engineering										
Machine Learning 1	2.0	VO	3.0	SS					compulsory for major, Minor 1 and Minor 2 if not completed in the bachelor's programme	English
Machine Learning 1	1.0	UE	1.5	SS					compulsory for major, Minor 1 and Minor 2 if not completed in the bachelor's programme	English
Foundations										
Neurophysiology & Information Processing in Human	1.0	LU	1.0	WS	1.0					English
Cognitive Neuroscience	2.0	VO	3.0	WS	3.0					English
Methods of Functional Brain Research	2.0	VO	3.0	SS	3.0					English
Biosignal Processing	2.0	VO	3.0	WS	3.0					English
Biosignal Processing	2.0	UE	3.0	WS	3.0					English
Nonlinear Signal Processing	2.0	VO	3.0	SS						English
Nonlinear Signal Processing	1.0	UE	2.0	SS						English
Biostatistics and Experimental Design	2.0	VU	3.0	WS						English
Subtotal					13.0	0.0	0.0	0.0		
Brain-Computer Interfaces										English
Introduction to Brain-Computer Interfacing	1.0	VO	1.5	WS						English
Non-Invasive Brain-Computer Interfaces	2.0	VO	3.0	SS	3.0	3.0				English
Non-Invasive Brain-Computer Interfaces	2.0	KU	3.0	SS	3.0	3.0				English
Non-invasive Brain-Computer Interfaces 2	2.0	KU	3.0	WS		3.0				English

Course	SSt	Type of course	ECTS	Semester	Compulsory component				Notes / Recommendation	Language
					Major	Minor 1	Minor 2	Minor 3		
Neurocomputing, Seminar	2.0	SE	3.5	SS						English
Neuroimaging with EEG, fNIRS and fMRI	1.0	SE	2.0	WS	2.0	2.0				English
Imaging Laboratory	2.0	LU	3.0	SS						English
Inverse Problems in Biomedical Engineering	2.0	VO	3.0	SS	3.0					English
Inverse Problems in Biomedical Engineering	2.0	UE	2.0	SS						English
Machine Learning 2	2.0	VO	3.0	SS	3.0	3.0				English
Machine Learning 2	1.0	KU	2.0	SS	2.0	2.0				English
Principles of Brain-Computation	2.0	VO	3.0	SS	3.0					English
Principles of Brain-Computation	1.0	KU	2.0	SS	2.0					English
Computational Intelligence Seminar A	2.0	SE	3.5	WS						English
Computational Intelligence Seminar B	2.0	SE	3.5	SS						English
Deep Learning	2.0	VO	3.0	WS						English
Deep Learning	1.0	KU	2.0	WS						English
Network Science	3.0	VU	5.0	WS						English
Optimization for Computer Science	2.0	VO	3.0	WS						English
Optimization for Computer Science	1.0	UE	2.0	WS						English
Seminar/Project Machine Learning & Neuroinformatics / Brain-Computer Interfacing	1.0	SP	6.0	J	6.0					English
Subtotal	34.0		61.5		27.0	16.0	0.0	0.0		
Neural Engineering										
Selected Topics Neural Engineering	2.0	SE	3.0	SS			3.0			English
Medical Instrumentation	2.0	VU	3.0	WS						English
Interdisciplinary Team-taught Lecture Series: Trends in Neurorehabilitation	2.0	VO	3.0	SS			..			English
Rehabilitation Engineering	2.0	VO	3.0	WS			3.0			English
Neuroprosthetics	2.0	VO	3.0	WS			3.0			English
Neuroprosthetics	1.0	LU	2.0	SS						English
Biological Control, Modeling and Simulation	2.0	VO	3.0	SS			3.0			English
Biological Control, Modeling and Simulation	2.0	UE	3.0	SS						English
Biomedical Sensor Systems, Laboratory	2.0	LU	3.0	SS			3.0			English
Subtotal					0.0	0.0	15.0	0.0		
Overall total for the compulsory component					**40.0**	**16.0**	**15.0**	**0.0**		

Abbreviations: J: annually; KU: design exercise; LU: laboratory course; SE: seminar; SP: seminar project; SS: summer semester; SSt: semester hours; UE: exercise; VO: lecture; VU: lecture with integrated exercises; WW: winter semester

The technical catalogue of electives **c5 – Health Care Engineering** comprises:

- the major: **Biomedical Device Design, Safety and Regulation;**
- Minor 1: **Clinical Engineering**, and
- Minor 2: **Cellular Electrophysiology and Sensors**.

Catalogue of electives: c5 – Health Care Engineering

Course	SSt	Type of course	ECTS	Semester	Compulsory component				Notes / Recommendation	Language
					Major	Minor 1	Minor 2	Minor 3		
Prerequisites from the bachelor's degree programme in Biomedical Engineering										
Krankenhaustechnik	2.0	VO	3.0	SS					compulsory for Minor 1 if not completed in the bachelor's programme	German
Control of Medica Instrumentation	2.0	VO	3.0	SS					compulsory for Major if not completed in the bachelor's programme	English
Biomedical Device Design, Safety and Regulation										
Medizinische Gerätetechnik	2.0	VO	3.0	WS	3.0					German
Medizingerätesicherheit, Labor	2.0	LU	3.0	SS	3.0					German
Qualitäts- und Risikomanagement für Medizinprodukte	2.0	VO	3.0	WS	3.0					German
Medizinprodukterecht	2.0	VO	3.0	SS	3.0					German
Biomedical Sensor Systems 2	1.5	VU	2.0	SS	2.0					English
Practical Analog Circuit Design	2.0	UE	3.0	SS	3.0					English
Practical Analog Circuit Design, Laboratory	1.0	LU	1.5	SS	1.5					English
EMC of Electronic Systems	2.0	VO	3.0	WS	3.0					English
Grundlagen elektrischer Antriebe	1.5	VO	2.0	WS	2.0					German
Advanced Control in Biomedical Systems	2.0	VU	3.0	SS	3.0					English
Development of Electronic Systems	4.0	VO	6.0	WS	6.0					English
MB-Grundausbildung HCE 1	3.0	VU	4.0	WS	4.0					German
CAD	2.0	VU	3.0	SS	3.0				recommended VU "MB-Grundausbildung HCE 1"	German
CAE	2.0	VU	2.0	WS					recommended for major	German
Qualitäts- und Risikomanagement für Medizinprodukte	1.0	UE	1.5	WS						German
Medizinische Gerätetechnik	2.0	LU	3.0	SS						German
EMC of Electronic Systems, Laboratory	1.0	LU	2.0	WS					recommended for major	English
Grundlagen der Hochfrequenztechnik	2.0	VO	3.0	WS						German
Grundlagen der Hochfrequenztechnik	1.0	UE	2.0	WS						German
Energietechnik für biomedizinische TechnikerInnen	2.0	VO	3.0	SS						German
Microcontroller	1.5	VO	2.0	WS					recommended for major	English

Course	SSt	Type of course	ECTS	Semester	Compulsory component				Notes / Recommendation	Language
					Major	Minor 1	Minor 2	Minor 3		
Development and Design of Biomedical Devices	2.0	VO	3.0	WS						English
Subtotal					39.5	0.0	0.0	0.0		
Clinical Engineering										
GL der Hygiene und Mikrobiologie	2.0	VO	3.0	WS		3.0				German
Predictive Healthcare Information Systems	2.0	VO	3.0	WS		3.0				English
Krankenhaustechnik, Labor	2.0	LU	3.0	WS		3.0				German
Gesundheitssysteme und ökonomische Aspekte	2.0	SE	3.0	SS		3.0				German
Krankenhaus- und Projektmanagement	2.0	VO	3.0	WS		3.0				German
Rehabilitation Engineering	2.0	VO	3.0	WS						English
Health Care Engineering, Projekt	2.0	PT	3.0	SS						English
Medical Laser Technology	2.0	VO	3.0	WS						English
Strahlenschutz in der Medizin	2.0	VO	3.0	WS						German
Subtotal					0.0	15.0	0.0	0.0		
Cellular Electrophysiology and Sensors										
Cellular Electrophysiology and Models	2.0	VO	3.0	WS			3.0			English
Cellular Electrophysiology and Models, Laboratory	1.0	LU	1.5	SS			1.5		recommended VO "Cellular Electrophysiology and Models"	English
Biomedical Sensor Systems, Laboratory	2.0	LU	3.0	SS			3.0			English
Basics of Microelectronics	2.0	VO	3.0	WS			3.0			English
Chemical Analytics and Sensors	3.0	VO	4.5	SS			4.5			English
Sensor Networks	2.0	VU	3.0	SS						English
Medical Instrumentation	2.0	VU	3.0	WS						English
Biosignal Processing	2.0	VO	3.0	WS					recommended for Minor 2	English
Molecular Diagnostics	2.0	VO	3.0	SS						English
Molecular Diagnostics	2.0	LU	2.0	SS						English
Applied Electrophysiology and Sensors	2.0	VU	3.0	WS					recommended for Minor 2	English
Subtotal					0.0	0.0	15.0	0.0		
Overall total for the compulsory component					**39.5**	**15.0**	**15.0**	**0.0**		

Abbreviations: KU: design exercise; LU: laboratory course; PT: project; SE: seminar; SS: summer semester; SSt: semester hours; UE: exercise; VO: lecture; VU: lecture with integrated exercises; WW: winter semester

The non-technical catalogue of electives **b1 – Business, Law, Management and Soft Skills** is designed to be a minor.

Catalogue of electives: b1 – Business, Law, Management and Soft Skills						
Course	**SSt**	**Type of course**	**ECTS**	**Semester**	**Compulsory**	**Language**
Encyclopedia Business Economics	3.0	VO	4.5	SS	4.5	English
Encyclopedia Business Economics	2.0	UE	3.0	SS	3.0	English
Financial Management	2.0	VO	3.0	SS	3.0	English
Management Control Systems	3.0	VO	4.5	WS	4.5	English
Rhetoric und Presentation	2.0	SE	2.0	WS		English
Purchasing and Supply Management	3.0	VO	4.5	WS		English
Marketing Management	3.0	SE	3.0	SS		English
Research Design in Management Science	2.0	SE	2.0	WS		English
Buchhaltung und Bilanzierung	1.0	VO	1.0	WS		German
Buchhaltung und Bilanzierung	1.0	UE	1.5	WS		German
Kosten- und Erfolgsrechnung	1.0	VO	1.5	WS		German
Kosten- und Erfolgsrechnung	2.0	UE	2.0	WS		German
Bürgerliches Recht und Unternehmensrecht	2.0	VO	3.0	WS		German
Arbeitsrecht	2.0	VO	3.0	WS		German
Patentrecht	2.0	VO	3.0	WS		German
Steuerrecht	2.0	VO	3.0	WS		German
Marketing Intelligence	1.0	SE	1.0	SS		German
Betriebssoziologie	2.0	VO	3.0	WS		German
AK Controlling	4.0	SE	4.0	WS		German
Overall total for the compulsory component					**15.0**	

Abbreviations: SE: seminar; SS: summer semester; SSt: semester hours; UE: exercise; VO: lecture; WW: winter semester

The catalogue of electives **b2 – Bioinformatics** is designed to be a minor.

Catalogue of electives: b2 – Bioinformatics						
Course	**SSt**	**Type of course**	**ECTS**	**Semester**	**Compulsory**	**Language**
Biostatistics and Experimental Design	2.0	VU	3.0	WS	3.0	English
Statistical Genomics	2.0	VO	3.0	WS	3.0	English
Evolutionary Genomics (NEU)	2.0	VO	3.0	SS	3.0	English
Molecular Biology and Biochemistry of Genes	1.5	VO	2.0	WS	2.0	English
Machine Learning 2	2.0	VO	3.0	SS	3.0	English
Statistical Genomics	2.0	UE	3.0	WS		English
Evolutionary Genomics (NEU)	2.0	UE	3.0	SS		English
Molecular Diagnostics	2.0	VO	3.0	SS		English
Molecular Diagnostics	2.0	LU	2.0	SS		English
Perl programming for Bioinformatics (BioPerl)	5.0	VU	7.5	SS		English
System Biology (NEU)	2.0	VO	3.0	SS		English
System Biology (NEU)	2.0	UE	2.0	SS		English
Strukturelle Bioinformatik - Laborübungen	2.0	LU	2.0	WS		German

Strukturelle Bioinformatik - Molecular Modeling	2.0	VO	3.0	SS		German/English
Machine Learning 2	1.0	KU	2.0	SS		English
Molecular and Cellular Imaging	2.0	VO	3.0	SS		English
Biological Control, Modeling and Simulation	2.0	VO	3.0	SS		English
Biological Control, Modeling and Simulation	2.0	UE	3.0	SS		English
Biosignal Processing	2.0	VO	3.0	WS		English
Biosignal Processing	2.0	UE	3.0	WS		English
Knowledge Discovery and Data Mining 1	2.0	VO	3.0	SS		English
Knowledge Discovery and Data Mining 1	1.0	KU				English/German
Genetics	2.0	VO	3.0	WS		English
Biochemische Analytik	2.0	VO	3.0	WS		German
Biochemistry I	3.75	VO	5.625	SS		English
Biochemistry II	1.5	VO	2.0	WS		English
Bionanotechnology	2.0	VO	3.0	SS		English
Evolution	2.0	VO	3.0	WS		German
Genetic Engineering	2.0	VO	3.0	SS		German
Introduction to Biophysics and Biochemistry	2.0	VO	3.0	SS		English
Molekulare Analytik und Spektroskopie	2.66	VO	3.5	SS		German
Molekulare Humangenetik	2.0	VO	3.0	SS		German
Genregulation	2.0	VO	3.0	SS		German
Analyse von DNA- und Proteinsequenzen	2.0	UE	3.0	WS		German
Overall total for the compulsory component					**14.0**	

As an addition to the elective courses listed in § 5a, courses with the title “Selected Topics in [catalogue name: plus subheading]” can also be assigned to the corresponding catalogues of electives. These courses have descriptive subtitles and are offered with a total scope of 1-3 SSt for lectures and/or 1-2 SSt for exercises. Courses with different subtitles shall be classified as different courses.

“Replacement courses”: For this combination of major and minor, compulsory courses in the minor must be replaced according to the table.

Major	**Minor**	**Compulsory course in the minor to be replaced**	**Replacement course**
(1) Biomechanics: Modeling and Simulation	Biomedical Imaging	Medical Image Analysis VO	Microscopy VO
(2) Biomedical Instrumentation and Sensors	Neural Engineering	Medical Instrumentation VU Rehabilitation Engineering VO	Interdisciplinary Team-taught Lecture Series: Trends in Neurorehabilitation VO Neuroprosthetics LU
(3) Biomedical Instrumentation and Sensors	Cellular Electrophysiology and Sensors	Chemical Analytics and Sensors VO Biomedical Sensor Systems Laboratory LU	Sensor Networks VU Medical Laser Technology VO EMC of Electronic Systems, Laboratory LU
(4) Biomedical Imaging and Sensing	Biomolecular Analytics	Chemical Analytics and Sensors VO	Biomaterials VO Biomedical Sensor Systems 2 VU

(5)	**Biomedical Imaging and Sensing**	Bioinstrumentation	Chemical Analytics and Sensors VO	Molecular Diagnostics VO Biomedical Sensor Systems 2 VU
(6)	**Biomedical Imaging and Sensing**	Neural Engineering	Biological Control, Modeling and Simulation VO	Biological Control, Modeling and Simulation UE
(7)	**Biomedical Imaging and Sensing**	Cellular Electrophysiology and Sensors	Chemical Analytics and Sensors VO	Microscopy VO*) Microscopy LU*)
(8)	**Biomedical Imaging and Sensing**	Brain Computer Interfacing	Machine Learing 2 VO	Deep Learning VO
(9)	**Biomedical Imaging and Sensing**	Bioinformatics	Biostatistics and Experimental Design VU Machine Learning 2 VO	Statistical Genomics UE Knowledge Discovery and Data Mining 1 VO
(10)	**Computational Neuroscience**	Biomedical Imaging	Methods of Functional Brain Research VO	Biooptics VO Biooptics UE
(11)	**Computational Neuroscience**	Bioinformatics	Machine Learning 2 VO	Knowledge Discovery and Data Mining 1 VO
(12)	**Biomedical Device Design, Safety and Regulation**	Medical Electronics	EMC of Electronic Systems VO Practical Analog Circuit Design UE	Medical Instrumentation VU Rehabilitation Engineering VO
(13)	**Biomedical Device Design, Safety and Regulation**	Bioinstrumentation	Advanced Control in Biomedical Systems VU	Medical Laser Technology VO

Abbreviations: LU: laboratory course; UE: exercise; VO: lecture; VU: lecture with integrated exercises
*)Note: These course units may not be chosen from catalogue c5 of the minor, but rather from catalogue c3 of the major.

§ 5b Free-choice subject

The courses to be completed as part of the free-choice subject are designed to provide individual emphasis and further development of the students. They can be freely selected from the courses offered by any recognised Austrian or foreign universities, as well as universities of applied sciences and university colleges for education. A recommendation for this can be found in Part 3 of the Annex.

In addition, students are recommended to spread free-choice courses over the entire length of the programme.

If a course is assigned the same number of ECTS credit points in all curricula in which it is a compulsory or an elective course, it shall be allocated the same number of ECTS credit points when taken as a free-choice subject. If a course has been allocated varying numbers of ECTS credit points, the minimum number of assigned ECTS credit points is to be allocated to the course when taken as a free-choice subject.

Courses that are not intended either as a compulsory course or as an elective course are assigned 1 ECTS credit point for each semester hour (SSt). However, if such courses are lecture-type courses (VO), they are assigned 1.5 ECTS credit points for each semester hour.

§ 6 Admission to examinations

Admission to examinations is not subject to any prerequisites.

In order to assist students in completing their degrees in a timely manner, courses with continual assessment must allow students to submit, supplement or repeat partial course requirements no later than two weeks after commencement of the semester following the course.

§ 6a Guidelines for the allocation of places on courses

(1) If the number of students registered for a course exceeds the number of available places, parallel courses are to be provided.

(2) If it is not possible to offer a sufficient number of parallel courses (groups), the students are to be admitted to the course according to the following priority ranking:
   a) Students who are required to complete the course according to their curriculum have priority.
   b) Further students are to be ranked according to the sum of the successfully completed courses of the respective study programme (total ECTS credit points).
   c) Students who have met the participation requirement at an earlier date are ranked by date.
   d) Students who have already been placed on a waiting list or who have to repeat the course are to be given priority on the next course.
   e) The further ranking is made according to the grade of the examination or the average grade of the examinations (weighted on the basis of the ECTS credit points) of the respective course(s) that are specified as the participation requirement.
   f) Students who do not need to complete such courses in order to fulfil their curriculum are only considered based on the number of free places. It is possible to be included on a separate waiting list. The above-mentioned provisions shall apply accordingly.

(3) Students who complete a part of their studies at TU Graz in the context of mobility programmes are given priority for up to 10% of the available places.

§ 7 Examination regulations

Courses are evaluated individually.

1. Examinations for courses held as lectures (VO) cover the complete content of the course.
2. For courses held as lectures with integrated exercises (VU), exercise-based courses (PT, UE), design exercises (KU), laboratory courses (LU), seminar-type courses (SE, SP), and excursions (EX), a student's performance is continually assessed on the basis of that student's contributions and/or through accompanying tests. The assessment must always consist of at least two examinations.
3. Examinations with positive results are to be assessed as "very good" (1), "good" (2), "satisfactory" (3) or "sufficient" (4); those with negative results are to be assessed as "insufficient" (5). Specially indicated courses and excursion-type courses are assessed as "successful participation" or as "unsuccessful participation".
4. If a subject includes separate examinations for the relevant courses, the overall subject grade is to be determined by:
   a) multiplying the grade of each examination result in connection with the subject with the ECTS credit points of the corresponding course;
   b) adding the values calculated according to lit. a);

c) dividing the result of the addition by the sum of the ECTS credit points of the courses, and
d) rounding the result of the division to a whole-numbered grade if required. The grade must be rounded up if the decimal place exceeds 0.5. Otherwise, the grade must be rounded down.

The types of courses are explained in Part 4 of the Annex.

In addition to the types of courses, the maximum group sizes are as follows:

1. The maximum group size for exercise-based courses (UE), exercise components of lectures with integrated exercises (VU) and for design exercises (KU) is 30 students.
2. The maximum group size for seminars (SE) and excursions (EX) is 15 students.
3. The maximum group size for laboratory courses (LU) is 6 students.
4. The maximum group size for projects (PT) and seminar projects (SP) is 8 students. Alternatively, the Dean of Studies can commission the seminar/project with individual mentoring.

Lectures with integrated exercises (VU) are divided into lecture and exercise components, with 2/3 of the semester hours (SSt) being allocated to lecture components and 1/3 being allocated to exercise components.

§ 7a Final examination before a committee

Admission to the master's degree examination before a committee requires proof of the positive assessment of all examination results according to § 4 and § 5 above as well as proof of the positive assessment of the master's thesis.

The final examination before a committee takes place before an examination senate composed of three persons who are appointed by the Dean of Studies on a proposal from the student. The supervisor of the master's thesis must be part of the examination senate. In the event of the supervisor's incapacity, he/she can suggest a substitute.

During the master's degree examination before a committee, students must present their master's thesis written in accordance with the regulations, and must defend the thesis before the members of the examination senate in the subsequent oral examination. The final examination before a committee may not last longer than one hour.

§ 7b Degree certificate

The master's degree certificate contains the following information:

a) the major according to § 5 above and its assessment;
b) the minor incl. elective courses according to § 5 above and their assessment;
c) the title and the assessment of the master's thesis;
d) the assessment of the final examination before a committee;
e) the entirety of the ECTS credit points for successfully completed free-choice courses from the free-choice subject, as defined in § 5b above, and
f) the overall assessment

§ 8 Transitional provisions

Students of the master's programme in Biomedical Engineering who began their studies on October 1st, 2016 will be subject to the current version of the 2021 curriculum as of October 1st, 2021.

Regular students who started their master's degree programme in Biomedical Engineering before 1 October 2016 are entitled to continue and complete their studies until 30 September 2019 according to the previously valid curriculum as published in the University Gazette of TU Graz dated 2 May 2011. If the study programme is not completed within this period of time, students are subject to this curriculum for the rest of the study period. Students are entitled to voluntarily opt for the new curriculum at any time within the admission periods. To this end, a written irrevocable declaration must be sent to the Registration Office.

All courses that were completed when they were included in an earlier version of the curriculum for the bachelor's or master's degree programme in Biomedical Engineering and were not already assigned to the bachelor's degree programme in Biomedical Engineering may be credited in the master's degree programme in Biomedical Engineering. In this case, an individual subject is compiled (individual major and/or minor), whereby the Dean of Studies makes a decision on the proposal of the student and a name is defined for this subject (individual major/minor). If there is a difference of less than 10 ECTS credit points compared to a catalogue of electives listed in § 5a, the name may remain the same. All courses selected for an individual subject compilation must be completed.

§ 9 Legal validity

This curriculum 2016 in the version 2021 shall come into effect on 1 October 2021.

Versions of the curriculum:

Curriculum	Version	TU-GRAZonline Abbreviation	Published in the Newsletter TU Graz
2016	2016	16W	Newsletter of 03.08.2016, 21 copies
2016	2018	18W	Newsletter of 21.03.2018, 12a copies
2016	2021	21W	

Annex to the curriculum of the master's degree programme in Biomedical Engineering

Part 1 of the Annex:

Descriptions of the elective subjects listed in § 5a

Technical elective subject: c1 – Biomechanics

In the specialisation Biomechanical Engineering, the major Biomechanics: Modeling and Simulation and the minor Biomaterials are offered. Those studying the specialisation are

provided with a broad overview of the important, rapidly growing field of bioengineering. A wide range of topics is available, ranging from the basic theory of materials to biomechanical modelling and simulation, and numerical methods, with the focus on analysing the phenomena of biomaterials on the nano, micro or macro level in experiments, theoretically and numerically. This approach enables students to acquire a thorough understanding of biomechanics, which cannot be achieved through qualitative studies alone. In this way, students are equipped in the best possible way for the subject-specific industry as well as for research and development.

Major: *Biomechanics – Modeling and Simulation*

Subject content: The major provides the basics necessary for biomechanical modelling and simulation from the level of proteins to organs, based on experimental data. In particular, the mechanics of proteins and cells, biological and bio-based materials, healthy and diseased biological tissue, and tissue engineering are studied. The focus is on the finite element method (FEM), which has proven itself as a universal application method used by engineers to calculate complex materials, structures and processes – the application is taught in the Computational Biomechanics course.

Learning outcomes: After completing the major, students are able to simulate stresses and deformations in biomaterials and structures (cells, arteries, implants, etc.) and biomechanical processes using computer modelling. The knowledge acquired can be used in both mechanical engineering and civil engineering. Students are given an insight into the artificial production of biological tissue, which can replace or regenerate patients' diseased tissue.

Formal prerequisites: Completion of a subject-specific bachelor's degree programme in Biomedical Engineering, Mechatronics and Medical Engineering or a comparable degree programme.

Minor: *Biomaterials*

Subject content: The minor deals mainly with biological (and bio-based) materials, particularly with cells, biologically and artificially produced tissue and microscopy techniques, which can be used to identify the structure of these materials. In addition, the basics of the finite element method are taught in more detail.

Learning outcomes: After completing the minor, students have acquired knowledge that enables them to understand and analyse the structure and function of biomaterials, particularly of biologically and artificially produced tissue. This is made possible using microscopic, mathematical and numerical methods.

Formal prerequisites: Completion of a subject-specific bachelor's degree programme in Biomedical Engineering, Mechatronics and Medical Engineering or a comparable degree programme.

Technical elective subject: c2 – Biomedical Instrumentation and Sensors

The specialisation Biomedical Instrumentation and Sensors consists of the major Biomedical Instrumentation and Sensors and the minors Biomolecular Analytics, Medical Electronics and Bioinstrumentation. Students acquire extensive skills to understand biophysical and chemical mechanisms of sensors and transducers, their interaction with the

physiological system and the environment as well as the basics of the hardware necessary for signal processing and of hardware-related signal processing, and skills to use them to develop measurement, analysis and diagnosis systems. They have acquired the ability to solve complex problems that occur at the interface between biosystems or analytes and technical systems, and to develop systems for the optimum yield of diagnostic information.

Major: *Biomedical Instrumentation and Sensors*

Subject content: The subject provides in-depth knowledge from the fields of hardware-related aspects of biomedical measuring and diagnostic instruments, particularly of medical electronics, biosignal processing, biomedical sensor technologies, nanotechnological approaches for biosensors and biomedical analytics.

Learning outcomes: After completing the subject, students are able to independently create solutions to develop hardware and hardware-related components in biomedical sensor systems, measurement systems, laboratory analysis systems and diagnosis systems, and to implement them.

Formal prerequisites: There are no formal prerequisites, but basic knowledge of electronics and biomedical equipment technology is an advantage.

Minor: *Medical Electronics*

Subject content: The minor enables a specialisation focussing on analogue hardware development and provides further knowledge of electronics and microcontroller programming. The minor is intended as a specialisation for the major Biomedical Instrumentation and Sensors.

Learning outcomes: After completing the minor, students are able to design and optimise electronic assemblies for biomedical applications and to launch their production.

Formal prerequisites: There are no formal prerequisites, but basic knowledge of electronics and biomedical equipment technology is an advantage.

Minor: *Biomolecular Analytics*

Subject content: The minor is intended as a complementary subject to majors from other specialisations of the master's degree programme in Biomedical Engineering and cannot be studied in combination with the major Biomedical Instrumentation and Sensors. It broadens students' knowledge in the field of instrumental analytics, molecular diagnostics and the nanotechnological basics of biomedical sensor systems.

Learning outcomes: After completing the minor, students understand sensor and analysis systems that are based on molecular mechanisms. They are able to use this knowledge to solve complex assignments requiring strong interdisciplinary thinking.

Formal prerequisites: There are no formal prerequisites, but basic knowledge of electronics and biomedical equipment technology is an advantage.

Minor: *Bioinstrumentation*

Subject content: The minor is intended as a complementary subject to majors from other specialisations of the master's degree programme in Biomedical Engineering and cannot be studied in combination with the major Biomedical Instrumentation and Sensors. It broadens students' knowledge of several particularly important topics in biomedical instrumentation. In contrast to the two other minors in the specialisation, each of which focus on a certain aspect, it aims to provide a broad overview of biomedical instrumentation.

Learning outcomes: After completing the minor, students understand hardware concepts in medical engineering. They are able to use this knowledge to solve complex assignments, e.g. system integration and industrial design.

Formal prerequisites: There are no formal prerequisites, but basic knowledge of electronics and biomedical equipment technology is an advantage.

Technical elective subject: c3 – Biomedical Imaging and Sensing
The specialisation Biomedical Imaging and Sensing aims to familiarise students with the basic principles, equipment and methods to gather, process, analyse and visualise biomedical information. This field is an essential pillar in the diagnostic and therapeutic continuum and a prerequisite for further personalisation in medicine. Two minors allow students from other majors to become acquainted with specific topics of Biomedical Imaging and Sensing. Through the universality of the principles and methods used as well as the broad education in engineering basics, the possible sphere of activity extends far beyond biomedical issues.

Major: *Biomedical Imaging and Sensing*

Subject content: The major focuses on methods to gather diagnostic data and on biomedical imaging for morphological and functional information. It offers a range of modern methods and deals comprehensively with the underlying methods of preparing, analysing and quantitating biomedical data. In connection with the imaging techniques, the basics of and current developments in image processing and visualisation are addressed. For specific focus areas of the field, nuclear magnetic resonance and biooptics, diagnostic issues are addressed universally, from the methodological basics to the analysis, and are discussed in the context of alternative methods. The focus is also on various aspects for the determination of biomarkers in these fields.

Learning outcomes: After completing the study programme, students have acquired the knowledge and ability to develop methods and systems for diagnostic issues, treatment monitoring and governance of interventions, and to enable the successful use of these systems in healthcare. In addition, they are able to process, evaluate quantitatively and visualise biomedical data and images.

Formal prerequisites: Completion of a subject-specific bachelor's degree programme in Biomedical Engineering or a comparable degree programme.

Minor: *Optical Microscopy*

Subject content: The minor focuses on the basics and principles of biooptics, and also deals with the key microscopic methods in biomedicine. In addition, image processing methods are taught.

Learning outcomes: After completing the study programme, students understand the principles of biooptics and microscopy, and are able to define possible areas of application for microscopic methods and make concrete proposals for a particular problem. The basics and methods of biooptics should be mastered to an extent that they enable innovative methods to be developed and implemented.

Formal prerequisites: Completion of a subject-specific bachelor's degree programme in Biomedical Engineering or a comparable degree programme.

Minor: *Biomedical Imaging*

Subject content: The minor focuses on the methods of medical imaging and the processing and analysis of the data obtained. It is intended for students who either wish to supplement their curriculum in this field or who require medical image data for their major.

Learning outcomes: After completing the minor, students are able to describe the concepts of medical imaging, to understand and present typical technical solutions, to explain the advantages and disadvantages of imaging strategies, and to select and use image processing methods.

Formal prerequisites: Completion of a subject-specific bachelor's degree programme in Biomedical Engineering or a comparable degree programme.

Technical elective subject: c4 – Computational Neuroscience

Major: *Computational Neuroscience*

Subject content: The subject provides access to the most important methods currently known to further develop brain–computer interfaces, on the one hand, and to examine processes in the central nervous system with the help of computational methods on the other. In addition, practical experience of state-of-the-art software from the fields of machine learning, neural networks, simulation and modelling of technical systems, and mapping and imaging is promoted. As a result of this topic's interdisciplinary nature, the subject contains courses from the fields of biomedical engineering, computer science and neurosciences. The subject focuses on the practical implementation of the content learnt.

Learning outcomes: After completing the subject, students are familiar with the key algorithms, techniques and development of brain–computer interfaces and their applications, and the analysis of processes in the central nervous system. They know the advantages and disadvantages of the various methods and are able to solve practical and theoretical problems independently, and to examine brain processes for an assigned task or to design a brain–computer interface and create it accordingly.

Formal prerequisites: There are no formal prerequisites, but basic knowledge of computational intelligence, signal processing and programming is an advantage.

Minor: *Brain-Computer Interfacing*

Subject content: This minor focuses on the basics and principles of brain-computer interfaces, additionally dealing with the main methods of machine learning, functional brain mapping, and neural networks.

Learning outcomes: After completing the study programme, students are capable of setting up a brain-computer interface on their own, implementing the signal processing chain, including machine learning, and evaluating the data obtained. They will also learn the principles of functional brain mapping.

Formal prerequisites: Completion of a subject-specific bachelor's degree programme in Biomedical Engineering.

Minor: *Neural Engineering*

Subject content: This minor focuses on the basics and principles of rehabilitation and neurorehabilitation. The principles of neuroprosthetics are also taught. The unit also covers modelling and simulation principles.

Learning outcomes: After completing the programme, students will be familiar with the principles of rehabilitation technology and neurorehabilitation. This knowledge will enable students to create and implement new methods. The unit also teaches the basics and principles of neuroprosthetics, enabling students to develop and model new methods in this domain.

Formal prerequisites: Completion of a subject-specific bachelor's degree programme in Biomedical Engineering or comparable courses of study.

Technical elective subject: c5 – Health Care Engineering
The specialisation Health Care Engineering consists of the major "Biomedical Device Design, Safety and Regulation" and the two minors "Clinical Engineering" and "Cellular Electrophysiology and Sensors". Students acquire extensive skills that enable them to understand biophysical, electrophysiological, and medical and biological connections and to use them to develop biomedical devices and point-of-care technologies. They have learnt how to design and construct new biomedical systems and equipment, to recognise, monitor and assess safety risks, and to develop strategies and methods for healthcare provision in general.

Major: *Biomedical Device Design, Safety and Regulation*

Subject content: The subject provides students with knowledge for the conception, construction and safety assessment of biomedical modules, equipment and systems. These range from laboratory diagnostic systems to point-of-care technologies to be used directly on patients. As a result of this specialisation's interdisciplinary nature, the subject contains courses to deepen knowledge in the fields of electrical engineering, electronics and control technology, the basics of mechanical engineering and construction, and sensor

technologies as well as product development and safety concepts of biomedical equipment and systems.

Learning outcomes: After completing the major, students are able to design biomedical equipment and systems with complex measurement and control functions independently and implement them constructively, taking into account the safety aspects of medical products. They know the basic tools for designing equipment and systems and can reflect critically on and assess the entire product development process.

Formal prerequisites: Completion of a subject-related bachelor's degree programme in Biomedical Engineering, Mechatronics and Medical Engineering or a comparable degree programme.

Minor: *Clinical Engineering*

Subject content: The subject acquaints students with selected aspects of clinical engineering from the fields of equipment technology, and hospital technology, safety and organisation.

Learning outcomes: After completing the minor, students are able to apply and assess hospital processes and to assess the use of selected technologies.

Formal prerequisites: Major in Health Care Engineering is recommended.

Minor: *Cellular Electrophysiology and Sensors*

Subject content: The subject provides students with knowledge of electrophysiological processes and mechanisms on the level of cells, tissues and organs, and introduces the methods and sensor concepts to measure and interpret electrophysiological, biochemical and biophysical processes.

Learning outcomes: After completing the minor, students are able to model electrophysiological processes and validate them metrologically. In addition, students are familiar with selected principles of biomedical sensors, and are able to apply and evaluate these.

Formal prerequisites: Major in Health Care Engineering or Biomedical Instrumentation and Sensors is recommended.

Non-technical elective subject: b1 – Business, Law, and Management

Minor: *Business, Law, and Management*

Subject content: The subject cannot be chosen as a major. If it is chosen as a minor, the focus is on the basics of business management in terms of content. In addition, supplementary options include the legal aspects of operational management, accounting tools and management tools, aspects of industrial sociology and basic rhetorical training.

Learning outcomes: After completing the minor, students have acquired the necessary basics to be able to support or assume management positions in companies successfully.

Formal prerequisites: None

Elective subject: b2 – Bioinformatics

Minor: *Bioinformatics*

Subject content: The subject cannot be chosen as a major. The main focus of this minor is a combination of computer science, biological and mathematical methods to answer biomedical questions.

Learning outcomes: After completing the minor, students are able to

- understand current questions and problems from the biomedical sciences and translate them into the world of computer science and mathematics,
- to apply available mathematical models and IT approaches and programs, to question them critically and to modify them if necessary, and
- to translate proposed solutions from mathematics and computer science back into the world of life sciences.

Formal prerequisites: Completion of a subject-related bachelor's degree programme in Biomedical Engineering or a comparable degree programme.

Part 2 of the Annex:

Recognition and equivalence list

Courses for which the equivalence or recognition is defined in this part of the Annex to the curriculum do not require separate recognition by the Dean of Studies. Individual recognition awarded by means of an official decision made by the Dean of Studies according to § 78 UG is also possible.

An equivalence list defines the equivalence of successfully completed courses of this curriculum and of the previous curriculum. This equivalence applies in both directions, that is, successfully completed courses of the previous curriculum may be credited in this curriculum and successfully completed courses of this curriculum may be credited in the previous curriculum.

Courses that are the same with regard to name (even if this is an English translation of the German name) and type, number of ECTS credit points and number of semester hours are considered to be equivalent, and are therefore not listed explicitly in the equivalence list.

Equivalence list:

Present curriculum 2016 in the version 2021				Previous curriculum 2016 in the version 2018			
Course	**SSt**	**Type of course**	**ECTS**	**Course**	**SSt**	**Type of course**	**ECTS**
Applied Electrophysiology and Sensors	2.0	VU	3.0	SC Computational Bioengineering	2.0	SE	3.0
CAD	2.0	VU	3.0	CAD	2.0	KU	3.0
Computer Vision	2.0	VU	2.5	Computer Vision 1	1.5	VU	2.5
Gesundheitssysteme und ökonomische Aspekte	2.0	SE	3.0	Gesundheitssysteme und ökonomische Aspekte	2.0	VO	3.0
Inverse Problems in Biomedical Engineering	2.0	VO	3.0	Inverse Problems in Medical Imaging	2.0	VO	3.0
Inverse Problems in Biomedical Engineering	2.0	UE	2.0	Inverse Problems in Medical Imaging	2.0	UE	2.0
Machine Learning 1	2.0	VO	3.0	Computational Intelligence	2.0	VO	3.0
Machine Learning 1	1.0	UE	1.5	Computational Intelligence	1.0	UE	1.5
Machine Learning 2	2.0	VO	3.0	Machine Learning	2.0	VO	3.0
Machine Learning 2	1.5	KU	2.0	Machine Learning	1.0	KU	2.0
Physical Effects for Sensors	2.0	VO	3.0	Physics of Modern Materials	2.0	VO	3.0
Qualitäts- und Risikomanagement für Medizinprodukte	2.0	VO	3.0	Grundlagen des Qualitätsmanagements in der Medizin	2.0	VO	3.0
Qualitäts- und Risikomanagement für Medizinprodukte	1.0	UE	1.5	Grundlagen des Qualitätsmanagements in der Medizin	1.0	UE	1.5

Abbreviations: LU: laboratory course; PR: project; SE: seminar; SP: seminar project; SSt: semester hours; UE: exercise; VO: lecture; VU: lecture with integrated exercises

The equivalence list in the curriculum for the master's degree programme in Biomedical Engineering from 2011 remains valid.

A list of recognition, on the other hand, defines in which cases positively completed lectures of the previous curriculum are recognized as positively completed lectures of the current curriculum, whereby no automatic crediting in the opposite direction is planned.

Recognition list:

Present Curriculum 2016 in the version 2021				Previous Curriculum 2016 in the version 2018			
Course	**SSt**	**Type of course**	**ECTS**	**Course**	**SSt**	**Type of Course**	**ECTS**
Biomedical Sensor Systems, Laboratory	2,0	LU	3,0	Medical Instrumentation	2,0	VU	3,0
Cognitive Neuroscience	2,0	VO	3,0	Information Processing in Humans	2,0	VO	3,0
Deep Learning	2,0	VO	3,0	Neural Networks	2,0	VO	3,0
Deep Learning	1,0	KU	2,0	Neural Networks	1,0	KU	2,0

Part 3 of the Annex:

Recommended free-choice courses

Free-choice courses can be freely chosen from the courses offered at any recognised Austrian and foreign universities, universities of applied sciences and university colleges for education according to § 5b of this curriculum.

In order to broaden students' basic knowledge in the subjects of this study programme, courses in foreign languages, social competence, technology assessment and women's and gender studies are recommended. In particular, we would like to refer students to the courses offered by the TU Graz service department Languages, Key Competencies and In-House Training, the Centre for Social Competence of Uni Graz as well as the Inter-University Research Centre for Technology, Work and Culture (IFZ).

Part 4 of the Annex:

Types of courses offered by TU Graz

The types of courses are defined in the relevant regulations of the standard curriculum (decision of the Senate of Graz University of Technology dated 6 October 2008, announced in University Gazette No. 5 dated 3 December 2008), as follows:

1. Lectures (VO)
   In lecture-type courses, students are given a didactically well-structured introduction to the sub-areas of the subject and its methods. In lectures, the content and methods of a subject are presented.

2. Exercise-based courses (UE, KU, PT, EX)
   In exercises, abilities and skills are taught as part of a scientific pre-vocational education to deepen or broaden the subject matter of the respective lectures. These exercises may comprise practical, experimental, theoretical or design work. The curriculum may specify that the successful completion of the exercise is a requirement to register for the examination of the respective lecture.

   a) UE
      In exercises, students develop the ability to apply their subject knowledge to solve specific problems.

   b) KU
      In design exercises, abilities and skills are taught as part of a scientific pre-vocational education to deepen or broaden the subject matter of the respective lectures by means of design work. Special equipment or a specially equipped room is required.

   c) PT
      In projects, experimental, theoretical or design applied work is carried out, or small research papers are written, taking into account all necessary steps. Projects are completed with a written paper that is part of the assessment. Projects can be carried out as teamwork or individual work; in the case of teamwork, it must still be possible to assess individual performance within the team.

   d) EX
      Excursion-type courses help to illustrate and consolidate the content of this type of course. Due to their practical relevance outside the place of study, excursions help to illustrate the content developed in other types of courses.

3. Lecture with integrated exercises (VU)

In addition to the introduction in sub-areas of the subject and its methods, lectures with integrated exercises (VU) also offer guidance on independent acquisition of knowledge or independent application using examples. The percentage of lectures and exercises is specified in the curriculum. These courses are courses with continual assessment.

4. Laboratory courses (LU)
   Laboratory courses (LU) deepen and/or broaden the subject matter of the respective lectures by means of practical, experimental or design work. Students are taught abilities and skills as part of a scientific pre-vocational education and training with particularly intensive tutoring. An essential component of the laboratory courses is the drawing up of short logs on the work carried out.

5. Seminar-type courses (SE, SP)
   Seminar-type courses enhance scientific work and discussion, and are intended to introduce students to expert-level discourse and argumentation. In this context, students have to write papers or give an oral presentation and take part in critical discussions. Seminars are courses with continual assessment.

   a) SE
      Seminars introduce students to scientific methods, to the development and critical assessment of their own work results, and to special topics in scientific literature, and provide them with exercises in technical discussions.

   b) SP
      In seminar projects, students apply scientific methods to work on experimental, theoretical or design applied problems; or they carry out short research assignments, taking into account all the necessary steps. Seminar projects are completed with a written paper and an oral presentation that are part of the assessment. Seminar projects can be carried out as teamwork or individual work; in the case of teamwork, it must still be possible to assess individual performance within the team.

The regulations referred to at the beginning also encompass provisions concerning the implementation and assessment of the different types of courses. In particular, they stipulate the following:

In lectures (type of course VO), the assessment takes place by way of a final examination that – at the discretion of the examiner – may be a written examination, an oral examination, a written and an oral examination, as well as a written or an oral examination. The examination procedure must be announced in the course description.
Courses of the type VU, SE, SP, UE, KU, PT, EX and LU are courses with continual assessment.