Curriculum for Biomedical Engineering M.Sc.

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1 Introduction to Medical Engineering / Einführung in die Medizintechnik, 1st Sem.

Introduction to Medical Engineering					
Workload 180 h	**Credits/CP** 6	**Semester** 1	**Frequency of module** Once a year		**Duration** 1 Semester
Module a) Medical Engineering Lab b) Fundamentals of Medical Engineering	**Teaching Language** English	**Contact hours** a) 2 SWS / 22,5 h b) 2 SWS / 22,5 h	**Self-study** a) 67,5 h b) 67,5 h	**Class size** a) 24 b) 24	

2 **Learning outcomes**

On successful completion of this module you should be able to

Knowledge: After successful participation in the module, students will

- Know the basics of biomedical engineering and its related industry
- Receive updates on recent medical research topics
- Receive in depth knowledge of focus topics in the biomedical field based on the lecturers expertise
- Be introduced and on-boarded into product development processes and regulatory affairs

Comprehension: After successful completion of the module, students will be able to

- Understand the role of a medical engineer
- Understand the differences and commonalities to other engineering disciplines
- Acknowledge the importance of regulatory affairs and the respect for safe medical products

Application: After successful completion of the module, students will be able to

- Think and act scientifically within the field of biomedical engineering
- Apply related standards, guidelines and laws related to the medical market
- Apply selected methods and principles within the Technical Documentation
- Apply knowledge from focus topics in the biomedical field
- Applied engineering techniques within practicum sessions

Analysis: After successful completion of the module, students will be able to:

- Navigate in various disciplines of medical engineering and establish their own interest within this field
- Deep dive into research and industry topics

Synthesis: After successful completion of the module, students will be able to:

- Understand business and engineering process in the medical industry
- Receive a general overview of the medical engineering field and exchange pre-knowledge with peers of the semester.

3 **Individual component content**

a) Medical Engineering Lab

Practical training on mechano-electrical principles and experiments related to medical products

b) Fundamentals of Medical Engineering

Introduction into the origin of medical engineering discipline
Relation of patient safety to regulatory and biocompatible factors
Product development
Selected Medical devices, systems, implants, instruments and materials

4 **Teaching methods**

a) Lecture, Practical training / Lab
b) Lecture, Seminar

5 **Prerequisites**

Bachelor Degree studies
Undergraduate programming skills, basic electronic circuits and signal analysis skills (Signal acquisition, amplifier design, signal)
Receptive to engineering work approaches (Researching, presentation skills, engineering math)

6 **Methods of assessment**

a) 2 oral examinations on practical tasks (each 50%)
b) 1 exam

7 **Applicability of module**

Mandatory module in BME/elective in other study programs if places are available

8 **Person responsible for module/ lecturer**

Prof. Dr. Massimo Kubon

9	**Reading list** (Core texts and recommended texts) - Hosseinzadeh, H. (2025). Fundamentals of medicine for biomedical engineering. Springer Nature Switzerland. - Boccato, Carlo, Sergio Cerutti, and Joerg Vienken, eds. *Medical Devices: Improving Health Care Through a Multidisciplinary Approach*. Springer, 2022. - Bronzino, J. D. ed. (2014): The Biomedical Eningeering Handbook, 4th edition, CRC Press, 2014. - Carr/Brown,. (2000): "Introduction to Biomedical Equipment Technology", Prentice Hall, 2000

2 Simulation, 1st Sem.

<table>
<tr><td colspan="7">Simulation</td></tr>
<tr><td colspan="2"></td><td>Workload
180 h</td><td>Credits/CP
6</td><td>Semester
1</td><td>Frequency of module
Once a year</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="2">Module
a) Simulationstechnik (Simulation)
b) Computermathematik</td><td colspan="2">Teaching Language
english</td><td>Contact hours
a) 2 SWS / 22,5 h
b) 2 SWS / 22,5 h</td><td>Self-study
a) 67,5 h
b) 67,5 h
Class size
a) 30
b) 30</td></tr>
<tr><td>2</td><td colspan="6">Learning outcomes
On successful completion of this module you should be able to
Application (3):
- describe and generalize mathematical models for processes
- solve initial value problems numerically
- apply the Method of Lines to translate a partial differential equation to a system of ordinary differential equations
- apply methods of parameter identification to identify parameters of static and dynamic systems based on measured data
- implement dynamic systems in SIMULINK and design closed-loop controllers
Analysis (4) / Synthesis (5):
- calculate steady states and analyze their stability
- determine parameters in dynamical systems
- outline the ideas of relevant scientific publications, reproduce results and inspect for reproducibility
- understand mathematical problems and solve these by implementing appropriate algorithms in MATLAB
- compile graphical user interfaces and implement methods to prevent user based software errors.</td></tr>
<tr><td>3</td><td colspan="6">Individual component content
a) Ordinary differential equations:
- Steady states, asymptotic stability
- Numerical solution with MATLAB ODE solvers
- Reaction kinetics: enzyme reactions, pseudo steady state hypothesis
- fitting ODE parameters
- Numerical solution of partial differential equations: Method of lines
b)MATLAB/SIMULINK programming skills:
- vector based calculus
- import, export and graphic representation of data and simulation results
- functions and scripts for automated execution of algorithms
- parameter identification using MATLAB functions
- compiling graphical user interfaces using MATLAB GUIDE
- toolboxes and blocksets in SIMULINK
- implementing dynamic systems in SIMULINK
- SIMULINK based controller design</td></tr>
<tr><td>4</td><td colspan="6">Teaching methods
a) Lecture, MATLAB exercises
b) Lecture, MATLAB exercises</td></tr>
<tr><td>5</td><td colspan="6">Prerequisites
Undergraduate Mathematics:
- Matrices: systems of linear equations, determinant;
- Calculus: (partial) derivatives, elementary differential equations

Basics of text based programming:
- Boolean algebra
- Basic algorithms (loops, conditions)
- Use of functions/methods, local and global variables</td></tr>
<tr><td>6</td><td colspan="6">Methods of assessment
a) Simulation: 1 written examination (50%), 1 presentation (50%)
b) Computermathematik: 1 assignment (100%)</td></tr>
<tr><td>7</td><td colspan="6">Applicability of module
Mandatory module in BME/elective in other study programs</td></tr>
<tr><td>8</td><td colspan="6">Person responsible for module/ lecturer
Dr. Jörn Kretschmer</td></tr>
</table>

9	**Reading list (Core texts and recommended texts)** a) Murray, J. D. (2002): Mathematical Biology. Springer-Verlag, 2002. Teufel, P. E. (2004): Eine Dosierungshilfe für Insulin bei Typ 1 Diabetis. Dissertation, Universität Ulm, 2004. Bergman, R. N. (2003): The Minimal Model of Glucose Regulation: A Biography. In: Novotny, J. A., Green, M. H., Boston, R. C. (eds.) Mathematical Modeling in Nutrition and the Health Sciences. Advances in Experimental Medicine and Biology, Volume 537, Kluwer Academic/Plenum Publishers, New York b) Beucher, O. (2008): "MATLAB und Simulink: Grundlegende Einführung für Studenten und Ingenieure in der Praxis", Volume 4, Pearson Studium MATLAB GUIDE toolbox tutorial: http://www.mathworks.com/access/helpdesk/help/techdoc/creating_guis/bqz6p81.html

3 Measurement Technology/ Messtechnik, 1st Sem.

Messtechnik / Measurement						
	Workload 180 h	**Credits/CP** 6	**Semester** 1	**Frequency of module** Once a year		**Duration** 1 Semester
1	**Module** a) Programming b) Sensorik	**Teaching Language** English	**Contact hours** a) 20 h b) 2 SWS / 22,5 h	**Self-study** a) 70 h b) 67,5 h	**Class size** a) 30 b) 30	
2	**Learning outcomes** On successful completion of this module, you should be able to **Application (3)**: - Build basic electronic circuits to read digital and analog inputs - Use appropriate libraries to use various sensors and actuators - Apply bitwise operators - employ interrupt service routines in order to react to events - apply print/read customization to direct input/output to specific hardware - Use arrays and pointers to access and store data - Create functions, classes and libraries to optimize code **Analysis (4):** - Analyze serial communication signals					
3	**Content** **Individual component content** a) C/C++ Basics: - Local/global variables - Preprocessor directives - Console output/keyboard input - Pointers - Bitwise operators - Arrays - Digital I/O, Interrupts - Analog-to-Digital Conversion - Serial communication, I2C bus, SPI bus - Basic electronics (LEDs, resistors, floating inputs, pull-up/pull-down circuits) b) Biomedical sensors - General biomedical signal processing - Origin and characteristics of biomedical signals - Biopotential amplifiers - Analog signal processing - Digital signal processing - General requirements for safety - Electrocardiogram - Electroencephalogram - Electromyogram - Invasive and noninvasive blood pressure measurement - Infrared temperature measurement - Ultrasound measurement systems - Magnetic resonance imaging					
4	**Teaching methods** a) Lecture, lab b) Lecture, student's projects					
5	**Prerequisites** **a)** Basics of text based programming b) Basics of electrical engineering and electronics, basics in anatomy and electrophysiology					
6	**Methods of assessment** a) programming: assignments, lab assessment **b)** 1 written examination					

7	**Applicability of module** Mandatory module in BME/elective in other study programs
8	**Person responsible for module/ lecturer** Dr. Jörn Kretschmer
9	**Literature** (Core texts and recommended texts) a) - Mike Banahan, Declan Brady, Mark Doran: The C Book. Addison Wesley, 1991. http://publications.gbdirect.co.uk/c_book/ b) - John D. Enderle, Susan M. Blanchard, Joseph D. Bronzino: Introduction to biomedical engineering. Elsevier Academic Press, 2005. - Eugene N. Bruce: Biomedical signal processing and signal modeling. Wiley, 2009.

4 Modeling and Systems Theory / Modellbildung und Systemtheorie 1st Sem.

Modeling and systems theory					
	Workload 180 h	**Credits/LP** 6	**Semester** 6	**Frequency of course** once a year	**Duration** 1 Semester

1	**Module**	**Language**	**Contact hours**	**Self study**	**Class size**
	a) Modeling b) Sytems Theory	english	a) 2 SWS / 22,5 h b) 2 SWS / 22,5 h	a) 37,5 h b) 37,5 h	a) 30 b) 30

2 Learning outcome

Knowledge (1):

upon successful completion of the module you should be able to (,)

- know the terminology and basic principles of control theory

Understanding (2):

upon successful completion of the module you should be able to(,)

- understand modeling (for) in the context of controlled systems and processes
- understand the difference between open and closed loop control and (are) be able to illustrate the mathematical principles of controlled systems in Laplace and time scale.
- design a speed and position controlled system

Application (3):

upon successful completion of the module you should be able to(,),

- Mathematically describe power systems with elastically coupled mechanical structures
- determine the stability of open and closed loop systems
- establish mathematical models (ordinary differential equations) of different controlled systems

Analysis (4):

upon successful completion of the module you should be able to(,)

- analyze the statistical and dynamical behavior of controlled systems in both time and frequency domain and determine their characteristics and physical parameters
- determine the resulting behavior of controlled systems for different inputs in the time domain and transform them into the frequency domain
- construct a p-controler as well as a cascading p- and pi-controller
- evaluate the quality of a controlled systems and its dynamical behavior
- graph a Bode-diagram of the frequency domain of controlled systems
- analyze the systems behavior using the Nyquist theorem and determine the amplification factor of a controlled system

3 Content

a) and b)

- Modeling of power systems and mechanical transmission elements
- Laplace-transformation
- Input and output signals in time and frequency domain
- Behavior of controlled systems in the time domain establishment of characteristics and physical parameters
- Pole zero plot
- Transfer elements and their transfer functions
- Block diagram
- Frequency response, Bode diagram, Nyquist plot
- Stability prameters, Hurwitz criterion, central limiting value theorem
- Linear controlled systems, Nyquist method
- P-/PI control

4 Teaching methods

a) lecture
b) b) lecture

5 Prerequisites

a) and b):
basics of measument and control theory, technical mechanics 1 and 2, dynamics, mathematics for engineers, physics

6 Methods of assessment

One written exam (50%) and homework during semester (50%)

7 Applicability of module

Mandatory module in BME/elective in other study programs

8 Person responsible for module/ lecturer

Prof. Dr. Ketterer

9	**Literature** a) & b)		
		H. Lutz, W. Wendt	Taschenbuch der Regelungstechnik Verlag Harri Deutsch, 7. Auflage 2007, ISBN 978-3817118076
		O. Föllinger	Regelungstechnik, Hüthig Verlag, 5. verbesserte Auflage 1985, ISBN 3-7785-1137-8
		R. Isermann	Identifikation dynamischer Systeme. Springer Verlag; Band I und Band II; 1988.
		R. Isermann	Regelungstechnik Band 1 - 3. Braunschweig, Wiesbaden: Friedrich Vieweg & Sohn, 1988.
		H. Unbehauen	Regelungstechnik Band 1 - 3. Braunschweig, Wiesbaden: Friedrich Vieweg & Sohn, 1988.
		S. Zacher	Übungsbuch Regelungstechnik, Vieweg + Teubner Verlag, 2010

5 Management competences/Management Kompetenzen, 1st Sem.

<table>
<tr><td colspan="7">Management competences</td></tr>
<tr><td colspan="2">Module Code</td><td>Workload
180 h</td><td>Credits
6</td><td colspan="2">Semester
1</td><td>Frequency of course
once a year</td><td>Duration
1 semester</td></tr>
<tr><td>1</td><td colspan="2">Module
a) Project management
b) Scientific writing
c) Language or any other course with management content</td><td>Language
English</td><td colspan="2">Contact hours
a) 2 SWS (22,5h)
b) 2 SWS (22,5h)
c) 2 SWS (22,5h)</td><td>Self-study
a) 67,5h
b) 67,5h
c) 67,5h</td><td>Class size
a) 24
b) 24
c) 24</td></tr>
<tr><td>2</td><td colspan="7">Learning outcome
On successful completion of this module you should be able to
Comprehension (2) / Application (3):
a) - understand the definition and key characteristics of a project, the project triangle, and different project types and organizational structures
- describe and compare traditional, agile, and hybrid approaches to project management
- describe and apply core tools for project initiation, planning, and controlling
b) understand and apply the basic principles of scientific writing in the generation of a scientific/experimental paper
c) gain management competences depending on content of course
Analysis (4)/ Synthesis (5):
a) - select and adapt project management methods to the specific context and size of a project
- develop a project charter, define requirements, and create a structured project plan including work packages, schedule, and resource allocation
- apply agile methods (Scrum, user stories) and evaluate their suitability compared to traditional approaches
b) - critically analyse ideas in the field of human machine Interaction in relation to the state of the art and edit them for presentation in a scientific paper
c) depends on content of the course</td></tr>
<tr><td>3</td><td colspan="7">Content
a) fundamentals of project management and product development process:
Introduction to PM; product development process; project proposal and project charter; requirements management; project planning (work packages, schedule, resource allocation); communication; project controlling and risk management; agile manifesto and Scrum
b) experimental from data to scientific publication
scientific writings the core objective, exercises are done with the important field of human machine interfaces
c) depends on course chosen</td></tr>
<tr><td>4</td><td colspan="7">Teaching methods
a) lecture,
b) lecture, seminar
c) depends on course chosen</td></tr>
<tr><td>5</td><td colspan="7">Prerequisites
Basic knowledge of literature search
Understanding of scientific publications</td></tr>
<tr><td>6</td><td colspan="7">Methods of assessment
a) written exam
b) written elaboration during semester
c) depends on course chosen</td></tr>
<tr><td>7</td><td colspan="7">Applicability of module
Mandatory module in BME/ elective in other study programs</td></tr>
<tr><td>8</td><td colspan="7">Person responsible for module /lecturer
Ulrich Kallmann</td></tr>
<tr><td>9</td><td colspan="7">Literature
a)
- Kuster, J., Bachmann, C., Hubmann, M., Lippmann, R., & Schneider, P. (2023). Project Management Handbook: Agile – Traditional – Hybrid. Springer.
- Singh, H., & Williams, P. S. (2021). A Guide to the Project Management Body of Knowledge: PMBOK Guide. Project Management Institute.
- Verzuh, E. (2016). The Fast Forward MBA in Project Management (5th ed.). Wiley.
Rubin, K. S. (2013). Essential Scrum: A Practical Guide to the Most Popular Agile Process. Addison-Wesley.
b)
- Thomas A. Lang (2009). How to Write, Publish, and Present in the Health Sciences: A Guide for Physicians and Laboratory Researchers. American College of Physicians.
- Michael Jay Katz (2009). From Research to Manuscript: A Guide to Scientific Writing. Springer Verlag.
- Mimi Zeiger (1999). Essentials of Writing Biomedical Research Papers. Second Edition. McGraw-Hill Professional</td></tr>
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6 Research practical /Forschungspraktikum, 2nd Sem. ME

Research practical medical engineering						
Module code	**Workload** 180 h	**Credits/CP** 6	**Semester** 2	**Frequency of module** Once a year	**Duration** 1 Semester	
1	**Module** Forschungspraktikum	**Teaching Language** english	**Contact hours** 2 SWS / 22,5 h	**Self-study** 157,5 h	**Class size** 20 in groups of 1 or 2 students	
2	**Learning outcomes** On successful completion of this module you should be able to **Analysis (4):** - plan and perform scientific investigations in the field of Biomedical Engineering - perform a focused literature research, evaluate and summarize the relevant state of the art **Synthesis (5)** - apply methods of Biomedical Engineering to a specific application - perform statistical analysis on experimental data **Evaluation (6):** - evaluate the quality of different approaches, - describe your work in a scientific report comparable to reports published on international conferences - summarize and explain results in a scientific presentation					
3	**Individual component content** From project description to scientific publication: - specification of project, especially formulation of a clear objective - Summarize the state of the art - selection and realization of appropriate methods - perform experiments to obtain significant results - discussion and critical review of the relevance of your obtained solution - formulation of a proper conclusion - short presentation of your research highlighting the main findings					
4	**Teaching methods** lecture, practical training, presentations					
5	**Prerequisites** Undergraduate programming, electronic circuits, signal analysis - basic understanding of medical concepts - Signal acquisition, signal analysis - optimization, model design Scientific writing and presentation skills:					
6	**Methods of assessment** - research (50%) - written report (30%) - presentation (20%)					
7	**Applicability of module** Mandatory module in BME/elective in other study programs					
8	**Person responsible for module/ lecturer**					
9	**Literature** - Reading list (Core texts and recommended texts) - Kramme,R. ed.. (2011): Medizintechnik. Springer-Verlag, 2011. - Bronzino, J. D. ed. (2014): The Biomedical Eningeering Handbook, 4th edition, CRC Press, 2014. Special scientific papers to be searched in relevant databases depending on the subject of research					

7 Medical Modeling/Medizinische Modellbildung, 2nd Sem. ME

Medical Modeling						
Module code	**Workload** 180 h	**Credits/CP** 6	**Semester** 2	**Frequency of module** Once a year		**Duration** 1 Semester
1	**Module** a) Computer Modeling in medical domains b) Medical computer Model lab	**Teaching Language** english	**Contact hours** a) 2 SWS / 22,5 h b) 2 SWS / 22,5 h	**Self-study** a) 67,5 h b) 67,5 h		**Class size** a) 20 b) 20
2	**Learning outcomes** On successful completion of this module you should be able to **Comprehension (2) / Application (3):** - understand the concept of system identification - describe different approaches to prove identifability - understand the importance of identifiability in model based therapy in Medicine **Analysis (4) / Synthesis (5):** - compare different modeling approaches - analyze properties of model formulations e.g. computational complexity, stability, identifiability - develop own models and derive formal mathematical representations - understand mathematical problems and solve these by implementing appropriate algorithms in MATLAB - combine approaches on different levels to "multi-level" models - derive simple approaches for model-based optimization in medical applications **Evaluation (6):** - demonstrate and explain results in a scientific presentation - determine model parameters in dynamical systems - analyze robustness of system, identify sensitivity on parameter settings.					
3	**Individual component content** a) From physiology to mathematical represenations: - Physiology of gas exchange, pulmonary mechanics, cardio-vascular systems - Modeling basics, system equations, transforms - Mathematicalrepresentations - Sensitivity analysis - hierarchically structured models b) From mathematical representations to therapeutic decisions: - Signal acquisition and evaluation - System identification, structural, practical identifiability - identification in hierarchies of models					
4	**Teaching methods** a) Lecture, practical training b) Lecture, practical training					
5	**Prerequisites** Undergraduate programming, electronic circuits, signal analysis, : - Physiology of organ systems - Signal acquisition, amplifier design, signal analysis Basics of engineering and presentation skills: - measurement devices - engineering math - scientific presentation					
6	**Methods of assessment** 1 written paper (50%), 1 presentation during Semester (50%)					
7	**Applicability of module** Mandatory module in BME/elective in other study programs					
8	**Person responsible for module/ lecturer** Prof. Mike Fornefett					

9	**Literature** (Core texts and recommended texts) a) Khoo, . (2011): -Verlag, 2011. Bronzino, J. D. ed. (2014): The Biomedical Eningeering Handbook, 4th edition, CRC Press, 2014. b) Lennart/Ljung. (2000): "Introduction to System Identification", Prentice Hall, 2000 Schranz, Chr (2013)

8 Signal processing/Signalverarbeitung, 2nd Sem. ME

<table>
<tr><td colspan="7">Signal processing</td></tr>
<tr><td colspan="2"></td><td>Workload
180 h</td><td>Credits/CP
6</td><td>Semester
1</td><td>Frequency of module
Once a year</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="2">Module
a) Image processing, Computer Graphics
b) Biosignal-Processing</td><td>Teaching Language
English</td><td>Contact hours
a) 2 SWS / 22,5 h
b) 2 SWS / 22,5 h</td><td>Self-study
a) 67,5 h
b) 67,5 h</td><td>Class size
a) 30
b) 30</td></tr>
<tr><td>2</td><td colspan="6">Learning outcomes
On successful completion of this module you should be able to
a)
Application (3):
- apply different methods of image processing
- apply different tools of image processing
Analysis (4):
- realize application possibilities of image processing
- assess results of image processing
- optimize methods of image processing
b)
Application (3):
- design a system for digital signal processing
- apply various window functions during discrete Fourier transform
- calculate parameters of digital filters
- apply different methods for coding / decoding of biosignals
- design systems for pattern recognition
Analysis (4):
- analyze the transfer functions of discrete systems in time and frequency domain
- assess results of a discrete Fourier transform and optimize the result
- optimize digital filters
- optimize systems for problem dependant pattern recognition</td></tr>
<tr><td>3</td><td colspan="6">Individual component content
a) Digitalization, histogram, Fourier-Transform, filtering, texture, classification, 3D-imaging, segmentation methods, colour quantification, data compression methods, JPEG, Wavelet-Transform, Radon-Transform
b) Digital Signal Processors
- Sampling and analog-digital/digital-analog conversion
- Discrete signals and systems
- Z-Transform, Discrete Fourier Transform
- Design of digital filters (FIR/IIR)
- Coding and decoding of signals
- Methods of pattern recognition</td></tr>
<tr><td>4</td><td colspan="6">Teaching methods
a) seminar
b) Lecture, student's projects</td></tr>
<tr><td>5</td><td colspan="6">Prerequisites
a) Basic Mathematics
b) Basics of electrical engineering and electronics</td></tr>
<tr><td>6</td><td colspan="6">Methods of assessment
a) Presentation & summary paper
b) 1 written examination (70%), 1 presentation (30%)</td></tr>
<tr><td>7</td><td colspan="6">Applicability of module
Mandatory module in BME/elective in other study programs</td></tr>
<tr><td>8</td><td colspan="6">Person responsible for module/ lecturer
Module: Prof. Dr. U. Busolt
Lecturer: Prof. Dr. U. Busolt / Prof. Dr. Mike Fornefett</td></tr>
</table>

9	**Literature** (Core texts and recommended texts) - Gonzalez, R.C., Woods, R.E.: *Digital Image Processing.* Sec. Ed., Prentice Hall 2003 - Abmayr: Einführung in die digitale Bildverarbeitung 2.Aufl., Stuttgart: Teubner 2002 - Tietze, U., Schenk, Ch.: Halbleiter-Schaltungstechnik, Springer, 2012. - Werner, M.: Digitale Signalverarbeitung mit MATLAB, Vieweg, 2012. Kammeyer, K-D., Kroschel, K.:Digitale Siganlverarbeitung, Teubner, 2012. Theodoridis, S.: Pattern Recognition, Elesevier, 2008.

9 Advanced Medical Technologies, 2nd Sem.

<table>
<tr><th colspan="7">Advanced Medical Technologies</th></tr>
<tr><td colspan="2"></td><td>Workload
180 h</td><td>Credits/CP
6</td><td>Semester
1</td><td>Frequency of module
Once a year</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="2">Module
a) Minimal Invasive Medicine / Technologies
b) Artificial Organs</td><td>Teaching Language
English</td><td colspan="2">Contact hours
a) 2 SWS / 22,5 h
b) 2 SWS / 22,5 h</td><td>Self-study
a) 67,5 h
b) 67,5 h
Class size
a) 30
b) 30</td></tr>
<tr><td>2</td><td colspan="6">Learning outcomes
On successful completion of this module you should be able to
Application (3):
- understand how to use Artif. Org. in an optimal manner (machine and device)
- decide upon parameters like external blood flow, pressures, etc..
- provide ideas for further development of Artif. Org.
- discuss features of minimally invasive diagnostic and surgical techniques with surgeons
Analysis (4):
- understand basics in mass transfer of most important components
- identify shortcomings of currently available surgical instrumentation
- analyse the requirements for instruments and equipment needed to implement new techniques
Synthesis (5):
- develop ideas for the technical implementation of new techniques</td></tr>
<tr><td>3</td><td colspan="6">Individual component content
a) Minimally Invasive Med.:
- Basic techniques of minimally invasive medicine (e.g. laparoscopy, endoscopy)
- Technical requirements: instruments, endoscopy, electrosurgery, navigation, manipulator systems, diagnostic systems
- Advanced optical methods in diagnosis and treatment
- Recent developments: NOTES, ….
b) Artificial Organs:
- Principles of membrane Processes
- Manufacturing of Membranes / Modules
- Mass transfer models in Art. Kidney, Art. Liver, Art. Lung
- Basics about individual processes (machines,..)</td></tr>
<tr><td>4</td><td colspan="6">Teaching methods
a) Lecture, Presentations, Excursion (Endoscopy department or Manufacturer)
b) Lecture, Exercises, Excursion to Manufacturer of Art. Organs and Machines for Appl.</td></tr>
<tr><td>5</td><td colspan="6">Prerequisites
a) Minimal Invasive Medicine / Technologies
- Basics of medical nomenclature and human anatomy
- Basic knowledge of surgical techniques and instrumentation
- Basic knowledge in optics, electricity and mechanics
b) Process Engineering:
- Mass Balances, Concentrations,..
- Basics in Diffusion, Convection, Phase Equlibria,..
- Basics in fluid dynamic (laminar flow, dimensionless numbers, etc..)</td></tr>
<tr><td>6</td><td colspan="6">Methods of assessment
a) 1 written examination (50%)
b) 1 written examination (50%)</td></tr>
<tr><td>7</td><td colspan="6">Applicability of module
Mandatory module in BME/elective in other study programs</td></tr>
<tr><td>8</td><td colspan="6">Person responsible for module/ lecturer
Module: Prof. Dr. Folker Wenzel
Lecture: LB Christina Winkler & LB Heiko Bär</td></tr>
</table>

9	**Literature** - Nathaniel J. Soper, Carol E.H. Scott-Connor (Eds.); Springer (2012): The SAGES Manual: Volume 1 Basic Laparoscopy and Endoscopy; ISBN 978-1-4614-2343-0 - Eloot, S. (2004): "Experimental and Numeric Modeling of Dialysis", PhD dissertation, Ghent University 2004, ISBN 9090186980 - Raff, M. et. al.(2002): "Advanced modeling of highflux hemodialysis", J. Membr., Sc. 5531 (2002),1-11 - Krause, B. et. al (2003): "Polymeric Membranes for Medical Applications", Chemie-Ing. Techn. (2003), 75

10 Electives/Wahlpflichtmodul, 2nd Sem.

Electives part 1 and 2						
		Workload 330 h	**Credits** 6	**Semester** 2. semester	**Frequency of module** twice a year	**Duration** 1 semester
1	**Module** 4 courses comprising at least 9 credits		**Language** german or english	**Contact hours** Dependent upon course chosen	**Self study** Dependent upon course chosen	**Class Size** Dependent upon course chosen
2	**Learning outcome** The modules allow the students to acquire in depth knowledge /consolidate existing knowledge in the field of medical technology, biomedicine and scientific competences. The detailed learning outcome depends upon the course chosen and can be found in the respective module description.					
3	**Content** Dependent upon the course chosen.					
4	**Teaching methods** Dependent upon the course chosen.					
5	**Prerequisite** Dependent upon the course chosen.					
6	**Assessment methods** Dependent upon the course chosen At least 4 course amounting to at least 8 credits must be completed with a graded assessment (Prüfungsleistung/PL).					
7	**Applicability of module** Mandatory module in BME/elective in other study programs.					
8	**Person responsible for module/ lecturer** Module: Dean od stud course lecturer: dependent upon the course chosen					
9	**Literature** dependent upon the course chosen					

11 Thesis, 3rd Sem.

<table>
<tr><td colspan="7">Master-Thesis</td></tr>
<tr><td colspan="2"></td><td>Workload
900 h</td><td>Credits
30 (22/2)</td><td>Semester
3</td><td>Frequency of course
each semester</td><td>Duration
1 semester</td></tr>
<tr><td>1</td><td colspan="6">Module
a) Thesis
b) Thesis Seminar
Language
German or English
Contact hours
a) 22 h
b) 2SWS (22,5h)
Self study
677,5
Class size
a) 24 in group sizes of one
b) 24 S</td></tr>
<tr><td>2</td><td colspan="6">Learning outcome
The thesis project can be done as a research project at the HFU or in a company. Students can also choose a thesis project abroad to gain additional social and language competence.

On successful completion of this module you should be able to
Application (3):
- organize and plan a scientific project independently
- chose the appropriate methods for a scientific project on the basis of the current scientific knowledge
- implement a thesis report summarizing a research project
- analyze and presents defined topics of higher complexity based on current scientific knowledge and methods
Analysis (4):
- critically analyse and evaluate a scientific project and include the results of this analysis in the future development of the project
- critically discuss a scientific project on the basis of current knowledge
- select the key results of a project die(?) and analyze and present them in the context of current scientific knowledge and literature.</td></tr>
<tr><td>3</td><td colspan="6">Content
a) scientific realization and summary of a chosen thesis project
b) Presentation of the thesis project</td></tr>
<tr><td>4</td><td colspan="6">Teaching methods
a) master-thesis
b) presentation</td></tr>
<tr><td>5</td><td colspan="6">Prerequisites
Dependent on the topics chosen</td></tr>
<tr><td>6</td><td colspan="6">Methods of assessment
a) 1 thesis (80%)
b) 1 presentation (20%)</td></tr>
<tr><td>7</td><td colspan="6">Applicability of module
Mandatory module in BME</td></tr>
<tr><td>8</td><td colspan="6">Person responsible for module /lecturer
Dean of study course
Primary supervisor: HFU professors and staff ,
Secondary supervisor: HFU professors and staff , visiting lecturer, external supervisor</td></tr>
<tr><td>9</td><td colspan="6">Literature
Dependent on the topic chosen</td></tr>
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