

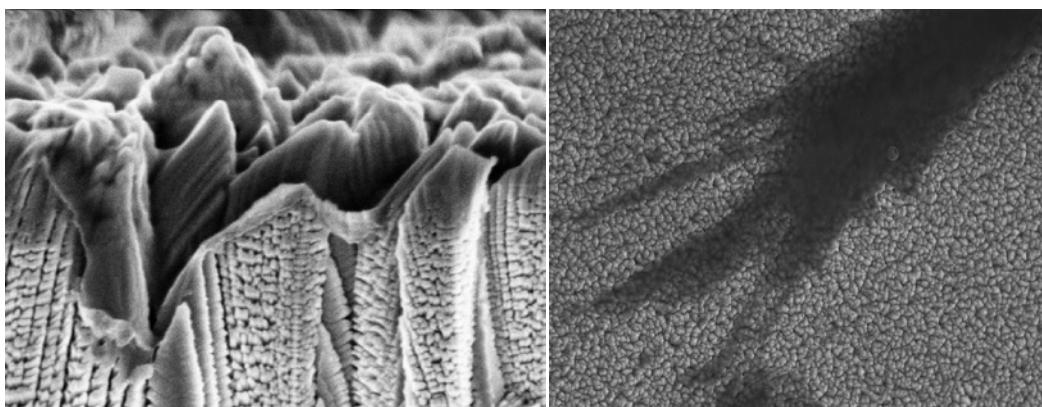
Module Compendium

for the Master's Degree Program

Master of Science

Biomedical Sciences (BMS)

Valid as of October 2016
School of Applied Chemistry



Double layer of TiO_2 and polymer; structuring of the surface and optimization of the chemical composition of the surface for the purpose of cell establishment

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Preliminary Remarks

This module compendium serves the purpose of providing students and instructors a detailed and comprehensive description of the curriculum of the degree program Master of Biomedical Sciences.

The module descriptions present the module goals and intended results of study as well as the contents of the individual courses. Furthermore, all information necessary for academic success is given in the module descriptions. They are also included in the diploma supplement to the master's degree program.

If you have any questions regarding several modules or the course of studies, please contact the office of the Dean of the Faculty of Applied Chemistry.

If you have questions regarding a particular module, please contact the responsible module coordinator. You will find a list of the module coordinators in the Internet, where this module compendium can also be found.

If you have questions regarding a particular course, please contact the instructor.



Introduction

Overview of the course of studies

The curriculum of the master degree program for Biomedical Sciences comprises 3 semesters. The diploma is a professional qualification and enables graduates of biomedicine with a master's degree in natural science to work in industry or in academia.

Important structural elements of the course of studies are

- Five theory modules in the first semester
- Three theory modules as 6-week compact courses in the second semester
- A 9-week research project in the second semester
- An elective module, to be absolved within the first two semesters
- A master's thesis, to be written within 6 months during the third semester.

The curriculum has been chosen so that graduates will be qualified to work in various fields, in particular in academic and industrial research in pharmaceuticals, medical technology (implants, regenerative medicine), biotechnology and diagnostics. The graduates' qualifications will be based on their education in the modern fields of material and surface sciences with regard to their application in biomedicine, but also on a profound knowledge of bioanalytics, pharmaceutical research and modern biotechnology. This can be seen in the modules „Materials and Applications in Biomedical Sciences“ (BMS2), „Analytical Methods in Biomedical Sciences“ (BMS1), „Advanced Pharmacology“ (BMS8) and „Biomedical Technologies“ (BMS7). Strategic planning and the development and licensing of products are covered in „Technology Management“ (BMS5), „Product Management“ (BMS3) and „Industry-Related Topics“ (BMS4). Technological aspects are covered in module BMS2 „Materials and Applications in Biomedical Sciences“, whereby transitions to cell culture techniques and diagnostics are a topic of discussion and research. Microfluidics and lab-on-a-chip technologies will surely see important diagnostic applications in the future and have recently claimed great attention in academic as well as industrial research.

The second semester begins with a 6-week compact seminar, dealing with the content of modules BMS7 „Biomedical Technologies“ and BMS8 „Advanced Pharmacology“. The main focus in the second semester will be a research project that is scheduled to last 9 weeks, to be supervised by a professor of the faculty. The project can be absolved at the faculty of Reutlingen University or at an external research institute such as the NMI in Reutlingen or the Fraunhofer Institute in Stuttgart. Furthermore, it is also possible to do the research project in an industrial research department. The project is to be accompanied by seminars relevant to the research topic.

The master's thesis shall be written in the third semester and can be done internally at Reutlingen University or at an external institute.

European Credit Transfer and Accumulation System (ECTS)

The Ministry for Science, Research and Art BW and the Conference of Ministers of Culture require the curriculum of study to be divided into modules. Student's performance is recorded by means of the „European Credit Transfer and Accumulation System“ (ECTS). In order to compare the performance of students at various institutions of higher learning—also foreign institutions—the ECT system is based not on the number of course hours per week, but rather on the time that students are required to invest in learning. In this way, student performance can be more objectively compared throughout Europe.

Full-time students can achieve 60 ECTS credit points per academic year. This approximates an average workload of 1800 hours of study. A credit point corresponds to 30 hours workload for a student of average intelligence and aptitude, whereby the workload includes the time during which the student



attends class and his/her study time outside of class. Class time is given as weekly number of hours (à 60 minutes) per course (WH).

Example:

WH*	Class attendance	Study time	Workload	Credit points
2	30 h	60 h	90 h	3

WH* = 1 WH equals 15 hours per semester, which normally consists of 15 weeks.

Students can only obtain the ECTS points if the required exams have been successfully and verifiably absolved. Credit points are awarded according to the “all or none” principle.



Overview of the modules in the course of studies

BMS1: Analytical Methods in Biomedical Sciences

Module No.	Module course	Semester	WH	Credit points
BMS1	Diagnostic Technologies	1	2	5
	Analytical Methods in Biomedical Sciences	1	2	

BMS2: Materials and Applications in Biomedical Sciences

Module No.	Module course	Semester	WH	Credit points
BMS2	Functional Implants & Surface Technologies	1	2	5
	Drug Release & Delivery Systems	1	2	

BMS3: Industry-Related Topics 1 (Drug Discovery & Development/ Introduction into medical technology)

Module No.	Module course	Semester	WH	Credit points
BMS3	Drug Discovery & Development	1	2	5
	Introduction into medical technology	1	2	

BMS4: Industry-Related Topics 2 (Regulatory Affairs/IP Management)

Module No.	Module course	Semester	WH	Credit points
BMS4	Regulatory Affairs	1	2	5
	IP Management	1	2	

BMS5: Technology Management

Module No.	Module course	Semester	WH	Credit points
BMS5	Innovation Management/ Project Management/ Project Management	1	4	5

BMS6: Statistics in Biomedicine

Module No.	Module course	Semester	WH	Credit points
BMS6	Quantitative Biology	1	2	5
	Medical Statistics	1	2	

BMS7: Biomedical Technologies

Module No.	Module course	Semester	WH	Credit points
BMS7	Biomedical Technologies	2	2	5
	Regenerative Medicine	2	2	

BMS8: Advanced Pharmacology

Module No.	Module course	Semester	WH	Credit points
BMS8	Biomedical Pharmacology	2	2	5
	Advanced Bioanalysis	2	2	

BMS9: Elective Module

Module No.	Module course	Semester	WH	Credit points
BMS9	Elective Subjects	2	4	5



BMS10: Scientific Methods

Module No.	Module course	Semester	WH	Credit points
BMS10	Information Retrieval and Evaluation	2	2	5
	Research Design	2	2	

BMS11: Scientific Research Project

Module No.	Module course	Semester	WH	Credit points
BMS11	Scientific Seminar	2	2	10
	Scientific Research Project (int./ext.) 9 Weeks	2	6	

BMS12: Master's Thesis

Module No.	Module course	Semester	WH	Credit points
BMS12	Master's Thesis Project and Defense (internal/external)	3		30
	Research Seminar for Master's Thesis	3	2	

ACM1: Spezielle Polymeranalytische Verfahren/ Specialized Polymer Analytical Methods

Module No.	Module course	Semester	WH	Credit points
ACM1	Thermische Analyse und Prozesssicherheit/ Thermal Analysis and Process Safety	1	2	5
	Rheologie/ Rheology	1	2	

ACM2: Chemical Engineering

Module No.	Module course	Semester	WH	Credit points
ACM2	Process Engineering and Industrial (Bio) Chemistry (in English)	1	4	5

ACM7: Polymerbasierte Materialien 2/ Polymer Based Materials 2

Module No.	Module course	Semester	WH	Credit points
ACM7	Hybridwerkstoffe/ Hybrid Materials	2	2	5
	Polymere & Flüssigkristalle/ Selected Soft Materials	2	2	

ACM8: Polymerbasierte Materialien 1/ Polymer Based Materials 1

Module No.	Module course	Semester	WH	Credit points
ACM8	Advanced Materials	2	2	5
	Konstruktion und Produktdesign/ Product Functionality Design	2	2	

PAM4: Process Analytical Technology I

Module No.	Module course	Semester	WH	Credit points
PAM4	Process Spectroscopy and Spectrometry	1	4	5

PAM6: Process Control (Sensors Fundamentals and Applications)

Module No.	Module course	Semester	WH	Credit points
PAM6	Sensors Fundamentals and Applications	1	4	5

PAM10: Process Analytical Technology II

Module No.	Module course	Semester	WH	Credit points
PAM10	Sampling and sample preparation	2	2	5
	Measuring and Control Technology	2	2	



PAM11: Bioanalytical Techniques

Module No.	Module course	Semester	WH	Credit points
PAM11	Microscopy and Optics	2	2	5
	In-Process Metabolomics	2	2	

BMS14: Module from other schools or universities

Module No.	Module course	Semester	WH	Credit points
PAM15	Modules from other schools or universities with at least 4 SWS and 5 ECTS-credits to be approved by examination commission			5



Assignment of Marks / Assessment of Quality

Relative ECTS Marks

The international standard foresees that the best 10% of those students who pass receive the mark „A“, regardless of which mark they may receive according to the German marking system. With this system, the performance of students who have passed can be compared more objectively, taking into account that different courses may have different degrees of difficulty.

Student performance	ECTS mark
the best 10%	A = excellent
the next 25%	B = very good
the next 30%	C = good
the next 25%	D = satisfactory
the next 10%	E = sufficient
	F = failing

Since a large number of students are necessary in order to correctly calculate the relative ECTS marks, the conventional German marking system (1-5) shall be used and adapted as shown in the table below (valid as of February 2011).

ECTS mark	German mark	ECTS definition	German translation
A	1,0 – 1,3	excellent	hervorragend
B	1,4 – 2,0	very good	sehr gut
C	2,1 – 2,7	good	gut
D	2,8 – 3,5	satisfactory	befriedigend
E	3,6 – 4,0	sufficient	ausreichend
FX/F	4,1 – 5,0	failing	nicht bestanden



Remarks Concerning the Description of Modules

The module descriptions are meant to offer students information regarding the course of studies, curriculum content, qualitative and quantitative requirements, the relationship of the individual modules to other modules and integration of the module into the general concept of the course of studies. The module descriptions are listed in tabular form.

The following remarks will help the reader to understand the terms used in the module descriptions.

Module description / abbreviation:

A module name and abbreviation have been assigned to every module. The module name provides information about the content of the module. The corresponding abbreviation begins with the first letter of the name of the degree program. It ends with a number of a sequence of numbers. Thus, the abbreviation BMS1 stands for the first module in Biomedical Sciences.

Courses:

The courses included in a module are listed separately.

Semester:

The semester in which a module must be absolved is indicated.

Person responsible for the module:

This person is responsible for the editing of the module.

Instructor:

Instructors are responsible for the content and organization of their courses and/or those courses which are held by an associate instructor.

Language:

The language in which the course is taught is indicated.

Integration with other courses of study:

In the event that a module is also offered in other courses of study, this shall be indicated.

Type of instruction/WH:

The type of instruction as well as the weekly hours of instruction are indicated in tabular form. The abbreviations stand for:

Lecture (L)

Exercise (E)

Lab work (LW)

Seminar (S)

Workload and credit points:

The workload consists of class attendance and study outside of class. The hours of class attendance are calculated by multiplying the WH (à 60 minutes) x 15, which is the normal number of weeks per semester, excluding the exam week.

The calculation of the time needed for study outside of class presupposes that students will require the time represented by the credit points. Each credit point represents 30 hours workload. The total workload is the sum of the workload resulting from class attendance and the workload resulting from study outside of class.

Requirements according to the examination regulations:

Students must have already completed the listed modules in order to participate in the respective module.

Recommended prerequisites:

Course instructors indicate the knowledge and proficiency that students should have in order to participate in and understand the subject matter of a course.

Goals of the module / desired outcome:

The goals of the module define the academic, technical and, if applicable, professional qualifications that should be achieved with this module. The desired outcome describes which knowledge, skills and competences are to be acquired through study.

Content:

The precise content of the course is described (operative level), with which the desired outcome is to be achieved.

Study and exam requirements:

The type of exam and its duration are indicated.

Media used:

The media (overhead projector, digital projector, flip chart, video, etc.) used in the course are indicated; furthermore, which documents are to be made available to the students when and in which form.

Literature:

A list of literature and, if applicable, information regarding multimedia-supported literature is provided. The literature list includes texts that will prepare students for the upcoming seminar as well as texts to accompany the course work during the semester.



Module Description

BMS1 - Analytical Methods in Biomedical Sciences

Course of studies	Biomedical Sciences (MSc)					
Module	Analytical Methods in Biomedical Sciences					
Abbreviation	BMS1					
Course(s)	<ul style="list-style-type: none"> Analytical Methods in Biomedical Sciences Diagnostic Technologies 					
Semester	1					
Person responsible for the module	Prof. Dr. Reinhard Kuhn					
Instructor	Prof. Dr. Reinhard Kuhn Prof. Dr. Ralf Kemkemer					
Language	English and German					
Status within the curriculum	Mandatory					
Type of course / WH	Course	L	E	LW	S	
	Analytical Methods in Biomedical Sciences	1			1	
	Diagnostic Technologies	2				
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Analytical Methods in Biomedical Sciences	30		45	75	
	Diagnostic Technologies	30		45	75	
	Total	60		90	150	5
Credit points	5					
Prerequisites for attending this course	See examination regulations					
Recommended knowledge / course work	Knowledge of biochemistry, bioanalytics, instrumental analytics, chemistry, material science, biology					

<p>Module goals / desired outcome</p>	<p>General knowledge Successful students will obtain</p> <ul style="list-style-type: none"> • Profound overview of current bioanalytical techniques that are significant in biomedical and pharmaceutical research • Profound understanding of materials for diagnostic applications • Profound understanding of technologies and functioning of laboratory diagnostics and applications • Fundamental understanding of principles of cell biology, cell culture techniques and molecular biology <p>Skills:</p> <ul style="list-style-type: none"> • Understanding of complex relationships in bioanalytics • Understanding of the aspects of material science that are relevant for R&D in biotechnology, pharmaceutical and diagnostics industries • Understanding of principles of interaction of biological systems and molecules with materials • Understanding of principles of structure of diagnostic systems and prerequisites for certain applications • Ability to name limitations of existing technologies • Ability to evaluate various methods of modern cell culture techniques and laboratory diagnostics • Ability to read and understand scientific publications <p>Social competences:</p> <ul style="list-style-type: none"> • Ability to prepare and deliver a scientific presentation for a seminar • Ability to do scientific research and to present scientific findings
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Content	<p>Analytical Methods in Biomedical Sciences The course consists of a lecture and a seminar. Students must choose a research topic on which they will prepare and hold a scientific presentation. The following fields of study will be covered in the lecture and seminar:</p> <ul style="list-style-type: none"> • Proteomics and metabolomics • Biomarkers • Pharmaceutical analysis • Clinical laboratory analysis • Selected topics of bioanalysis, e.g. blotting techniques, two-hybrid systems, FRET, Patch Clamp, <p>Diagnostic Technologies</p> <ul style="list-style-type: none"> • Structure, function and application of laboratory diagnostic methods, in particular micro-technologies and microfluidics, lab-on-a-chip technology, cell biology, cell culture technologies, microscopy
Study and exam requirements	Written exam (2h), presentation, term paper
Media used	Lecture, script as download, board, student presentations, digital projector, handouts
Literature	<ul style="list-style-type: none"> • Rehm, H., Letzel, T.: Der Experimentator – Proteinbiochemie/Proteomics, Spektrum Verlag • Vishal, S.: Biomarkers in Medicine, Drug Discovery and Environmental Health, Wiley • Matson, R.S.: Applying Genomic and Proteomic Microarray Technology in Drug Discovery, CRC Press • Lovric, J.: Introducing Proteomics, Wiley-Blackwell • Russel, S., Meadows, L.A., Russel, R.R.: Microarray Technology in Practice, Academic Press • Issaq, H.J.: Proteomic and Metabolomic Approaches in Biomarker Discovery, Academic Press • Lämmerhofer, M.: Metabolomics in Practice, Wiley-VCH • Molecular Diagnostics : Fundamentals, Methods and Clinical Applications, 2nd Edition, Lela Buckingham PhD, MB, DLM(ASCP) ISBN-13: 978-0-8036-2677-5, 2012 Paperback, 576 pages • Scientific publications

BMS2 - Materials and Applications in Biomedical Sciences

Course of studies	Biomedical Sciences (MSc)				
Module	Materials and Applications in Biomedical Sciences				
Abbreviation	BMS2				
Course(s)	<ul style="list-style-type: none"> • Functional Implants & Surface Technologies • Drug Release and Delivery Systems 				
Semester	1				
Person responsible for the module	Prof. Dr. Rumen Krastev				
Instructor	Prof. Dr. Ralf Kemkemer Prof. Dr. Rumen Krastev				
Language	English				
Status within the curriculum	Mandatory				
Type of course / WH	Course	L	E	LW	S
	Drug Release and Delivery Systems	2			
	Functional Implants & Surface Technologies	2			
Workload in hours	Course	Class attendance	Study outside of class	Total	CP
	Drug Release and Delivery Systems	30	45	75	
	Functional Implants & Surface Technologies	30	45	75	
	Total	60	90	150	5
Credit points	5				
Prerequisites for attending this course	See examination regulations				
Recommended knowledge / course work	Basic understanding (BSc-level) of chemistry, biology and biomedical technology, material sciences				
Module goals / desired outcome	Basic knowledge				

	<ul style="list-style-type: none"> - Knowledge of materials for biomedical application in in-vitro and in-vivo applications - Understanding of technologies for surface modifications for implants and related methods - Knowledge of biomedical implant technologies - application examples and challenges - Understanding of drug delivery concepts and application of polymers - Understanding of drug release methods, kinetics and applications <p>Technical competences:</p> <ul style="list-style-type: none"> - Students will be able to understand surface and polymer chemistry technologies and transfer these to appropriate applications in the biomedical field - Students will be able to identify technical working principles of complex implants - Students will be able to understand the complexity of tissue-material interaction and relate this to material properties - Students will be able to classify the suitability of different materials classes for specific applications - Students will be able to name limitations of current technologies in the field <p>Social competences:</p> <ul style="list-style-type: none"> - Students develop skills in research, reading and interpretation of scientific texts - Students gain an awareness of ethical aspects in the development of medical products.
Content	<ul style="list-style-type: none"> • Functional Implants & Surface Technologies Materials and design principles of passive and active implants, examples and applications, surfaces and surface modifications, technical principles of active implants (examples), micro and nanotechnology, surface chemistry, interaction of cells with materials. • Drug Release and Delivery Systems Medical devices (active and passive) as drug delivery systems examples and applications Approaches, formulations, technologies, and systems for transporting of active pharmaceutical compounds as needed to achieve the desired therapeutic effect Immobilization and delivery of “biologicals” e.g. peptides, proteins, antibodies, vaccines and gene based drugs Release based on diffusion, degradation, swelling, and affinity-based mechanisms Current approaches – site and time specific targeting, facilitated pharmacokinetics

	Example techniques – thin polymer film delivery, acoustic or light targeted delivery, liposomal delivery.
Study and exam requirements	Written exam (2h), presentation /assignments
Media used	PowerPoint slides, flip charts, board
Literature	<p>King M.R.: Principles of Cellular Engineering – Understanding the Biomolecular Interface, Academic Press, 2006</p> <p>Ritter A.B., et al.: Biomedical Engineering Principles, CRC Press, 2012</p> <p>Narayan R.: Biomedical Materials, Springer Publisher, 2009</p> <p>Ratner B.D. et al.: Biomaterial Sciences, Elsevier Oxford, 2012</p> <p>Wintermantel E., H. Suk-Woo Ha: Medizintechnik: Life Science Engineering, Springer 2009</p>



BMS3 - Industry-Related Topics 1

Course of studies	Biomedical Sciences (MSc)					
Module	Industry-Related Topics 1					
Abbreviation	BMS3					
Course(s)	<ul style="list-style-type: none"> • Drug Discovery & Development • Introduction into Medical Technology 					
Semester	1					
Person responsible for the module	Prof. Dr. Alexander Schuhmacher					
Instructor	Prof. Dr. Alexander Schuhmacher Prof. Dr. Günter Lorenz					
Language	English					
Status within the curriculum	Mandatory					
Type of course / WH	Course	L	E			
	Drug Discovery & Development	2				
	Introduction into Medical Technology	2				
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Drug Discovery & Development	30		45	75	
	Introduction into Medical Technology	30		45	75	
	Sum	60		90	150	5
Credit points	5					
Prerequisites for attending this course	See examination regulations					
Recommended knowledge / course work	Basic understanding, knowledge of the principles of pharmaceutical and medical technology industries Basic knowledge of natural sciences					

<p>Module goals / desired outcome</p>	<p>Basic knowledge of the pharmaceutical and medical technology industries</p> <p>Understanding of strategic and operational topics concerning drug discovery, drug development, medical and biomedical technologies.</p> <p>In “Drug Discovery and Development”, students will receive information on state-of-the-art developments, research, and expert opinions in the pharmaceutical industry. Furthermore, the key success factors in research and development (R&D) as well as value creators in pharmaceutical innovation will be discussed. The topics addressed in the textbook include the innovation process, pharmaceutical R&D, research and innovation strategies. Students will gain an overview of the pharmaceutical industry and how pharmaceutical R&D works operationally.</p> <p>In the “Introduction to Medical Technology”, students will gain a basic understanding of fundamental technologies in bio-medical engineering, focusing on the medical background and basic principles of related methods (MRT, CT, sonography, PET, dialysis, heart-lung machine, artificial lungs, stents, heart valves, pace makers). Students will know:</p> <ol style="list-style-type: none"> (1) the definition of biomedical engineering and (2) the basic principles and medical background of different technologies. <p>Thus, students will improve their ability to</p> <ol style="list-style-type: none"> (1) understand and use new vocabulary (2) read, summarize and discuss scientific topics and (3) prepare and present scientific results in the form of short presentations in teams.
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<p>Content:</p>	<p>Part 1: Drug Discovery and Development</p> <ul style="list-style-type: none"> • Global epidemiology • Pharma-economics • Drug costs • Financing of innovation • Drug targets • Preclinical safety • Pharmaceutical development • Translational medicine • Clinical development • Antibodies • Vaccines • Outsourcing • Pharmaceutical strategies <p>Part 2: Introduction to Medical Technologies</p> <p>Introduction</p> <ul style="list-style-type: none"> • Definition • Overview • Short summary of the basics <p>Medical background and technology fundamentals:</p> <p>Medical imaging</p> <ul style="list-style-type: none"> • MRT • CT • Sonography • PET • etc. <p>Life support systems:</p> <ul style="list-style-type: none"> • Dialysis • Heart-lung machine • Artificial lung • etc. <p>Implants</p> <ul style="list-style-type: none"> • Stent • Heart valve • Cochlear • Retinal
<p>Study and exam requirements</p>	<p>Preparation and presentation of at least one scientific topic in the module; written examination (2 hours)</p>
<p>Media used</p>	<p>Lecture, group work, interactive discussions, handouts, flip charts</p>

Literature	<ul style="list-style-type: none"> • Wintermantel, E., Ha, S. W.: Medizintechnik: Life Science Engineering. Interdisziplinarität, Biokompatibilität, Technologien, Implantate, Diagnostik, Werkstoffe, Zertifizierung, Business Springer, Berlin; Auflage: 5., überarb. u. erw. A. 2009 • Ratner, B. D., Hoffman A.S. et al. (eds.): Biomaterials Science - An Introduction to Materials in Medicine, Elsevier Academic Press, 2004 • Joseph Bronzino and Donald R. Peterson : The Biomedical Engineering Handbook, Fourth Edition: Four Volume Set, Crc Pr Inc; 2015 • Pierre Morgon (2014) Sustainable Development in the Healthcare System, Springer
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BMS4 - Industry-Related Topics 2

Course of studies	Biomedical Sciences (MSc)					
Module	Industry-Related Topics 2					
Abbreviation	BMS4					
Course(s)	<ul style="list-style-type: none"> Regulatory Affairs IP Management 					
Semester	1					
Person responsible for the module	Prof. Dr. Alexander Schuhmacher					
Instructor	Dr. Kuschel Prof. Dr. Alexander Schuhmacher					
Language	English					
Status within the curriculum	Mandatory					
Type of course / WH	Course	L	E			
	Regulatory Affairs	2				
	IP Management	2				
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Regulatory Affairs	30		45	75	
	IP Management	30		45	75	
	Sum	60		90	150	5
Credit points	5					
Prerequisites for attending this course	See examination regulations					
Recommended knowledge / course work	No specific knowledge required					

Module goals / desired outcome	<p>The primary goal is to understanding the strategic and operational relevance of regulatory affairs and intellectual property (IP) rights for high-tech industries, such as the pharmaceutical, biotechnology and medical device industries.</p> <p>More specifically, it is the understanding of formalities in the development and manufacturing of medical devices and pharmaceutical products – with a focus of the respective national and international registration and authorization rules.</p> <p>In Intellectual Property (IP) Management, students will gain knowledge of the international and European patent laws, patentability requirements, how to file a patent application and the writing of patent claims.</p>
Content:	<p>Regulatory affairs</p> <ul style="list-style-type: none"> • FDA • EMEA • ICH <p>IP Management</p> <ul style="list-style-type: none"> • European Patent Convention and Patent Cooperation Treaty • Filing a patent application • Searching for patents • Patentability analysis • Writing patent claims
Study and exam requirements	Written examination (2 hours)
Media used	Lecture, group work, interactive discussions, handouts, flip charts
Literature	<ul style="list-style-type: none"> • The European Patent Convention (http://documents.epo.org/projects/babylon/eponet.nsf/0/00E0CD7FD461C0D5C1257C060050C376/\$File/EPC_15th_edition_2013_de_bookmarks.pdf) • National and international guidelines as accessible via FDA and EMEA

BMS5 - Technology Management

Course of studies	Biomedical Sciences (MSc)					
Module	Technology Management					
Abbreviation	BMS5					
Course(s)	<ul style="list-style-type: none"> • Project Management • Innovation Management • Quality Management 					
Semester	1					
Person responsible for the module	Prof. Dr. Alexander Schuhmacher					
Instructor	Prof. Dr. Alexander Schuhmacher					
Language	English					
Status within the curriculum	Mandatory					
Type of course / WH	Course	L	E	LW	S	
	Project Management	2				
	Innovation Management	2				
Workload in hours	Course	Class attendance	Study outside of class	Total	CP	
	Project Management	30	45	75		
	Innovation Management	30	45	75		
	Total	60	90	150	5	
Credit points	5					
Prerequisites for attending this course	See examination regulations					
Recommended knowledge / course work	Basic understanding of project management					



Module goals / desired outcome	<p>Project Management: Ability to understand and use the principles of project management principles in managing a research project (time and costs). Ability to successfully lead a team</p> <p>Innovation Management: Understanding of innovation strategies and processes. Understanding of the significance of the context of innovation strategy for the daily business of researchers in an R&D organization. Ability to apply quality and quantitative evaluation methods in projects.</p>
Content	<p>Innovation Management</p> <ul style="list-style-type: none"> • Economic relevance of innovation • Innovation strategies • Innovation processes • Open innovation <p>Project management</p> <ul style="list-style-type: none"> • Time and cost planning of projects • Portfolio management • Scientific and financial evaluation of research projects • High-performance teams
Study and exam requirements	Written examination (2h)
Media used	Lecture, group work, interactive discussions, handouts, flipcharts
Literature	<p>Gassmann O. et al. (2004) Leading Pharmaceutical Innovation. Springer Verlag</p> <p>Schein EH (1997) Organizational Culture and Leadership. Jossey-Bass Publishers</p> <p>S. Nokes and S. Kelly. Guide to Project Management. FT Press (2003)</p> <p>PMI (2008) The Standard for Portfolio Management. 2nd edition. Project Management Institute</p> <p>Alexander Schuhmacher, Markus Hinder, Oliver Gassmann (2015) Value Creation in the Pharmaceutical Industry: The Critical Path Towards Innovation, Wiley International</p>

BMS6 –Statistics in Biomedicine

Course of studies	Biomedical Sciences (MSc)				
Module	Statistics in Biomedicine				
Abbreviation	BMS6				
Course(s)	<ul style="list-style-type: none"> Quantitative Biology Medical Statistics 				
Semester	1				
Person responsible for the module	Prof. Dr. Ralf Kemkemer				
Instructor	Prof. Dr. Ralf Kemkemer Prof. Dr. Rumen Krastev				
Language	English				
Status within the curriculum	Mandatory				
Type of course / WH	Course	L	E	LW	S
	Quantitative Biology	1	1		
	Medical Statistics	1	1		
Workload in hours	Course	Class attendance	Study outside of class	Total	CP
	Quantitative Biology	30	45	75	
	Medical Statistics	30	45	75	
	Sum	60	90		
			150	5	
Credit points	5				
Prerequisites for attending this course	See examination regulations				
Recommended knowledge / course work	Fundamentals of mathematics, IT, biology and medicine				
Module goals / desired outcome	General knowledge: <ul style="list-style-type: none"> Basic understanding of quantitative modes in cell biology and biomedical studies 				



	<ul style="list-style-type: none"> - Basic knowledge of principles of image processing and analysis in cell biology - Basic knowledge of statistical methods and data analyses - Basic knowledge of principles of experiment design - Knowledge of data visualization <p>Technical competences:</p> <ul style="list-style-type: none"> - Ability to use software tools for statistics, data and image analysis and data visualization - Ability to use databases for simple data retrieval - Ability to identify and use appropriate methods in statistics - Ability to develop simple quantitative models in cell biology - Ability to perform and interpret simple statistical methods and tests - Ability to recognize the limitations of statistical tests <p>Social competences and skills:</p> <ul style="list-style-type: none"> - Ability to research, interpret and present scientific results
Content	<ul style="list-style-type: none"> • Quantitative biology Models in biology: advantages and challenges as well as related mathematical methods Basic biophysics of cells and tissues Quantitative image analysis in cell biology (microscopy images) Data visualization in biomedical sciences • Medical and pharmaceutical statistics Statistics in clinical practice: gathering, interpreting and presenting statistical data from medical studies Design of experiments for drug development, optimization and approval procedures Approval of test hypothesis in clinical studies
Study and exam requirements	Written exam (2h), presentation, term paper
Media used	PowerPoint slides, flip charts, board, computer, software tools
Literature	Quantitative Biology: From Molecular to Cellular Systems Michael E. Wall, ISBN 9781439827222, 2012 by CRC Press Research Methods for the Biosciences, 2nd Edition, D. Holmes, P. Moody, and D. Dine, Oxford University Press 2011

	Statistical methods in medical research, P Armitage, G Berry, J N S Matthews, Blackwell Scientific Publications (Oxford, Boston) 2002
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BMS7 - Biomedical Technologies and Regenerative Medicine

Course of studies	Biomedical Sciences (MSc)					
Module	Biomedical Technologies					
Abbreviation	BMS7					
Course(s)	<ul style="list-style-type: none"> • Regenerative Medicine • Biomedical Technologies - Biofabrication 					
Semester	2					
Person responsible for the module	Prof. Dr. Petra Kluger					
Instructor	Prof. Dr. Petra Kluger					
Language	English					
Status within the curriculum	Mandatory					
Type of course / WH	Course	L	E	LW	S	
	Biomedical Technologies	2				
	Regenerative Medicine	2				
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Biomedical Technologies	30		45	75	
	Regenerative Medicine	30		45	75	
	Total	60		90	150	5
Credit points						
Prerequisites for attending this course	See examination regulations					
Recommended knowledge / course work	Cell biology, physiology, biomaterials, tissue engineering, biomedical engineering					



<p>Module goals / desired outcome</p>	<ul style="list-style-type: none"> • <i>students get insight into biofabrication technologies for future perspectives in biomedical engineering</i> • <i>students get an overview of the materials and techniques used in Regenerative Medicine; state of the art in various clinical applications and the global market</i> <p><i>students know:</i></p> <ul style="list-style-type: none"> • <i>how to define biofabrication</i> • <i>basic principles for automation, especially for automated cell and tissue culture as well as clinical applications</i> • <i>different biofabrication technologies, their characteristics and their pros & cons</i> • <i>needed properties for a bioprint, different materials used as bioprint and their limitations</i> • <i>possible applications of these biofabrication technologies in biomedical sciences</i> <ul style="list-style-type: none"> • <i>how to define regenerative medicine</i> • <i>the characteristics of stem cells and their clinical use</i> • <i>different matrix components and their properties as well as the clinical applications of different matrices</i> • <i>the regulatory framework</i> • <i>key facts concerning the global regenerative medicine market</i> • <i>the state of the art in selected applications and the challenges</i> <p><i>students improve their ability in:</i></p> <ul style="list-style-type: none"> • <i>understanding and use new vocabulary</i> • <i>read, summarize and discuss about scientific topics prepare and present these results and short presentation in teams</i>
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Content	<p>Biomedical Technologies - Biofabrication</p> <ul style="list-style-type: none"> • Introduction Biofabrication • Overview of different biofabrication technologies • Lab automation for cell and tissue cultures • Bioinks for scaffold and tissue fabrication <p>Regenerative Medicine</p> <ul style="list-style-type: none"> • Definition and short summary of fundamentals • Stem cells (basics and clinical applications) • Matrix (basics and clinical applications) • State-of-the-art clinical applications • Regulatory affairs and market
Study and exam requirements	One written exam for the module (120 min)
Media used	Lecture, interactive discussions, group work, flip chart, PCs
Literature	<ul style="list-style-type: none"> • Gustav Steinhoff, Regenerative Medicine: From Protocol to Patient, Springer 2013 • Anthony Atala, Robert Lanza, James A., Thomson, and Robert M. Nerem, Principles of Regenerative Medicine, Elsevier, 2008 • Ratner, B. D., Hoffman A.S. et al. (eds.): Biomaterials Science - An Introduction to Materials in Medicine, Elsevier Academic Press, 2004 • Joseph Bronzino and Donald R. Peterson : The Biomedical Engineering Handbook, Fourth Edition: Four Volume Set, Crc Pr Inc; 2015



BMS8 - Advanced Pharmacology

Course of studies	Biomedical Sciences (MSc)					
Module	Advanced Pharmacology					
Abbreviation	BMS8					
Course(s)	<ul style="list-style-type: none"> • <i>Biomedical</i> Pharmacology • Advanced Bioanalysis 					
Semester	2					
Person responsible for the module	Prof. Dr. Reinhard Kuhn					
Instructor	Prof. Dr. Reinhard Kuhn Dr. Nicolas Lembert					
Language	English and German					
Status within the curriculum	Mandatory					
Type of course / WH	Course	L	E	LW	S	
	<i>Biomedical</i> Pharmacology	1			1	
	Advanced Bioanalysis	2				
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Pharmacology	30		45	75	
	Advanced Bioanalysis	30		45	75	
	Total	60		90	150	5
Credit points	5					
Prerequisites for attending this course	See examination regulations					
Recommended knowledge / course work	Knowledge of biochemistry, bioanalytics and instrumental analytics, biology, fundamentals of pharmacology					

<p>Module goals / desired outcome</p>	<p>General knowledge:</p> <ul style="list-style-type: none"> • Profound overview of current bioanalytical techniques relevant for biomedical as well as pharmaceutical research • Understanding of mode of action of drugs <p>Skills:</p> <ul style="list-style-type: none"> • Understanding of drug interaction in the human organism • In-depth knowledge of Pharmacokinetics and Pharmacodynamics • Understanding of the use of modern analysis systems in personalized medicine • Understanding of the functioning of microarray- and gene-chip-systems • Ability to read and understand scientific publications <p>Social competences:</p> <ul style="list-style-type: none"> • Preparation and presentation of a scientific presentation for a seminar • Ability to do scientific research and present scientific findings
<p>Content</p>	<p>Analytical Methods in Biomedical Sciences</p> <ul style="list-style-type: none"> • Genomics and Transcriptomics • DNA structure and isolation • Cloning and sequencing • Advanced polymerase chain reaction • DNA/RNA microarray technology • Karyotype analysis • Biomarker research • Personalized medicine • Examples of personalized medicine <p>Biomedical Pharmacology</p> <ul style="list-style-type: none"> • Introduction to pharmacokinetics • Introduction to pharmacodynamics • Drug interaction • Drug impact on <ul style="list-style-type: none"> - stomach & gut - blood - blood vessels, kidney - heart - hormones • Neuropharmacology (ataractics, Parkinson's, analgesics)
<p>Study and exam requirements</p>	<p>Written exam (2h)</p>

Media used	Lecture, script for download, board, student presentations, digital projector, handouts
Literature	<ul style="list-style-type: none"> • J Licino, ML Wong, Pharmacogenomics, Wiley-VCH (2003) • RS Matson, Applying Genomic and Proteomic Microarray Technology in Drug Discovery, CRC Press (2013) • C Mühlhardt, Der Experimentator: Molekularbiologie/Genomics, Spektrum Akad. Verlag (2002) • H Rehm, Der Experimentator: Proteinbiochemie/Proteomics, Spektrum Akad. Verlag (2002) • AM Lesk, Introduction to Genomics, Oxford University Press 2nd Ed. (2012) • NC Mishra, Introduction to Proteomics, Wiley (2010) • M Lämmerhofer, W Weckwerth, Metabolomics in Practice, Wiley-VCH (2013) • S Russel, LA Meadows, RR Russel, Microarray Technology in Practice, Elsevier Academic Press (2009) • Wissenschaftliche Publikationen



BMS9 - Elective Module

Course of studies	Biomedical Sciences (MSc)					
Module	Elective Module					
Abbreviation	BMS9					
Course(s)	Elective course(s)					
Semester	2					
Person responsible for the module	Prof. Dr. Reinhard Kuhn					
Instructor	Prof. Dr. Reinhard Kuhn					
Language	English					
Status within the curriculum	Mandatory					
Type of course / WH	Course	L	E	LW	S	
	Elective Subject I	2				
	Elective Subject II	2				
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Elective Subject I	30		45	75	
	Elective Subject II	30		45	75	
	Sum	60		90	150	5
Credit points	5					
Prerequisites for attending this course	See examination regulations					
Recommended knowledge / course work	None					
Module goals / desired outcome						
Content						
Study and exam requirements	Students must document successful participation in a university course					
Media used	Dependent on elective					
Literature	Dependent on elective					

BMS10 –Scientific Methods: Information Retrieval and Evaluation and Research Design

Course of studies	Biomedical Sciences (MSc)					
Module	Scientific Methods: Information Retrieval and Evaluation and Research Design					
Abbreviation	BMS10					
Course(s)	<ul style="list-style-type: none"> • Information Retrieval and Evaluation • Research Design 					
Semester	2					
Person responsible for the module	Prof. Dr. Ralf Kemkemer					
Instructor	Prof. Dr. Ralph Lehnert (Information retrieval) Prof. Dr. Ralf Kemkemer (Research design)					
Language	English					
Status within the curriculum	Mandatory					
Type of course / WH	Course	L	E	LW	S	
	Information Retrieval and Evaluation	1	1			
	Multivariate Data Analysis	1	1			
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Information Retrieval and Evaluation	30		45	75	
	Research Design	30		45	75	
	Total	60		90	150	5
Credit points	5					
Prerequisites for attending this course	See examination regulations (Studien- und Prüfungsordnung)					
Recommended knowledge / coursework	Basic understanding (BSc-level) of biology, biomedical technology and IT					



<p>Module goals / desired outcome</p>	<p>General knowledge: Successful students will obtain</p> <ul style="list-style-type: none"> • overview of how to use relevant literature data bases with respect to scientific publications, patents, reviews, and monographs • understanding of how search engines and citation management programs function and can be used • Basic understanding of scientific institutions, scientific methods and history of science • Knowledge of principles of good scientific practice • Understanding of important concepts of research, e.g. hypothesis definition, literary research, planning of experiments, evaluation of experiments and data presentation • Understanding of science funding and scientific writing <p>Skills: Successful students will be able</p> <ul style="list-style-type: none"> • to conduct systematic and efficient scientific literature searches (source identification and exploitation) • to efficiently evaluate and document relevant publications and text/content therein • to cite literature correctly according to respective scientific standards and to save citations using citation managers • Understanding of advantages, disadvantages and limitations of scientific methods • Ability to design a basic research project and write a proposal therefore • Ability to plan a research project <p>Social competences:</p> <ul style="list-style-type: none"> • Ability to work in a self-organized manner and as a member of a team • Ability to do work target-oriented and systematically
<p>Content</p>	<p>Information Retrieval and Evaluation</p> <ul style="list-style-type: none"> • Reference data bases, search engines, citation managers • Literature search examples/exercises based on concrete scientific questions <p>Research Design</p> <ul style="list-style-type: none"> • Principles of scientific methods and history • Structure and organization of German and international scientific institutions • Principles of science funding • Principles of scientific research and literary research with practical examples



	<ul style="list-style-type: none"> • Aspects of a scientific project (hypothesis, planning, research, financing, data evaluation,...) • Scientific writing (proposals, publications), review process
Study and exam requirements	Presentation, assignments, proposal
Media used	Lecture, board, overheads, lecture notes, handouts, exercise sheets, software practicals in CIP-pool
Literature	<p>Research Methods for the Biosciences, 2nd Edition, D. Holmes, P. Moody, and D. Dine, Oxford University Press 2011</p> <p>Scientific Publications</p>



BMS11 - Scientific Research Project

Course of studies	Biomedical Sciences (MSc)					
Module	Scientific Research Project					
Abbreviation	BMS11					
Course(s)	<ul style="list-style-type: none"> • Research Project, internal/ external 9 Weeks • Research Seminar 					
Semester	2					
Person responsible for the module	Prof. Dr. Reinhard Kuhn					
Instructor	All instructors within the faculty					
Language	English or German					
Status within the curriculum	Mandatory					
Type of course / WH	Course	L	E	LW	S	
	Research Project	-	-	9 weeks	-	
	Seminar	-	-	-	2	
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Research Project			300	300	
	Seminar	30		-	30	
	Total				330	11
Credit points	11					
Prerequisites for attending this course	See examination regulations					
Recommended knowledge / course work	30 credit points from the 1 st and 2 nd semesters					



<p>Module goals / desired outcome</p>	<p>Ability to implement acquired research ability in a defined research project</p> <p>General knowledge:</p> <ul style="list-style-type: none"> • In-depth knowledge of a defined field of research <p>Skills:</p> <ul style="list-style-type: none"> • Independent work on a defined research project within a team • Evaluation and implementation of scientific literature • Preparation and presentation of a scientific topic <p>Technical competences</p> <ul style="list-style-type: none"> • Application of modern strategies for finding scientific solutions • <p>Social competences:</p> <ul style="list-style-type: none"> • Ability to promote team work within a research project
<p>Content</p>	<p>Research Project and Seminar: Students will work independently on a defined research project, preferably in a research group at Reutlingen University or at an external research institute (e.g. NMI at the University of Tübingen or the Fraunhofer Institute in Stuttgart). Students will work under the direction of a professor of our faculty. The research project may also be done in an industrial R&D department, provided a professor of the Faculty of Applied Chemistry supervises the project. Each student will research a defined scientific topic, present his/her findings to a board of experts and prepare a scientific publication of the results. In addition, students will attend seminars on the topic of research.</p>
<p>Study and exam requirements</p>	<p>Scientific work within a research project (50%), presentation of results (25%), preparation of publication (25%)</p>
<p>Media used</p>	<p>Digital projector, PowerPoint slides</p>
<p>Literature</p>	<p>Dependent on topic of research project</p>



BMS12 - Master Thesis

Course of studies	Biomedical Sciences (MSc)					
Module	Master's Thesis					
Abbreviation	BMS12					
Course(s)	<ul style="list-style-type: none"> • Master's Thesis Project and Defense (internal/ external) • Research Seminar to Master's Thesis 					
Semester	3					
Person responsible for the module	Prof. Dr. Reinhard Kuhn					
Instructor	All instructors of the faculty					
Language	English or German					
Status within the curriculum	Mandatory					
Type of course / WH	Course	L	E	LW	S	
	Master's Thesis	-	-		-	
	Seminar	-	-	-	2	
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Master's Thesis			840	840	28
	Seminar	30		30	60	2
	Total				900	30
Credit points	30					
Prerequisites for attending this course	See examination regulations					
Recommended knowledge / course work	Successful completion of research project					

<p>Module goals / desired outcome</p>	<p>Ability to implement acquired research abilities within a defined research project</p> <p>General knowledge</p> <ul style="list-style-type: none"> • Ability to do detailed and in-depth research on a defined scientific field of study <p>Skills</p> <ul style="list-style-type: none"> • Ability to work independently in a team on a defined research project • Ability to evaluate and implement insights / findings of scientific literature • Ability to prepare and present scientific results <p>Technical competences</p> <ul style="list-style-type: none"> • Ability to apply modern strategies for finding scientific solutions • <p>Social competences:</p> <ul style="list-style-type: none"> • Ability to promote team work in a research group
<p>Content</p>	<p>Students will work independently on a defined research project, preferably in a research group at the Reutlingen University or at an external research institute (e.g. NMI at the University of Tübingen or the Fraunhofer Institute in Stuttgart). Students will work under the direction of a professor of our faculty. Their work will culminate in a master's thesis, to be written by each student individually and independently. The thesis work may also be done in an industrial R&D department, provided a professor of the Faculty of Applied Chemistry supervises the project. Each student will research a defined scientific topic, present his/her findings to a board of experts and prepare a scientific publication of the results. Work on the thesis will be accompanied by regular attendance of seminars on the topic of research.</p>
<p>Study and exam requirements</p>	<p>Master's thesis: The master's thesis will be evaluated by the mentoring professor as well as by a second reviewer</p> <p>Seminar on topics related to master's thesis: After completing the master's thesis, students will hold an oral presentation on their work</p>
<p>Media used</p>	<p>Oral presentation, written thesis, digital projector, PowerPoint slides</p>
<p>Literature</p>	<p>Dependent on research project</p>



BMS13 - Internship Semester - Zusätzliches Modul nur für Studierende mit 180 ECTS Bachelor Abschluss.

Course of studies	Angewandte Chemie (MSc)					
Module	Internship semester					
Abbreviation	ACM-14					
Course(s)	Internship semester					
Semester	1					
Person responsible for the module	Prof. Dr. Reinhard Kuhn					
Instructor	All instructors of faculty					
Language	English or German					
Status within the curriculum						
Type of course / WH	Course	L	E	LW	S	
	Internship semester	-	-	-	-	
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Internship semester			900	900	30
	Total			900	900	30
Credit points	30					
Prerequisites for attending this course	See examination regulations					
Recommended knowledge / course work	Successful completion of semesters 1 and 2					



<p>Module goals / desired outcome</p>	<p>Knowledge:</p> <ul style="list-style-type: none"> • insight into the structure, organization and operations of an industrial company or a research institution <p>Skills:</p> <ul style="list-style-type: none"> • introduction to the independent processing of specific tasks within projects <p>Competencies:</p> <ul style="list-style-type: none"> • ability for determining the status of development / research by literature search • Acquiring the skills for independent implementation of projects • Competence for systematic and structured approach • competence to work scientifically <p>Social competence:</p> <ul style="list-style-type: none"> • learning the manners and practices in the work environment • improve the team and communication skills through participation in the working group • intercultural competence acquisition
<p>Content</p>	<p>The internship semester is performed in close co-operation between the internship site, the student and the internship Office of the school of Applied Chemistry.</p> <p>In 24 weeks, interns work on projects in their industrial enterprises or their institutions, which are connected to the thematic study content of the curriculum.</p>
<p>Study and exam requirements</p>	<p>Continuous assessment, regular reporting, preparation of a project report manuscript, certificate of the internship site</p>
<p>Media used</p>	
<p>Literature</p>	<p>Depends on actual project</p>

Katalog Wahlpflichtmodule (WP)/ Catalogue Elective Modules

ACM1 - Specialized polymer analytical methods

Course of studies	Angewandte Chemie (MSc)					
Module	Specialized polymer analytical methods					
Abbreviation	ACM1					
Course(s)	<ul style="list-style-type: none"> • Thermal Analysis and Process Safety • Rheology 					
Semester	1					
Person responsible for the module	Prof. Dr. Andreas Kandelbauer					
Instructor	Prof. Dr. Andreas Kandelbauer Prof. Dr. Roy Hornig					
Language	German					
Status within the curriculum	Mandatory in ACM / elective in others					
Type of course / WH	Course	L	E	LW	S	
	Thermal Analysis and Process Safety	2				
	Rheology	2				
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Thermal Analysis and Process Safety	30		45	75	
	Rheology	30		45	75	
	Total	60		90	150	5
Credit points	5					
Prerequisites for attending this course	See examination regulations					
Recommended knowledge / course work	Physics, chemistry, mathematics					

<p>Module goals / desired outcome</p>	<p>Knowledge</p> <ul style="list-style-type: none"> • Principles and theory of thermal analytical methods such as Differential Scanning Calorimetry (DSC), Thermogravimetry (TGA), Dynamic Mechanical Analysis (DMA), Rheology, Reaction Calorimetry (RC) and other calorimetric methods • Determination of basic characteristic values of material constants (melting points, glass transition temperatures, reaction enthalpies, etc.) • Derivation of complex information from calorimetric and rheometric measurements (reaction kinetics, activation energy barriers, thermal stability parameters, etc.) • Derivation of data which are relevant in the context of thermal process safety • Derivation and prediction of technologically important information regarding process windows, process optimization and process safety <p>Skills</p> <ul style="list-style-type: none"> • How complex experiments must be set-up in order to study the physical / chemical systems (guidelines for thermal and rheological analysis) • Specialized data treatment methods • Derivation of technologically relevant information from thermal and rheological data • Mathematical methods for Data treatment (kinetic modelling) • Use of commercial software packages <p>Technical competences</p> <ul style="list-style-type: none"> • Competence to select thermal and rheological analysis protocols depending on the problem • Competence to critically examine experimental results • Correct use of thermal and rheological material data and application of these data for process understanding and optimization • Competence to interpret such technical systems in the students' future careers or to virtually understand, operate and master complete processes based on the acquired knowledge. • Competence to assess critically conventional solutions, to improve or to replace them with new solutions. <p>Social competence</p> <ul style="list-style-type: none"> • Self-organization • Target-oriented working • Ability to think conceptually
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	<ul style="list-style-type: none"> • Development and strengthening of team and communication skills
Content	<p>1. Thermal Analysis and Process Safety</p> <ul style="list-style-type: none"> • Basics and application of standard and advanced thermal analytical and calorimetric methods in the laboratory • Principles and experimental set-ups of different kinds of calorimetry • Judgement of the advantages and disadvantages, application fields and limits of the various thermal analytical methods • Reaction calorimetry / microcalorimetry, Application of real-time temperature / heat-flow measurements in chemical reactions • Classic and advanced means of data treatment (e.g., model-based and model-free kinetic data analysis) • Prerequisites for obtaining good data • Derivation of quality relevant characteristic data • Use of thermal data in the risk assessment of thermally stimulated physical/chemical processes <p>2. Rheology</p> <ul style="list-style-type: none"> • Rheometric characteristics and numbers • Flow and viscosity curves • Velocity gradients during processing / manufacturing • Influences on viscosity • Newtonian and non-Newtonian liquids • Methods of practical viscosity measurement • Methods of absolute viscosity measurement • Different types of viscosimeters (such as capillary viscosimeter and other) • Data collection and data evaluation of flow curves with practical exercises • Recognize faulty measurements • Determination of viscoelastic properties of liquids and solids • Systematics of rheological analysis
Study and exam requirements	Written examination (2h), presentation
Media used	Lecture, board, digital projector, handouts



Literature	<p>Ehrenstein GW, Riedel G, Trawiel, Thermal Analysis of Plastics: Theory and Practice, Hanser, 2004</p> <p>Frick A, Stern C, DSC-Prüfung in der Anwendung, Hanser, 2013</p> <p>Sarge SM, Höhne GWH, Hemminger W, Calorimetry. Fundamentals, Instrumentation, and Applications, Wiley, 2014</p> <p>Stoessel F, Thermal Safety of Chemical Processes. Risk Assessment and Process Design, Wiley, 2008</p> <p>Vyazovkin S, Isoconversional Kinetics of Thermally Stimulated Processes, Springer, 2015</p> <p>Wissenschaftliche Originalliteratur (Aufgaben-bezogene Artikel aus peer-reviewed Zeitschriften)</p> <p>Brummer R, Rheology Esseentials of Cosmetic and Food Emulsions, Springer Berlin, 2005</p> <p>Mezger Th, The Rheology Handbook, Vincentz, 2006</p> <p>Schramm G, Einführung in die Rheologie und Rheometrie, Gebr. Haake, Karlsruhe</p>
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ACM2 - Chemical Engineering

Course of studies	Angewandte Chemie Master / Biomedical Sciences Master / Process Analysis & Technology Management Master					
Module	Chemical Engineering					
Abbreviation	ACM2					
Course(s)	Process Engineering and Industrial (Bio) Chemistry					
Semester	1					
Person responsible for the module	Prof. Dr. Wolfgang Honnen					
Instructor	Prof. Dr. Ralf Kemkemer, Prof. Dr. Wolfgang Honnen					
Language	English					
Status within the curriculum	Mandatory in ACM / elective in others					
Type of course / WH	Course	L	E	LW	S	
	Process Engineering and Industrial (Bio) Chemistry	4				
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Process Engineering and Industrial (Bio) Chemistry	60		90	150	5
	Total	60		90	150	5
Credit points	5					
Prerequisites for attending this course	See examination regulations					
Recommended knowledge / course work	Physics, chemistry, mathematics					

<p>Module goals / desired outcome</p>	<p>Knowledge</p> <ul style="list-style-type: none"> • Knowledge of important fundamentals in chemical engineering • Knowledge of the importance of mechanical and thermal unit operations • Knowledge of important examples of industrial chemical and bio chemical plants <p>Skills</p> <ul style="list-style-type: none"> • Ability to apply principles of fluid mechanics in calculations for technical processes • Ability to understand the physical basis of chemical engineering and to govern methods based on it. • Ability to understand the significance of heat and mass transfer and in nature and technology and estimate and calculate heat and mass transfer processes <p>Technical competences</p> <ul style="list-style-type: none"> • Competent application of the mechanical and thermal unit operations, which are important in the assessment of devices or equipment in the process engineering industries • Competence to interpret such technical systems in the students' future careers or to virtually understand, operate and master complete processes based on the acquired knowledge. • Competence to assess critically conventional solutions, to improve or to replace them with new solutions. <p>Social competence</p> <ul style="list-style-type: none"> • Ability to think conceptually • Development and strengthening of team and communication skills
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Content	<ol style="list-style-type: none"> 1. Fundamentals of chemical engineering <ul style="list-style-type: none"> • Mass and energy conservation • Fluid mechanics (fluid statics, fluid dynamics, Bernoulli's energy equation and metering of flows with examples) • Phase transitions • Heat and mass transfer 2. Selection of mechanical and thermal unit operations <ul style="list-style-type: none"> • Mixing and agitation • Filtration • Heat exchange, in particular heat transfer processes with phase change • Distillation • Adsorption • Absorption • Crystallization • Drying 3. Selected flowsheets (examples of industrial chemical and bio-chemical plants)
Study and exam requirements	Written examination (2h), presentation
Media used	Lecture, board, digital projector, handouts
Literature	<p>Jess, Andreas; Wasserscheid, Peter: Chemical Technology, An Integral Textbook, Wiley-VCH (2013)</p> <p>McCabe, Warren L.; Smith, Julian C.;Harriott, Peter: Unit Operations of Chemical Engineering, International Edition, McGraw-Hill Higher Education, 7th ed. (2005)</p> <p>Doran, Pauline M.: Bioprocess Engineering Principles, Academic Press, 2. ed. (2012)</p> <p>Katoh, Shigeo; Horiuchi, Jun-ichi; Yoshida, Fumitake: Biochemical Engineering, A Textbook for Engineers, Chemists and Biologists, Wiley-VCH , 2nd, rev. and enl. ed. (2015)</p>

ACM7 - Polymerbasierte Materialien 2 / Polymer Based Materials 2

Course of studies	Angewandte Chemie (MSc)					
Module	Polymer-basierte Materialien 2					
Abbreviation	ACM7					
Course(s)	Polymere und Flüssigkristalle / Selected Soft Materials Hybridwerkstoffe / Hybrid Materials					
Semester	2					
Person responsible for the module	Prof. Dr. Ralph Lehnert					
Instructor	Prof. Dr. Ralph Lehnert (Polymere und Flüssigkristalle) Prof. Dr. Roy Hornig (Hybridwerkstoffe)					
Language	Deutsch					
Status within the curriculum	Pflichtmodul in ACM / elective in others					
Type of course / WH	Course	L	E	LW	S	
	Polymere und Flüssigkristalle	2				
	Hybridwerkstoffe	2				
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Polymere und Flüssigkristalle	30		45	75	
	Hybridwerkstoffe	30		45	75	
	Total	60		90	150	5
Credit points	5					
Prerequisites for attending this course	Laut Studien- und Prüfungsordnung					
Recommended knowledge / course work	Physik, Chemie, Mathematik					



<p>Module goals / desired outcome</p>	<p>Erweitertes Grundlagenwissen ausgewählter polymerwissenschaftlicher Inhalte mit Schwerpunkt auf Struktur-Funktionalitätsbeziehungen und Grenzflächen.</p> <p>Kenntnisse</p> <ul style="list-style-type: none"> • Vertieftes Grundlagenwissen über Eigenschaften, Ordnungszustände, Strukturbildung und Phasenübergänge verschiedener Arten weicher Materie. • Zusammenhänge zwischen mikroskopischen Eigenschaften, mesoskopischer Ordnung und makroskopischen Materialeigenschaften. • Grundverständnis der Kompatibilität zwischen verschiedenen Materialien (organisch/polymer-anorganisch) • Formulierung und Compounding von Elastomeren • Technologische Verfahren zur Herstellung von Kunststoff-Metallverbunden <p>Fertigkeiten</p> <p>Erfolgreiche Studenten</p> <ul style="list-style-type: none"> • verstehen materialwissenschaftliche Aspekte von Relevanz für Anwendung und F&E in Polymerindustrie und industrieller Werkstoffentwicklung • verstehen wie makroskopische Eigenschaften von mikroskopischen und/oder mesoskopischen Stellgrößen abhängen • können relevante Materialien für vorgegebene Anwendungen / Eigenschaftsprofile (z.B. Polymere, Lösemittel, Elastomere, Haftvermittler) auswählen <p>Fachliche Kompetenzen</p> <ul style="list-style-type: none"> • Zusammenhangswissen zur Lösung polymerwissenschaftlicher Problemstellungen in der Anwendung • Material- und Methodenauswahl unter technologischen Aspekten • Studenten kennen Anwendungsbreite und Limitation bestehender Materialien und Technologien • Vorgehensweise zur Werkstoffkompatibilisierung <p>Soziale Kompetenzen</p> <ul style="list-style-type: none"> • Fördern des abstrakten Denkvermögens • Selbstorganisation und Motivation • Teamfähigkeit
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Content	<p>4. Polymere und Flüssigkristalle</p> <ul style="list-style-type: none"> • Kräfte, Energien, Zeit- und Längenskalen in polymerer und flüssigkristalliner Materie verschiedener Phasen • Stabilität, Phasenverhalten, Ordnungszustände, Selbstorganisationsphänomene, Rolle von Ober- und Grenzflächeneffekten • Eigenschaften von Polymeren in Lösung, Schmelze und Festkörper sowie von Flüssigkristallen <p>2. Hybridwerkstoffe</p> <ul style="list-style-type: none"> • Grundlagen Klebstoff- und Elastomertechnologie • Kompatibilität zwischen Kunststoffen und Metallen • Reinigung und Aktivierung von Substratoberflächen • Chemie und Technologie der Haftvermittler • Technologie der Elastomer-Metallverbunde • Prüfverfahren und Qualitätskontrolle
Study and exam requirements	Klausur 2h, Präsentation
Media used	Tafelanschrieb, Overheads, Skriptum, Tischvorlagen
Literature	<p>Gedde, UW, Polymer Physics, Kluwer Academic Publishers, 2001</p> <p>Jones, R. A. L.: Soft Condensed Matter, Oxford University Press, 2002</p> <p>Hamley, I, Introduction to Soft Matter. Synthetic and Biological Self-assembling Materials, Wiley, 2000</p> <p>Kickelbick G, Hybrid Materials, Wiley-VCH, 2008</p> <p>Stokes RJ, Evans DF, Fundamentals of Interfacial Engineering, Wiley-VCH, 1997</p> <p>Plüddemann EP, Silane Coupling Agents, 2nd edition, Kluwer, 1991</p> <p>Mittal KL, Pizzi A, Adhesion Promotion Techniques. Technological Applications, Marcel Dekker, 2002</p> <p>Ausgewählte wissenschaftliche Originalarbeiten und Review-Artikel</p>

ACM08 - Polymerbasierte Materialien 1

Course of studies	Angewandte Chemie MSc					
Module	Polymerbasierte Materialien 1					
Abbreviation	ACM-08					
Course(s)	Advanced Materials Product Functionality Design					
Semester	2					
Person responsible for the module	Prof. Dr. Andreas Kandelbauer					
Instructor	Prof. Dr. Andreas Kandelbauer (Advanced Materials) Prof. Dr. Richard Schilling (Product Functionality Design)					
Language	Deutsch					
Status within the curriculum	Pflichtmodul in ACM / elective in others					
Type of course / WH	Course	L	E	LW	S	
	Advanced Materials	2				
	Product Functionality Design	2				
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Advanced Materials	30		45	75	
	Product Functionality Design	30		45	75	
	Total	60		90	150	5
Credit points	5					
Prerequisites for attending this course	Laut Studien- und Prüfungsordnung					
Recommended knowledge / course work	Physik, Chemie, Mathematik					

<p>Module goals / desired outcome</p>	<p>Vertieftes Grundlagenwissen ausgewählter materialwissenschaftlicher Inhalte mit Schwerpunkt auf Struktur-Funktionalitätsbeziehungen. Einführung in anwendungsorientierte Fragestellungen der wechselseitigen Abhängigkeit zwischen Materialfunktionalität und Produkteigenschaften.</p> <p>Kenntnisse</p> <ul style="list-style-type: none"> • Kennenlernen der Eigenschaften und Strukturen von Hochleistungspolymeren, Anwendungen • Architekturen und Chemismus verschiedener Nanomaterialien, Hochleistungspolymere und Polymerverbundwerkstoffe • Spezielle Strategien zur Performanceverbesserung von Werkstoffen • Prinzipien der Verbundwerkstofftechnologie; Herstellungs- und Verarbeitungsverfahren • Methodenkompetenz für eine funktionsgerechte, designorientierte Materialauswahl und ein materialgerechtes Design • Problemlösungskompetenz zur Formulierung von Design- und Materialanforderungsprofilen <p>Fertigkeiten</p> <ul style="list-style-type: none"> • Studenten verstehen materialwissenschaftliche Aspekte von Relevanz für Anwendung und F&E in Polymerindustrie, Medizinprodukte-Industrie und Werkstoffentwicklung • Verständnis, wie makroskopische Eigenschaften von mikroskopischen Eigenschaften abhängen • Fähigkeit über wissenschaftliche Literatur und Datenbanken relevante Materialien für bestimmte Anwendungen / Eigenschaftsprofile auszuforschen • Analytisch-systematische Suche und Auswahl von komplexen Materialsystemen anhand von Material- und Produktlastenheften • Umgang mit Software zur Materialauswahl, Eigenschaftsvorhersage und Prototypen-konstruktion • Umsetzung von funktionalen Materialkonzepten von der Modellbildung bis zum Prototypen <p>Fachliche Kompetenzen</p> <ul style="list-style-type: none"> • Studenten können Anwendungsbreite und Limitation bestehender Materialien und Technologien benennen • Zusammenhangswissen zur Lösung materialwissenschaftlicher Problemstellungen
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	<ul style="list-style-type: none"> • Materialauswahl unter technologischen und Designgesichtspunkten <p>Soziale Kompetenzen</p> <ul style="list-style-type: none"> • Fördern des abstrakten Denkvermögens • Selbstorganisation und Motivation • Teamfähigkeit
Content	<p>1. Advanced Materials</p> <ul style="list-style-type: none"> • Hochleistungsfasern • Hochleistungspolymere • Hochleistungsverbundwerkstoffe • Biobasierte Materialien • Nanomaterialien u. a. „Emerging Technologies“ • Spezielle Funktionalitäten: Selbstheilung, interaktive („stimulus-responsive“) Materialien, „smarte“ Materialien • Herstellung und Verarbeitung von Verbundwerkstoffen (SMC, BMC, Pultrusion, RIM, RTM, etc.) • Spezielle und aktuelle Themen anhand konkreter wissenschaftlicher Originalliteratur <p>2. Product Functionality Design</p> <ul style="list-style-type: none"> • Allgemeine Prinzipien der mathematisch-physikalischen Modellbildung anhand konkreter technischer Fragestellungen • Methoden der systematischen Materialauswahl • Durchführung von Life-Cycle Analysen • Grundlegende Konzepte der ökologischen und nachhaltigen Produktion • Abstimmung von Design und Material zur Optimierung der Gebrauchseigenschaften anhand von Fallbeispielen • Verfahren zur Beschleunigung des Designprozesses durch z.B. 3D-Scanning Methoden • Rapid Prototyping und moderne Verarbeitungsmethoden wie z.B. 3D-Druck
Study and exam requirements	Continuous Assessment, Klausur 2h, Hausarbeit, Präsentation
Media used	PPT, Tafelanschrieb, Overhead-Folien, Skriptum, Tischvorlagen, Formelsammlungen, Übungen



Literature	<p>Ullmann´s Encyclopedia of Industrial Chemistry, Wiley 2012</p> <p>Ghosh SK, Self-Healing Materials, Wiley, 2012</p> <p>Krueger A, Carbon Materials and Nanotechnology, Wiley, 2012</p> <p>Dodiuk H, Goodman S, Handbook of Thermosetting Plastics, CRC / Elsevier, 2014</p> <p>KLumar C, Nanomaterials for the Life Sciences (Series) Vols. 1-10, Wiley, 2012</p> <p>Current scientific original papers</p> <p>Kickelbick G, Hybrid Materials, Wiley-VCH, 2008</p> <p>Stokes RJ, Evans DF, Fundamentals of Interfacial Engineering, Wiley-VCH, 1997</p> <p>Methodik der Werkstoffauswahl: Der systematische Weg zum richtigen Material, Carl Hanser Verlag GmbH & Co. KG; Auflage: 1 (2006), ISBN-10: 9783446406803</p> <p>Nash WA, Schaum's Outline of Strength of Materials (Schaum's Outlines) 432 Seiten , Schaum Outline Series; Auflage: 4 Sub (1998) Englisch , ISBN-13: 978-0070466173</p> <p>Software: CES Edu Pack 2013, Grantadesign, Cambridge</p>
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PAM4 –Process Analytical Technology I

Course of studies	Process Analysis and Technology Management (MSc)					
Module	Process Analytical Technology I					
Abbreviation	PAM4					
Course(s)	Process Spectroscopy and Spectrometry					
Semester	1					
Person responsible for the module	Prof. Dr. Karsten Rebner					
Instructor	Prof. Dr. Karsten Rebner					
Language	English					
Status within the curriculum	Mandatory					
Type of course / WH	Course	L	E	LW	S	
	Process Spectroscopy and Spectrometry	4				
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Process Spectroscopy and Spectrometry	30		45	75	
	Optofluidics System Technologies	30		45	75	
	Total	60		90	150	5
Credit points	5					
Prerequisites for attending this course	See examination regulations (Studien- und Prüfungsordnung)					
Recommended knowledge / course work	Knowledge of instrumental analysis					



Module goals / desired outcome	<p>The lecture explores the concepts of Process Analytical Technology and its application in the process industry especially chemical and pharmaceutical industry from the point of view of the analytical chemist.</p> <p>General knowledge:</p> <p>Successful students will obtain</p> <ul style="list-style-type: none"> • knowledge to implement process analyzers for monitoring and control of productions plants. • an overview of apply process analyzers in combination with microfluidic systems for medical and biomedical sensing and manipulation. <p>Skills:</p> <p>Successful students will be able</p> <ul style="list-style-type: none"> • to build upon and extend the theoretical and instrumental concepts of process analyzers • to develop the competence and confidence applying process spectroscopy for different industry branches. • assessing analyzer benefits and the trade-off between initial capital costs and ongoing cost-of ownership <p>Social competences:</p> <ul style="list-style-type: none"> • Ability to work in a self-organized manner and as a member of a team • Ability to do work target-oriented and systematically
Content	<ul style="list-style-type: none"> • Understanding Processes and How to Improve Them • Implementation of Process Analytical Technologies • UV-Visible Spectroscopy for On-line Analysis • Infrared Spectroscopy for Process Analytical Applications • Process Raman Spectroscopy • Process Mass Spectrometry • Optofluidics System Technology
Study and exam requirements	Written exam (2h), term paper (solving exercise sheet and submitting solutions which will be marked)
Media used	Lecture, board, overheads, lecture notes, handouts, exercise sheets



Literature	<ol style="list-style-type: none">1. Kessler RW (Ed.): Prozessanalytik Strategien und Fallbeispiele aus der industriellen Praxis, Wiley-VCH, 20062. Bakeev: Process Analytical Technology: Spectroscopic Tools and Implementation Strategies for the Chemical and Pharmaceutical Industries, Wiley-VCH, 2010.3. Rabus: Optofluidics System Technology, De Gruyter, 20144. Undey, Low, Menezes, Koch: PAT Applied in Biopharmaceutical Process Development and Manufacturing, CRC Press 2012
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PAM6 –Process Control (Sensors Fundamentals and Application)

Course of studies	Process Analysis and Technology Management (MSc)					
Module	Process Control (Sensor Fundamentals and Applications)					
Abbreviation	PAM6					
Course(s)	Process Control: Sensor Fundamentals and Applications					
Semester	1					
Person responsible for the module	Prof. Dr. Ralph Lehnert					
Instructor	Prof. Dr. Ralph Lehnert					
Language	English					
Status within the curriculum	Mandatory					
Type of course / WH	Course	L	E	LW	S	
	Design of Experiment	2	1	1		
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Sensor Fundamentals and Applications	45		105	150	5
	Total	45		105	150	5
Credit points	5					
Prerequisites for attending this course	See examination regulations (Studien- und Prüfungsordnung)					
Recommended knowledge / course work	Knowledge of physics, physical chemistry, instrumental analytics					



<p>Module goals / desired outcome</p>	<p>General knowledge: Successful students will obtain</p> <ul style="list-style-type: none"> • overview of basic electrical and optical measuring methods as well as signal processing approaches • understanding of functional principles, designs and performance factors of physical and bio/chemical sensors • hands-on experience in using sensors in practical situations <p>Skills: Successful students will be able</p> <ul style="list-style-type: none"> • to analyze and solve a concrete measuring task • to interpret sensor data sheets • to select, put into operation, implement and operate commercial sensors and sensor systems in laboratory and production contexts • to design and build simple customized sensors • to perform adequate basic post-acquisition signal processing and data evaluation <p>Social competences:</p> <ul style="list-style-type: none"> • Ability to work in a self-organized manner and as a member of a team • Ability to do work target-oriented and systematically
<p>Content</p>	<p>The course consists of a lecture and accompanying class exercises as well as practicals, all treating:</p> <ul style="list-style-type: none"> • Basic concepts of sensor technology, actor technology, signal processing and evaluation • Working principles, designs and components of physical, chemical and biochemical sensors • Application of such sensors to specific measuring tasks
<p>Study and exam requirements</p>	<p>Written exam (2h), term paper (solving exercise sheet and submitting solutions which will be marked)</p>
<p>Media used</p>	<p>Lecture, board, overheads, lecture notes, handouts, exercise sheets</p>

Literature	<ol style="list-style-type: none">1. Gründler, P. : Chemical Sensors, Springer, 20072. Hauptmann, P.: Sensors: Principles and Applications, Prentice-Hall, 19933. Eggins, B. R. : Chemical Sensors and Biosensors, John Wiley & Sons, 20044. Niebuhr, J., Lindner G.:Physikalische Messtechnik mit Sensoren, Oldenbourg Verlag, München, 20115. Freudenberger, A. : Prozessmesstechnik, Vogel Verlag, Würzburg, 2000.
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PAM10 -Process Analytical Technology II

Course of studies	Process Analysis and Technology-Management (MSc)					
Module	Process Analytical Technology II					
Abbreviation	PAM10					
Course(s)	Sampling and sample preparation SSP Measuring and Control Technology MCT					
Semester	2					
Person responsible for the module	Prof. Dr. Karsten Rebner					
Instructor	Prof. Dr. Karsten Rebner Prof. Dr. Jörg Ingo Baumbach					
Language	English					
Status within the curriculum	Mandatory					
Type of course / WH	Course	L	E	LW	S	
	Sampling and sample preparation	2				
	Measuring and Control Technology	2				
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Sampling and sample preparation	30		45	75	
	Measuring and Control Technology	30		45	75	
	Total	60		90	150	5
Credit points	5					
Prerequisites for attending this course	See examination regulations					
Recommended knowledge / course work	basic knowledge of measurement of physical and chemical analytical methods					

<p>Module goals / desired outcome</p>	<p>General knowledge:</p> <p>Successful students will obtain</p> <ul style="list-style-type: none"> • a general introduction to industrial sampling systems • state of the art extract techniques for organic and inorganic analytes • Sampling preparation in biological measurements • knowledge about the wide range of rather simple sensors as used to measure temperature, pressure, humidity, acceleration and density • overview about online process analytical methods with chemical background like FTIR, NIR, MIR, MS, GC/MS, MCC/IMS, LC/MS <p>Skills</p> <p>Successful students will be able</p> <ul style="list-style-type: none"> • outlining the reasons why sampling is often unreliable and some ways to improve them • calculating of time delay effects in each segment of the sample transport system. • evaluating existing or proposed locations for the sampling nozzle and making a decision. • to develop strategies to make samples compatible to the analyzers they serve • to interpret sensor, spectrometric and spectroscopic data with respect to remote process control • to compare laboratory and process analytical methods and results of applications in the field and in the lab • to compare on-line, in-line, at-line and off-line methods including sampling strategies and control technologies • to bring sampling strategies and measurement and control techniques together within industrial and non-industrial monitoring systems
<p>Content</p>	<p>Sampling and sample preparation</p> <ul style="list-style-type: none"> • Core Principles of Sample System Design • Evaluation and Design of Sample Transport Lines • Location and Design of Process Sampling Taps • Preconditioning the Process Sample • Sample Conditioning and Disposal • Sample Isolation and Switching Systems <p>Measuring and Control Technology</p>



	<ul style="list-style-type: none"> • Sensors: temperature, pressure, humidity, density, refraction index • Chemical sensors • Process-Spectrometers: GC, LC, MS, IMS, NMR, • Process-Spectroscopy: FTIR, NIR, MIR, Raman, • Differences laboratory and process analysis • Measuring and control technology as part of the quality management system • Measurement and control technology and process engineering • Interpretation of analytical data sets and remote sensing
Study and exam requirements	Written examination (2h), presentation / assignments
Media used	PowerPoint slides, flip charts, board, software practicals in CIP-Pool
Literature	<ol style="list-style-type: none"> 1. Tony Waters, Industrial Sampling Systems, 2014, Swagelok 2. Cazes, Analytical Instrumentation Handbook, CRC Press, 2012 3. John Kenkel, Analytical Technics for Technicians, CRC Press, 2003 4. Michael E. Schwartz, Analytical techniques in combinatorial chemistry, Marcel Dekker, 2000 5. Jack Cazes, Analytical Instrumentation Handbook, Marcel Dekker, 2005 6. Paul, C.H. Li: Fundamentals of Microfluidics and Lab on a Chip for biological analysis and discovery, CRC Press, 2010 7. Michael E. Swartz, Ira S. Krull: Analytical Validation, CRC Press 2012 8. Donald A. Burns, Emil W. Ciurczak: Handbook of Near-Infrared Analysis – CRC Press, 2008 9. David M. Scott, Industrial Process Sensors, CRC Press, 2008 10. Krzysztof Iniewski, Smart sensors for industrial applications, CRC Press 2013 11. Hassan Y. Aboul-Enein et al. Quality and Reliability in Analytical Chemistry, CRC Press 2001 12. Kessler, R. Prozessanalytik, Strategien und Fallbeispiele aus der industriellen Praxis, Wiley, 2006 13. Scientific publications



PAM11 -Bioanalytical Techniques (BT)

Course of studies	Process Analysis and Technology-Management (MSc)					
Module	Bioanalytical Techniques (BT)					
Abbreviation	PAM 11					
Course(s)	Microscopy and Optics In-Process Metabolomics IPM					
Semester	2					
Person responsible for the module	Prof. Dr. Jörg Ingo Baumbach					
Instructor	Prof. Dr. Marc Brecht Prof. Dr. Jörg Ingo Baumbach					
Language	English					
Status within the curriculum	Mandatory					
Type of course / WH	Course	L	E	LW	S	
	Microscopy and Optics	2				
	In-Process Metabolomics	2				
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Microscopy and Optics	30		45	75	
	In-Process Metabolomics	30		45	75	
	Total	60		90	150	5
Credit points	5					
Prerequisites for attending this course	See examination regulations					
Recommended knowledge / course work	Knowledge of biochemistry, bioanalytics, instrumental analytics, chemistry, material science, fundamental knowledge of optics, sensors and spectrometers, biology					

<p>Module goals / desired outcome</p>	<p>General knowledge</p> <p>Successful students will obtain</p> <ul style="list-style-type: none"> • Profound overview of current in-process metabolomics including different bioanalytical techniques that are significant in clinical, biomedical and pharmaceutical research and practice • Profound understanding of advantages and disadvantages of different methods in metabolomics, especially for clinical and diagnostic applications • Profound understanding of technologies and functioning of laboratory investigations, diagnostics and applications <p>Skills:</p> <ul style="list-style-type: none"> • Understanding of complex relationships in bioanalytics • Understanding of the aspects of material science that are relevant for R&D in biotechnology, pharmaceutical and diagnostics industries • Understanding of principles of interaction of biological systems and molecules with different materials including nutrition effects • Understanding of principles of structure of sensoric, spectrometric and diagnostic systems and pre-requisites for certain applications in life science, medical applications and fermentation processes • Ability to name limitations of existing analytical technologies • Ability to evaluate various methods of laboratory diagnostics • Ability to read and understand scientific publications <p>Social competences:</p> <ul style="list-style-type: none"> • Students develop skills in research, reading and interpretation of scientific texts • Students gain an awareness of process aspects in the development of control of metabolomics processes.
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Content	<p>Optical technologies are a cornerstone of all analytical technologies. The lecture starts with a short repetition of geometric optics. We will discuss wave optics in free space and waveguides, followed by the basic function of lasers including modes in optical resonators and Fourier transformations in the description of optical setups. Then we will consider aberrations of optical elements, lens design and technical optics. In the second part we will focus on microscopy, we will discuss the resolution of a conventional microscope as well as methods of resolution improvement like structured illumination, 4Pi, STED, STROM and FLIM microscopy and single-molecule sensitive detection. In all parts examples for applications will be give.</p> <p>Mostly, processes in biology and more general in life sciences are related to exchange of material and energy - all are highly parallel running. In general, analytical technologies and strategies including data analysis are mostly well understood. In contrast, on the other hand metabolic processes are not well described, including Genomics and Proteomics. Especially, regulatory processes need still further investigation. Therefore, the lectures will consider metabolomic processes the influence of different materials and pharmaceuticals. Here, metabolome stands for all characteristic metabolic processes within a cell, a tissue, an organ or an organism. Therefore, effects of flow rates, metabolite levels, activities of enzymes and interactions between different metabolic pathways and interactions of different compartments are considered and discussed in detail. Especially, metabolic processes, interactions and relations between cells and the identification and quantification of metabolites are discussed. Basis analytical methods like GC/MS, LC/MS, NMR und Ion-Mobility-Spectrometry (IMS) are included, relation between Genomics, Proteomics and Metabolomics exemplarily explained and conclusions with respect to regulatory processes at medical and biological processes including fermentation and human health characterization.</p>
Study and exam requirements	Written examination (2h), presentation / assignments
Media used	PowerPoint slides, flip charts, board
Literature	<p>Hecht, E.: Optics, Addison-Wesley, 2001 Demtröder, W.: Laser spectroscopy I & II, Springer; 5th ed. 2014 Murphy, D.B.: Fundamentals of Light Microscopy and Electronic Imaging, Wiley-Blackwell; 2nd ed. 2012 Issaq, H.J.: Proteomic and Metabolomic Approaches in Biomarker Discovery, Academic Press, 2013</p>



	<p>Lämmerhofer, M., Weckwerth, W.: Metabolomics in Practice: Successful Strategies to Generate and Analyze Metabolic Data, Wiley-VCH, 2013</p> <p>Weckwerth, W.: The Handbook of Plant Metabolomics (Molecular Plant Biology), Wiley Blackwill, 2013</p> <p>Teresa Whei-Mei Fan, Andrew N. Lane: The handbook of metabolomics. Humana Press 2016</p> <p>Alessandra Sussulini: Metabolomics: From Fundamentals to Clinical Applications (Advances in Experimental Medicine and Biology) 2016</p> <p>David Beale: Microbial Metabolomics: Applications in Clinical, Environmental, and Industrial Microbiology – Springer, 2016</p> <p>Scientific publications</p>
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BMS14 – Module from other schools or universities

Course of studies	Biomedical Sciences BMS (MSc)					
Module	Module from other schools or universities					
Abbreviation	BMS14					
Course(s)	Modules from other schools or universities with at least 4 SWS and 5 ECTS-credits to be approved by examination commission					
Semester	1 or 2					
Person responsible for the module	Prof. Dr. Reinhard Kuhn					
Instructor						
Language	English or German					
Status within the curriculum						
Type of course / WH	Course	L	E	LW	S	
	Internship semester	-	-	-	-	
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Module from other schools or universities	60		90	150	5
	Total			90	150	5
Credit points	5					
Prerequisites for attending this course	See examination regulations					
Recommended knowledge / course work						
Module goals / desired outcome	depending on the selected module					

Content	depending on the selected module
Study and exam requirements	depending on the selected module
Media used	depending on the selected module
Literature	depending on the selected module

