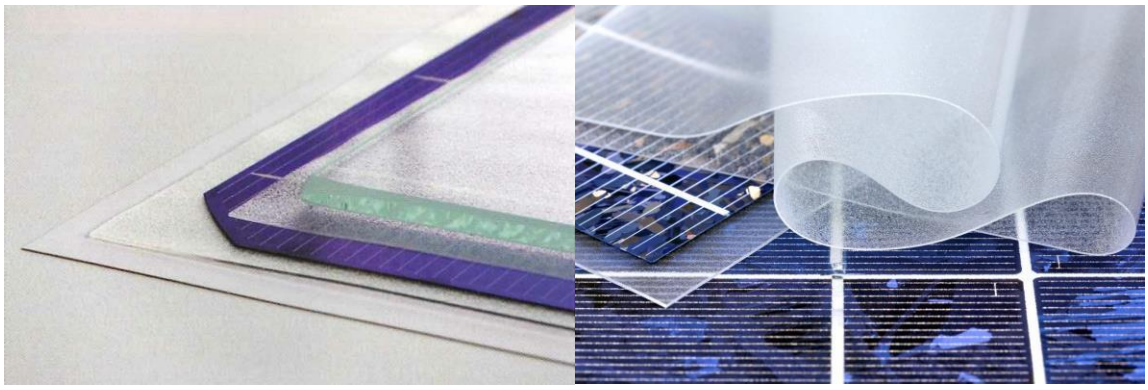
Modulhandbuch

für den Master-Studiengang

M.Sc. Angewandte Chemie (ACM)

erstellt im Oktober 2016 von der Fakultät Angewandte Chemie



Photovoltaik Modul (links) mit Tectosil (Wacker Chemie AG), einem Verkapselungsmaterial auf Basis eines thermoplastischen Silikon-Elastomers (Detail rechts). Die einzelnen Schichten sind: Deckschichtglas, Tectosil Lage, Solarzelle, Tectosil Lage, Rückseitenlage. Tectosilfilme werden als Rollenware mit Releasefolie vertrieben (mit freundlicher Genehmigung von Wacker Chemie AG)

Quelle: Lorenz G, Kandelbauer A, Patterson RF (2013) „Chapter 9: Silicones“, in: Dodiuk-Kenig H, Goodman S (Eds.) Handbook of Thermoset Plastics, 3rd edition, William Andrew Inc., ISBN 978-1455731077

Inhalt

1. Vorbemerkungen

Dieses Modulhandbuch soll den Studierenden und den Lehrenden die Inhalte des Curriculums des Studiengangs Master of Science Angewandte Chemie detailliert und umfassend darstellen.

Die jeweiligen Modulbeschreibungen in diesem Handbuch stellen die Modulziele und die angestrebten Lernergebnisse sowie die konkreten Inhalte der enthaltenen Lehrveranstaltungen vor. Darüber hinaus liefern sie alle zum erfolgreichen Studienablauf notwendigen Informationen. Sie sind auch Bestandteil des Diploma-Supplements des Mastergrades.

Sollten Sie Fragen haben, die mehrere Module oder den Studienverlauf betreffen, so wenden Sie sich bitte an das Dekanat der Fakultät Angewandte Chemie.

Sollten Sie Fragen zu einem speziellen Modul haben, so wenden Sie sich bitte direkt an den entsprechenden Modulkoordinator. Eine Auflistung der Modulkoordinatoren finden Sie im Internet, wo auch das Modulhandbuch zu finden ist.

Sollten Sie Fragen zu einer speziellen Veranstaltung haben, so wenden Sie sich bitte direkt an den jeweiligen Dozenten oder die jeweilige Dozentin.

2. Einführung

2.1 Übersicht über das Studium

Das Curriculum des Master-Studienganges Angewandte Chemie umfasst eine Studiendauer von 3 Semestern. Übergeordnetes Ziel dieses Masterprogramms ist es, den Studierenden eine vertiefte Fachkenntnis im Gebiet polymerer Werkstoffe, Verbundwerkstoffe und Hochleistungsmaterialien, so genannter „Advanced Materials“ zu vermitteln.

Dazu wird den Studierenden in den ersten beiden Semestern einerseits in den Modulen „Polymerbasierte Materialien 1 & 2“; „Materials and Applications in Biomedical Sciences“ die notwendige Stoffkenntnis zu derzeit und in absehbarer Zukunft wichtigen Materialien in verschiedenen Anwendungsfeldern vorgestellt. Schwerpunkt liegt auf dem Verständnis des Zusammenhangs zwischen molekularer Struktur und Eigenschaften. Andererseits erfahren die Studierenden in dazu komplementären Modulen („Chemical Engineering“, „Technology Management“ sowie Lehrveranstaltung „Konstruktion und Produktdesign“) wesentliche Grundlagen dazu, wie man das erworbene Wissen auf molekularer Ebene in die industrielle Praxis übersetzt.

Darüber hinaus befassen sich die Module Scientific Methods (SM) 1, 2 und 3 sowie Spezielle Polymeranalytische Verfahren (SPV) mit dem notwendigen Methodenspektrum, das erforderlich ist, um Materialien intelligent und effizient entwickeln und optimieren zu können (SM 1: Design of Experiments) und umfassend und vor allem multivariat, d. h. in ihrem komplexen Eigenschaftsspektrum charakterisieren und modellieren zu können (SM 2 und 3, SPV). Die wesentlichen Kompetenzen umfassen dabei vor allem methodisches Vorgehen, vernetztes Denken und Problemlösungsorientierung.

Gelegenheit, das Gelernte praktisch anzuwenden haben die Studierenden während der ersten beiden Semestern über die Arbeit an einem beide Semester überspannenden Forschungsprojekt („Projekt orientiertes Lernen (POL) 1 & 2“). Im Rahmen dieser im Team durchgeführten, intensiv betreuten und in aktuelle Forschungsprojekte an der Fakultät eingebetteten Projektarbeit steht den Studierenden viel Raum zur Verfügung, der Gelegenheit bietet, unter starker Eigeninitiative und Selbstorganisation für ein gegebenes Problem die relevanten Fragestellungen zu identifizieren und geeignete Methoden und spezielles Wissen zu erarbeiten. Zur weiteren Spezialisierung ist es den Studierenden möglich aus einem reichen Katalog an Wahlpflichtfächern zu wählen.

Das dritte Semester steht zur Erarbeitung der Abschlussarbeit (Masterthesis) zur Verfügung und dient damit dem ersten eigenständigen wissenschaftlichen Arbeiten.

2.2 European Credit Transfer an Accumulation System (ECTS)

Gemäß den Vorgaben des Ministeriums für Wissenschaft, Forschung und Kunst BW sowie der Kultusministerkonferenz sind die Studieninhalte in Module eingeteilt. Die erbrachte Studienleistung wird mit dem „European Credit Transfer and Accumulation System“ (ECTS) erfasst. Damit Studienleistungen, die in unterschiedlichen Hochschulen – auch im Ausland – erbracht werden, besser verglichen werden können, stützt sich das ECT-System nicht auf Semesterwochenstunden (SWS), die den Lehraufwand wiedergeben, sondern auf den Lernaufwand der Studierenden. Eine Vergleichbarkeit der Studienleistungen in Europa wird hierdurch möglich.

Pro akademisches Jahr kann der Studierende im Sinne des ECTS im Vollzeitstudium 60 Kreditpunkte erzielen. Dies entspricht einer mittleren Arbeitslast von 1800 Stunden Studium. Ein Kreditpunkt steht für 30 Stunden (h) Arbeitsaufwand des normal begabten Studierenden. Der Arbeitsaufwand setzt sich aus der Präsenzzeit an der Hochschule und aus der Zeit für das erforderliche Eigenstudium zusammen. Die Präsenzzeit wird in Semesterwochenstunden (SWS) angegeben. Dabei entspricht eine SWS einer vollen Zeitstunde.

Beispiel zur Veranschaulichung:

SWS*	Präsenz	Eigenstudium	Arbeitsaufwand	Kreditpunkte
2	30 h	60 h	90 h	3

SWS* = 1 SWS entspricht 15 h bei einem Durchschnitt von 15 Wochen pro Semester.

Gewährt werden die ECTS jedoch nur, wenn der oder die Studierende die erforderliche Prüfungsleistung auch nachweislich erbracht hat. Die Kreditpunkte werden nach dem Prinzip „Alles-oder-Nichts“ vergeben!

3. Übersicht über die Module im Studiengang

ACM1: Spezielle Polymeranalytische Verfahren/ Specialized Polymer Analytical Methods

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

ACM2: Chemical Engineering

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

ACM3: Materials and Applications in Biomedical Sciences

Module No.	Module course	Semester	WH	Credit points
ACM3	Functional Implants & Surface Technologies	1	2	2.5
ACM3	Drug Release and Delivery Systems	1	2	2.5

ACM4: Technology Management

Module No.	Module course	Semester	WH	Credit points
ACM4	Innovation Management/ Quality Management/ Project Management	1	4	5

ACM5: Scientific Methods 1: Design of Experiments (in english)

Module No.	Module course	Semester	WH	Credit points
ACM5	Scientific Methods 1: Design of Experiments & Exercises	1	4	5

ACM6: Projektorientiertes Lernen 1/ Project Oriented Learning 1

Module No.	Module course	Semester	WH	Credit points
ACM6	Forschungsseminar/ Research Seminar POL1	1	2	2.5
ACM6	Team Project POL1	1	4	2.5

ACM7: Polymerbasierte Materialien 2/ Polymer Based Materials 2

Module No.	Module course	Semester	WH	Credit points
ACM7	Hybridwerkstoffe/ Hybrid Materials	2	2	2.5
ACM7	Polymere & Flüssigkristalle/ Selected Soft Materials	2	2	2.5

ACM8: Polymerbasierte Materialien 1/ Polymer Based Materials 1

Module No.	Module course	Semester	WH	Credit points
ACM8	Advanced Materials	2	2	2.5
ACM8	Konstruktion und Produktdesign/ Product Functionality Design	2	2	2.5

ACM9: Wahlpflichtmodu/ Elective Module

Module No.	Module course	Semester	WH	Credit points
ACM9	Elective Subjects	2	4	5

ACM10: Scientific Methods 2: Multimodal Data Generation an Analysis (in English)

Module No.	Module course	Semester	WH	Credit points
ACM10	Scientific Methods2: Multimodal Data Generation an Analysis	2	4	5

ACM11: Scientific Methods 3: Information Retrieval and Evaluation, Multivariate Data Analysis

Module No.	Module course	Semester	WH	Credit points
ACM11	Scientific Methods3: Information Retrieval	2	2	2,5
ACM11	Scientific Methods3: Multivariate Data Analysis (MVA)	2	2	2,5

ACM12: Projektorientiertes Lernen 2/ Projekt Oriented Learning 2

Module No.	Module course	Semester	WH	Credit points
ACM12	Forschungsseminar/ Research Seminar POL2	2	2	2,5
ACM12	Team Project POL 2	2	4	2,5

ACM13: Masterthesis/ Master's Thesis

Module No.	Module course	Semester	WH	Credit points
ACM13	Masterthesis Projekt und Verteidigung/ Master's Thesis Project and Defense (internal/ external)	3		30
ACM13	Forschungsseminar zur Masterthesis/ Research Seminar to Master's Thesis	3	2	

Zusätzliches Modul für Studierende mit 180 ECTS Bachelor-Abschluss /
Additional Module only for students with 180 ECTS Bachelor's degree

ACM14: Internship semester

Module No.	Module course	Semester	WH	Credit points
ACM14	Internship semester	3		30

Katalog Wahlpflichtmodule (WP) / Catalogue elective Modules

PAM4: Process Analytical Technology I

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

PAM5 Industry-Related Topics (Regulatory Affairs, IP Management)

Module No.	Module course	Semester	WH	Credit points
PAM5	Regulatory Affairs	1	2	5
	IP Management	1	2	

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	

BMS1: Analytical Methods in Biomedical Sciences

Module No.	Module course	Semester	WH	Credit points
BMS1	Diagnostic Technologies	1	2	2.5
BMS1	Analytical Methods in Biomedical Sciences	1	2	2.5

BMS7: Biomedical Technologies

Module No.	Module course	Semester	WH	Credit points
BMS7	Regenerative Medicine	2	2	2.5
BMS7	Biomedical Technologies – Biofabrication	2	2	2.5

BMS8: Advanced Pharmacology

Module No.	Module course	Semester	WH	Credit points
BMS8	Biomedical Pharmacology	2	2	2.5
BMS8	Advanced Bioanalysis	2	2	2.5

ACM15: Modul anderer Fakultäten, Hochschulen oder Universitäten / Module from other schools or universities

Module No.	Module course	Semester	WH	Credit points
ACM15	Wählbare Module anderer Fakultäten, Hochschulen oder Universitäten mit mindestens 4 SWS bzw. 5 ECTS mit Zustimmung der Prüfungskommission/ elective modules from other schools or universities with at least 4 SWS and 5 ECTS-credits to be approved by examination commission.	1	4	5

4. Vergabe von Noten – Qualität

4.1 Relative ECTS Noten

International ist es Standard, dass die 10 % besten Studierenden die Note A erhalten, unabhängig von der Note, die sie nach dem deutschen Notensystem erhalten. Dieses System soll die Leistung der Studierenden objektiver machen, da schwere und auch leichte Veranstaltungen relativiert werden.

erfolgreiche Studierende	ECTS-Note
die besten 10%	A = hervorragend (excellent)
die nächsten 25%	B = sehr gut (very good)
die nächsten 30%	C = gut (good)
die nächsten 25%	D = befriedigend (satisfactory)
die nächsten 10%	E = ausreichend (sufficient)
	F = nicht bestanden (fail)

Da für die korrekte Berechnung der relativen ECTS Noten jedoch eine größere Anzahl von Studierenden als Datenbasis benötigt werden, wird für diesen Studiengang auch weiterhin die herkömmliche deutsche Notenskala von 1 bis 5 verwendet. Die deutsche Note wird nach folgendem Schema in die ECTS-Note (ECTS-Grade) umgeformt. (Anmerkung: aktueller Stand Februar 2011)

ECTS-Grade	**Deutsche Note**	**ECTS-Definition**	**Deutsche Übersetzung**
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	fail	nicht bestanden

5. Hinweise zur Beschreibung von Modulen

Die Beschreibung der Module soll den Studierenden eine zuverlässige Information über Studienverlauf, Inhalte, qualitative und quantitative Anforderungen und Einbindung in das Gesamtkonzept des Studienganges bzw. das Verhältnis zu anderen angebotenen Modulen bieten. Dazu sind die Module übersichtlich in tabellarischer Form dargestellt.

Im Folgenden finden Sie die einzelnen Punkte, die in der Tabelle ausgeführt werden, kurz erklärt. Modulbezeichnung / Kürzel:

Jedem Modul ist Modulbezeichnung und ein Kürzel zugeordnet. Die Modulbezeichnung gibt bereits Aufschluss über den Inhalt des Moduls. Das dazu gehörige Kürzel beginnt mit den Anfangsbuchstaben des Studiengangnamens und des Abschlusses, Abkürzung ACM (Angewandte Chemie: AC, Abschluss: Master M) und einer fortlaufenden Zahlenfolge beginnend mit 1.

Lehrveranstaltungen:
Hier werden die am Modul beteiligten Lehrveranstaltungen einzeln aufgeführt.

Studiensemester:
Hier wird das Studiensemester angegeben, in dem der Besuch des Moduls aufgrund der Studien- und Prüfungsordnung für den Studiengang vorgeschrieben ist.

Modulverantwortliche(r):
Der Modulverantwortliche ist für die redaktionelle Bearbeitung des Moduls verantwortlich.

Dozent(in):
Die Dozenten sind für die Ausgestaltung der jeweiligen, von Ihnen selbst oder durch einen Lehrbeauftragten durchgeführten Lehrveranstaltung verantwortlich.

Sprache:
Hier ist verbindlich festgeschrieben, in welcher Sprache die Veranstaltung durchgeführt wird.

Zuordnung zum Curriculum:
Werden einzelne Module auch in anderen Studiengängen angeboten, so ist dies hier angegeben.

Lehrform/SWS:
Die Lehrform und die Semesterwochenstunden (SWS) der einzelnen, am Modul beteiligten Lehrveranstaltungen werden tabellarisch zusammengestellt. Die Abkürzungen stehen für:
Vorlesung (V), Übungen (Ü), Praktikum (P), Seminar (S)

Arbeitsaufwand und Kreditpunkte:
Der Arbeitsaufwand teilt sich in Präsenz und in Eigenstudium. Für die Berechnung der Präsenz werden die SWS als Zeitstunden (h) mit den Semesterwochen (15 Wochen Lehrveranstaltungszeit, ohne Prüfungswoche) multipliziert.
Für die Berechnung des Eigenstudiums geht man von der Arbeitslast des Eigenstudiums in Zeitstunden aus, die in Kreditpunkten angegeben ist. Jeder Kreditpunkt steht für 30 h Arbeitslast. Die gesamte Arbeitslast berechnet sich aus der Summe der Arbeitslast der Präsenz und des Eigenstudiums.

Voraussetzungen nach Prüfungsordnung:

Die erfolgreiche Teilnahme der hier aufgeführten Module ist die Eingangsvoraussetzungen zur Teilnahme am Modul.

Empfohlene Voraussetzungen:
Hier sind die vom jeweiligen Dozenten für das Verstehen der Veranstaltung vorausgesetzten Kenntnisse aufgeführt.

Modulziel/ Angestrebte Lernergebnisse:
Qualifikationen, die mit diesem Modul erreicht werden sollen
In der Darstellung der angestrebten Lernergebnisse werden die erworbenen Kenntnisse, Fertigkeiten und Kompetenzen konkretisiert.

Inhalt:
Hier wird der konkrete Inhalt der einzelnen Lehrveranstaltungen (operative Ebene) dargestellt, mit dem die angestrebten Lernergebnisse erzielt werden sollen.

Studien-/Prüfungsleistungen:
Die Art der abzuleistenden Prüfung und ihr zeitlicher Umfang werden angegeben.

Medienformen
Angabe der in der Lehrveranstaltung eingesetzten Hilfsmittel (overhead, Flip Chart, Videofilm etc.) Angabe, wann und welche Unterlagen in der Lehrveranstaltung auf welche Weise den Studierenden zur Verfügung gestellt werden.

Literatur:
Auflistung und Angaben zur Literatur, gegebenenfalls Hinweise auf multimedial gestützte Lehr- und Lernprogramme, die zur Vorbereitung (siehe hierzu auch bei Lernhilfen) und Durchführung des Moduls von Interesse sind.

6. Modulbeschreibungen

ACM1 - Specialized polymer analytical methods

<table>
<tr><td>Course of studies</td><td colspan="5">Angewandte Chemie (MSc)</td></tr>
<tr><td>Module</td><td colspan="5">Specialized polymer analytical methods</td></tr>
<tr><td>Abbreviation</td><td colspan="5">ACM1</td></tr>
<tr><td>Course(s)</td><td colspan="5">• Thermal Analysis and Process Safety
• Rheology</td></tr>
<tr><td>Semester</td><td colspan="5">1</td></tr>
<tr><td>Person responsible for the module</td><td colspan="5">Prof. Dr. Andreas Kandelbauer</td></tr>
<tr><td>Instructor</td><td colspan="5">Prof. Dr. Andreas Kandelbauer

Prof. Dr. Roy Hornig</td></tr>
<tr><td>Language</td><td colspan="5">German</td></tr>
<tr><td>Status within the curriculum</td><td colspan="5">Mandatory in ACM / elective in others</td></tr>
<tr><td rowspan="4">Type of course / WH</td><td>Course</td><td>L</td><td>E</td><td>LW</td><td>S</td></tr>
<tr><td>Thermal Analysis and Process Safety</td><td>2</td><td></td><td></td><td></td></tr>
<tr><td>Rheology</td><td>2</td><td></td><td></td><td></td></tr>
<tr><td colspan="5"></td></tr>
<tr><td rowspan="5">Workload in hours</td><td>Course</td><td colspan="2">Class attendance</td><td>Study outside of class</td><td>Total</td><td>CP</td></tr>
<tr><td>Themal Analysis and Process Safety</td><td colspan="2">30</td><td>45</td><td>75</td><td></td></tr>
<tr><td>Rheology</td><td colspan="2">30</td><td>45</td><td>75</td><td></td></tr>
<tr><td colspan="5"></td></tr>
<tr><td>Total</td><td colspan="2">60</td><td>90</td><td>150</td><td>5</td></tr>
<tr><td>Credit points</td><td colspan="5">5</td></tr>
</table>

Prerequisites for attending this course	See examination regulations
Recommended knowledge / course work	Physics, chemistry, mathematics
Module goals / desired outcome	Knowledge • 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 Skills • How complex experiments must be set-up in order to study the physical / chemical systems (guidelines for thermal and rheological analysis) • Spezialized 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 Technical competences • 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.

	Social competence • Self-organization • Target-oriented working • Ability to think conceptually • Development and strengthening of team and communication skills

Content	1. Thermal Analysis and Process Safety • Basics and application of standard and advanced thermal analytical and calorimetric methods in teh 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 2. Rheology • 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 • Determinationof 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	Ehrenstein GW, Riedel G, Trawiel, Thermal Analysis of Plastics: Theory and Practice, Hanser, 2004 Frick A, Stern C, DSC-Prüfung in der Anwendung, Hanser, 2013 Sarge SM, Höhne GWH, Hemminger W, Calorimetry. Fundamentals, Instrumentation, and Applications, Wiley, 2014 Stoessel F, Thermal Safety of Chemical Processes. Risk Assessment and Process Design, Wiley, 2008 Vyazovkin S, Isoconversional Kinetics of Thermally Stimulated Processes, Springer, 2015 Wissenschaftliche Originalliteratur (Aufgaben-bezogene Artikel aus peer-reviewed Zeitschriften) Brummer R, Rheology Esseentials of Cosmetic and Food Emulsions, Springer Berlin, 2005 Mezger Th, The Rheology Handbook, Vincentz, 2006 Schramm G, Einführrung in die Rheologie und Rheometrie, Gebr. Haake, Karlsruhe

ACM2 - Chemical Engineering

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

this course	
Recommended knowledge / course work	Physics, chemistry, mathematics
Module goals / desired outcome	Knowledge • 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 Skills • 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 Technical competences • 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. Social competence • Ability to think conceptually • Development and strengthening of team and communication skills

Content	1. Fundamentals of chemical engineering • 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 • 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	Jess, Andreas; Wasserscheid, Peter: Chemical Technology, An Integral Textbook, Wiley-VCH (2013) McCabe, Warren L.; Smith, Julian C.;Harriott, Peter: Unit Operations of Chemical Engineering, International Edition, McGraw-Hill Higher Education, 7th ed. (2005) Doran, Pauline M.: Bioprocess Engineering Principles, Academic Press, 2. ed. (2012) Katoh, Shigeo; Horiuchi, Jun-ichi; Yoshida, Fumitake: Biochemical Engineering, A Textbook for Engineers, Chemists and Biologists, Wiley-VCH , 2nd, rev. and enl. ed. (2015)

ACM3 - Materials and Applications in Biomedical Sciences

<table>
<tr><td>Course of studies</td><td colspan="6">Biomedical Sciences (MSc)</td></tr>
<tr><td>Module</td><td colspan="6">Materials and Applications in Biomedical Sciences</td></tr>
<tr><td>Abbreviation</td><td colspan="6">ACM3</td></tr>
<tr><td>Course(s)</td><td colspan="6">• Functional Implants & Surface Technologies
• Drug Release and Delivery Systems</td></tr>
<tr><td>Semester</td><td colspan="6">1</td></tr>
<tr><td>Person responsible for the module</td><td colspan="6">Prof. Dr. Rumen Krastev</td></tr>
<tr><td>Instructor</td><td colspan="6">Prof. Dr. Ralf Kemkemer
Prof. Dr. Rumen Krastev</td></tr>
<tr><td>Language</td><td colspan="6">English</td></tr>
<tr><td>Status within the curriculum</td><td colspan="6">Mandatory</td></tr>
<tr><td rowspan="4">Type of course / WH</td><td colspan="3">Course</td><td>L</td><td>E</td><td>LW</td><td>S</td></tr>
<tr><td colspan="3">Drug Release and Delivery Systems</td><td>2</td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Functional Implants & Surface Technologies</td><td>2</td><td></td><td></td><td></td></tr>
<tr><td colspan="3"></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="5">Workload in hours</td><td>Course</td><td>Class attendance</td><td>Study outside of class</td><td colspan="2">Total</td><td colspan="2">CP</td></tr>
<tr><td>Drug Release and Delivery Systems</td><td>30</td><td>45</td><td colspan="2">75</td><td colspan="2"></td></tr>
<tr><td>Functional Implants & Surface Technologies</td><td>30</td><td>45</td><td colspan="2">75</td><td colspan="2"></td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Total</td><td>60</td><td>90</td><td colspan="2">150</td><td colspan="2">5</td></tr>
<tr><td>Credit points</td><td colspan="6">5</td></tr>
<tr><td>Prerequisites for attending this course</td><td colspan="6">See examination regulations</td></tr>
<tr><td>Recommended knowledge / course work</td><td colspan="6">Basic understanding (BSc-level) of chemistry, biology and biomedical technology, material sciences</td></tr>
</table>

Module goals / desired outcome	Basic knowledge - 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 - Understating of drug delivery concepts and application of polymers - Understanding of drug release methods, kinetics and applications Technical competences: - 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 Social competences: - 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	• 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 Immobilisation 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	King M.R.: Principles of Cellular Engineering – Understanding the Biomolecular Interface, Academic Press, 2006 Ritter A.B., et al.: Biomedical Engineering Principles, CRC Press, 2012 Narayan R.: Biomedical Materials, Springer Publisher, 2009 Ratner B.D. et al.: Biomaterial Sciences, Elsevier Oxford, 2012 Wintermantel E., H. Suk-Woo Ha: Medizintechnik: Life Science Engineering, Springer 2009

ACM4 - Technology Management

Course of studies	Angewandte Chemie (MSc)				
Module	Technology Management				
Abbreviation	ACM4				
Course(s)	• Quality Management • Innovation Management				
Semester	1				
Person responsible for the module	Prof. Dr. Alexander Schuhmacher				
Instructor	Dr. Held Prof. Dr. Alexander Schuhmacher				
Language	English				
Status within the curriculum	Mandatory in ACM				
Type of course / WH	Course	L	E	LW	S
	Innovation Management	2			
	Quality Management	2			
Workload in hours	Course	Class attendance	Study outside of class	Total	CP
	Innovation Management	30	45	75	
	Quality Management	30	45	75	
	Total	**60**	**90**	**150**	**5**
Credit points	5				
Prerequisites for attending this course	See examination regulations				
Recommended	Basic understanding of good laboratory practice, no special prerequisites				

knowledge / course work	
Module goals / desired outcome	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. Quality Management: • Understanding the concepts of quality management • Understanding the responsibilities and tasks of QM in daily business
Content	Innovation Management • Economic relevance of innovation • Innovation strategies • Innovation processes • Open innovation Quality Management • Basic systems of quality management • QM Tools & procedure • Normative systems and standards • Examples from industry
Study and exam requirements	Written examination (2h)
Media used	Lecture, group work, interactive discussions, board, digital projector, handouts
Literature	Gassmann O. et al. (2004) Leading Pharmaceutical Innovation. Springer Verlag Schein EH (1997) Organizational Culture and Leadership. Jossey-Bass Publishers S. Nokes and S. Kelly. Guide to Project Management. FT Press (2003) PMI (2008) The Standard for Portfolio Management. 2nd edition. Project Management Institute A. Schuhmacher, M. Hinder, O. Gassmann (2015) Value Creation in the Pharmaceutical Industry: The Critical Path Towards Innovation, Wiley International

ACM5 - Scientific Methods 1: Design of Experiment

Course of studies	Angewandte Chemie (MSc)					
Module	Scientific Methods 1 : Design of Experiment (DoE)					
Abbreviation	ACM5					
Course(s)	• Design of Experiment , lecture classes • Design of Experiment , class exercises					
Semester	1					
Person responsible for the module	Prof. Dr. Andreas Kandelbauer					
Instructor	Prof. Dr. Andreas Kandelbauer Prof. Dr. Ralph Lehnert					
Language	English					
Status within the curriculum	Mandatory					
Type of course / WH	Course	L	E	LW	S	
	Design of Experiment	2	2			
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Design of Experiment	60		90	150	5
	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 statistics and chemometrics					

Module goals / desired outcome	General knowledge Successful students will obtain • Profound overview of basic approaches and standard methods of current DoE • Profound understanding of applicability and limitations of statistical experimental designs • Hands-on experience using software packages for planning, evaluating, and visualizing experiments • Ability to plan experiments using scientifically sound approaches and conduct statistically correct analyses Skills: • Ability to use commercial software • Ability to select, use and understand mathematical operations for data analysis (inferring statistics, response surface methodology, regression analysis etc.) • Ability to transform scientific or technical problem in a form suitable for statistical analysis (selection of appropriate factors and response quantities) • Ability to understand, evaluate, summarize, and visualize complex statistical results and to identify experimental key factors • Ability to exploit optimization potential of chemical and technical processes using DoE Social competences: • Ability to work in a self-organized manner and as a member of a team • Ability to do work target-oriented and systematically
Content	**Design of Experiment** The course consists of a lecture and accompanying class exercises. Class examples will, to a large extent, be chosen from lecture contents. • Experimental domain, factor analysis, response surface analysis, orthogonality, general strategies in DoE • Screening- and optimization designs • Setting-up of experimental designs • Visualization and analysis of data from experimental designs • Handling of commercial software packages

Study and exam requirements	Written exam (2h), term paper (solving exercise sheet and submitting solutions which will be marked)
Media used	Lecture, script as download, board, projector, handouts
Literature	1. Box EP, Hunter JS, Hunter WG, Statistics for Experimenters. Design, Innovation, and Discovery, 2nd edition, Wiley, 2005 2. Myers RH, Montgomery DC, Response Surface Methodology. Process and Product Optimization Using Designed Experiments, Wiley, 2002 3. Cornell J, Experiments with Mixtures. Designs, Models, and the Analysis of Mixture Data, Wiley, 2002 4. Federer WT, King F, Variations on Split Plot and Split Block Experimental Designs, Wiley, 2007 5. Good PI, Hardin JW, Common Errors in Statistics (and how to avoid them), 2nd edition, Wiley, 2006

ACM6 - Projektorientiertes Lernen 1 / Project Oriented Learning 1

Course of studies	Angewandte Chemie (MSc)					
Module	Projektorientiertes Lernen 1 / Project Oriented Learning 1					
Abbreviation	ACM6					
Course(s)	Research Seminar Team Project					
Semester	1					
Person responsible for the module	Prof. Dr. Kandelbauer					
Instructor	Prof. Dr. Kandelbauer, Prof. Dr. Rebner, Prof. Dr. Lehnert, Prof. Dr. Lorenz, Prof. Dr. Baumbach, Prof. Dr. Brecht, Dr. Ostertag					
Language	German, English					
Status within the curriculum	Mandatory in ACM, PATM					
Type of course / WH	Course	L	E	LW	S	
	Research Seminar				2	
	Team Project			4		
Workload in hours	Course	Class attendance		Study outside of class	Total	CP
	Research Seminar	22,5		22,5	50	
	Team Project			100	100	
	Total	**22,5**		**122,5**	**150**	**5**
Credit points	5					
Prerequisites for attending this course	See examination regulations					
Recommended knowledge / course work	Physics, chemistry, mathematics					

Module goals / desired outcome	Objective is the education of the students in setting-up, planning and disseminating a research project proposal based on a sound state of the art for a specified research question. POL-1 is the introductory phase for POL-2 (ACM-12) Professional scientific methodological approach: Knowledge • Knowledge on defining a research project: how to structure complex scientific questions and break them down into single steps • Knowledge about and application of tools for practical project planning (Gantt-diagrams, decision gates, milestones, deliverables, etc.) • Knowledge about how to extract information from databases with regard to a specific research question • In-depth knowledge about a specific topic depending on the specified research question Skills • Effective use of technical and scientific data bases • Formulating state of the art • Formulating scientific hypotheses • Understanding scientific methodology • Practical planning of experiments (including logistic and organizational aspects) Technical competences • Selecting appropriate scientific methodology depending on the specific research question • Responsibility regarding research planning • Assimiliation of novel research questions, adaptation to / orientation in a new field • Formulation and writing of a state of the art focused on a very specific research question Social competence • Ability to think conceptually • Working in project teams • Coordinating a project / work organisation • Development and strengthening of team and communication skills
Content	The students will work in teams of 3 to 4 people on a defined research question. The research question is defined by the supervisor at the faculty and will be in accordance with current research activities at the department. The students will prepare a scientific and technological state of the art on this research question and based on this they will define a project plan addressing all relevant issues of a real research project (time schedule, resource plan, objectives, means to arrive at the objectives, required methods, hypotheses, etc.). This project plan will be disseminated as a formal project application with a special focus on a comprehensive state of the art. No single-person projects are admissible and all projects are

	hosted by the faculty exclusively. The actual research project plan set up by the students will then be realized in POL-2 in the subsequent semester. Preparatory activities such as training / instruction regarding specific methods, organisation of infrastructure / chemicals or even preliminary / orienting experiments that are required for competent formulation of a research proposal or smooth performance of the practical phase (POL-2) in the subsequent semester are possible within the module POL-1 but although recommended are not obligatory.
Study and exam requirements	Written seminar paper (= state of the art), oral presentation of project plan during semester
Media used	Lecture, board, digital projector, handouts
Literature	Chalmers AF (2007) Wege der Wissenschaft. Einführung in die Wissenschaftstheorie, 6. Auflage, Nachdruck, Springer Patzak G, Rattay G (2004) Projektmanagement, 4. Auflage, Linde International Baguley P (1999) Optimales Projektmanagement, Falken Scientific Original papers, depending on the specific research question H.F. Ebel et al. (2006) Schreiben und Publizieren in den Naturwissenschaften, Wiley-VCH Weinheim.

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				

Module goals / desired outcome	Erweitertes Grundlagenwissen ausgewählter polymerwissenschaftlicher Inhalte mit Schwerpunkt auf Struktur-Funktionalitätsbeziehungen und Grenzflächen. Kenntnisse • Vertieftes Grundlagenwissen über Eigenschaften, Ordnungszustände, Strukturbildung und Phasen-übergänge 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 Fertigkeiten Erfolgreiche Studenten • 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 Fachliche Kompetenzen • Zusammenhangswissen zur Lösung polymerwissen- • schaftlicher Problemstellungen in der Anwendung • Material- und Methodenauswahl unter technologischen Aspekten • Studenten kennen Anwendungsbreite und Limitation bestehender Materialien und Technologien • Vorgehensweise zur Werkstoffkompatibilisierung Soziale Kompetenzen • Fördern des abstrakten Denkvermögens • Selbstorganisation und Motivation • Teamfähigkeit

Content	4. Polymere und Flüssigkristalle • 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 2. Hybridwerkstoffe • 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	Gedde, UW, Polymer Physics, Kluwer Academic Publishers, 2001 Jones, R. A. L.: Soft Condensed Matter, Oxford University Press, 2002 Hamley, I, Introduction to Soft Matter. Synthetic and Biolological Self-assembling Materials, Wiley, 2000 Kickelbick G, Hybrid Materials, Wiley-VCH, 2008 Stokes RJ, Evans DF, Fundamentals of Interfacial Engineering, Wiley-VCH, 1997 Plüddemann EP, Silane Coupling Agents, 2nd edition, Kluwer, 1991 Mittal KL, Pizzi A, Adhesion Promotion Techniques. Technological Applications, Marcel Dekker, 2002 Ausgewählte wissenschaftliche Originalarbeiten und Review-Artikel

ACM8 - Polymerbasierte Materialien 1

Course of studies	Angewandte Chemie MSc				
Module	Polymerbasierte Materialien 1				
Abbreviation	ACM8				
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				

Module goals / desired outcome	Vertieftes Grundlagenwissen ausgewählter materialwissenschaftlicher Inhalte mit Schwerpunkt auf Struktur-Funktionalitätsbeziehungen. Einführung in anwendungsorientierte Fragestellungen der wechselseitigen Abhängigkeit zwischen Materialfunktionalität und Produkteigenschaften. Kenntnisse • 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 Fertigkeiten • 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 Fachliche Kompetenzen • Studenten können Anwendungsbreite und Limitation bestehender Materialien und Technologien benennen • Zusammenhangswissen zur Lösung materialwissenschaftlicher Problemstellungen • Materialauswahl unter technologischen und Designgesichtspunkten Soziale Kompetenzen • Fördern des abstrakten Denkvermögens • Selbstorganisation und Motivation • Teamfähigkeit

Content	1. Advanced Materials • 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 2. Product Functionality Design • 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	Ullmann´s Encyclopedia of Industrial Chemistry, Wiley 2012 Ghosh SK, Self-Healing Materials, Wiley, 2012 Krueger A, Carbon Materials and Nanotechnology, Wiley, 2012 Dodiuk H, Goodman S, Handbook of Thermosetting Plastics, CRC / Elsevier, 2014 KLumar C, Nanomaterials for the Life Sciences (Series) Vols. 1-10, Wiley, 2012 Current scientific original papers Kickelbick G, Hybrid Materials, Wiley-VCH, 2008 Stokes RJ, Evans DF, Fundamentals of Interfacial Engineering, Wiley-VCH, 1997 Methodik der Werkstoffauswahl: Der systematische Weg zum richtigen Material, Carl Hanser Verlag GmbH & Co. KG; Auflage: 1 (2006), ISBN-10: 9783446406803 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 Software: CES Edu Pack 2013, Grantadesign, Cambridge

ACM9 - Elective Module

Course of studies	Angewandte Chemie (MSc)				
Module	Elective Module				
Abbreviation	ACM9				
Course(s)	Elective course(s)				
Semester	2				
Person responsible for the module	Prof. Dr. Andreas Kandelbauer				
Instructor	All members of faculty				
Language	English or German				
Status within the curriculum	Mandatory in ACM / elective in others				
Type of course / WH	Course	L	E	LW	S
	Elective Subject	2			
	Elective Subject	2			
Workload in hours	Course	Class attendance	Study outside of class	Total	CP
	Elective Subject	30	45	75	
	Elective Subject	30	45	75	
	Total	**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	Student must document successful participation in a university course				
Media used	Depends on elective				
Literature	Depends on elective				

ACM10 - Scientific Methods 2: Multimodal Data Generation and Analysis

Course of studies	Angewandte Chemie MSc				
Module	Scientific Methods 2: Multimodal Data Generation and Analysis				
Abbreviation	ACM10				
Course(s)	Multimodal Data Generation and Analysis I Multimodal Data Generation and Analysis II				
Semester	2				
Person responsible for the module	Prof. Dr. Jörg Ingo Baumbach				
Instructor	Prof. Dr. Jörg Ingo Baumbach Prof. Dr. Karsten Rebner				
Language	English				
Status within the curriculum	Mandatory				
Type of course / WH	Course	L	E	LW	S
	Multimodal Data Generation and Analysis I	2			
	Multimodal Data Generation and Analysis II	2			
Workload in hours	Course	Class attendance	Study outside of class	Total	CP
	Multimodal Data Generation and Analysis I	30	45	75	
	Multimodal Data Generation and Analysis II	30	45	75	
	Total	60	90	150	5
Credit points	5				
Prerequisites for attending this course	See examination regulations				
Recommended knowledge / course work	Basic data handling procedures, data base structures				
Module goals / desired outcome	A large number of single and especially the combination of analytical methods find the way from laboratory applications into the environment outside to monitor different e.g. industrial processes. Besides temperature, pressure, flow, density and filling level specific data arising from sensors, spectrometers and spectroscops. Furthermore, in the field of medical diagnostics the data and more general the information of different methods including different time constants lime GC/MS and MCC/IMS are				

	combined. Sometimes, off-line and on-line data, bed-site and laboratory data – multimodal data are to be considered in process and medical monitoring processes. The students know and could calculate the sensitivity, the specificity, the accuracy, the uncertainty with respect to the question: how to make a decision. Errors should be considered and included into decision strategies. In contrast to multivariate methods investigating many variables of one method strategies to use combined methods were established, including multi-bloc methods, parallel factor analysis. Examples from real situations in different process and medical applications of sensors and spectrometers are considered in detail. **General knowledge:** Successful students will obtain • knowledge and methods to combine different methods directly. • Know how to of combining different measuring methods and how information could be generated with respect on process, bed-site or early recognition of different diseases. **Skills:** Successful students will be able • to describe the multimodal and big data landscape including examples of process analytical technology problems and approaches • identify the high level components in the data science lifecycles and associated data flow • to explain multimodal effects and why each impacts the collection, monitoring, storage, analysis and reporting • identify big data problems and be able to recast problems as data science questions. **Social competences:** • Ability to work in a self-organized manner and as a member of a team • Ability to do work target-oriented and systematically
Content	• Data Pre-Processing • Three-Way Component and Regression Models • PARAFAC: Parallel factor analysis • Multivariate analysis of multiblock and multigroup data • Data handling, big data and smart data • Data analysis and process monitoring/control • Supervised and unsupervised learning methods • Applications I: Exploratory analysis in chromatography, spectroscopy and designed data • Applications II: Exploratory analysis in chromatography, mass spectrometry, coupled methods like GC/MS, ion mobility spectrometry, coupled methods like MCC/IMS

	• NIST database, NIST chembook • Mathlab, Mathematica
Study and exam requirements	Written examination (2h), presentation / assignments
Media used	PowerPoint slides, flip charts, board, lecture videos, software Matlab PLS Toolbox,
Literature	Scientific publications

ACM11 - Scientific Methods 3: Information Retrieval and Evaluation, Multivariate Data Analysis

Studiengang:	M.Sc. Angewandte Chemie					
Modulbezeichnung:	Scientific Methods 3: Information Retrieval and Evaluation, Multivariate Data Analysis					
ggf. Modulniveau						
ggf. Kürzel	ACM11					
ggf. Untertitel						
ggf. Lehrveranstaltungen:	- Information Retrieval and Evaluation - Multivariate Data Analysis (MVA)					
Studiensemester:	2					
Modulverantwortliche(r):	Prof. Dr. Ralph Lehnert					
Dozent(in):	Prof. Dr. Ralph Lehnert (Information retrieval) Prof. Dr. Karsten Rebner (Multivariate data analysis)					
Sprache:	Englisch					
Zuordnung zum Curriculum	Pflichtmodul					
Lehrform/SWS:	Lehrveranstaltung		V	Ü	P	S
	Informationsgewinnung und -bewertung / Information Retrieval and Evaluation		1	1		
	Multivariate Datenanalyse / Multivariate Data Analysis		1	1		
Arbeitsaufwand in Stunden:	Lehrveranstaltung	Präsenz	Eigen-studium	Summe	CP	
	Informationsgewinnung und -bewertung / Information Retrieval and Evaluation	30	45			
	Multivariate Daten-analyse / Multivariate Data Analysis	30	45			
	Summe	**60**	**90**	**150**	**5**	
Kreditpunkte:	5					
Voraussetzungen für die Teilnahme	Laut Studien- und Prüfungsordnung					
Modulziel / Angestrebte Lernergebnisse:	In diesem Modul lernen die Studierenden, aus komplexen Datensätzen (Datenbankeinträgen, Texten, Zahlentabellen / numerischen Datensätzen) rasch und gezielt sinnvolle Information zu extrahieren Kenntnisse • Nutzung der einschlägigen Literaturdatenbanken in Bezug auf wissenschaftliche Originalarbeiten, Patentliteratur und Sekundärliteratur (Reviews, Bücher, etc.) • Handhabung und Einsatz von Suchmaschinen • Befähigung zur systematischen Literatursuche und Auswertung wissenschaftlicher Originalliteratur in Bezug auf konkrete Fragestellungen • Standardmethoden der Multivariaten Datenauswertung / Chemometrie					

	Fertigkeiten • Korrekte, effiziente und systematische Vorgehensweise bei der wissenschaftlichen Literatursuche (Quellenidentifikation und -nutzung) • Effizientes Suchen, Auswerten und Dokumentieren von relevanten Literaturstellen • Korrekte Zitierweisen • Kenntnis Zitatenverwaltungsprogramme • Mathematische Operationen zur Datenauswertung (Multivariate Statistik) • Umgang mit kommerzieller Software Fachliche Kompetenzen • Methoden der MVA problembezogen auswählen, anwenden und Ergebnisse kritisch bewerten. • Kompetentes und kritisches Erfassen und Zusammenfassen eines Stands der Technik Soziale Kompetenzen • Selbstorganisations- und Teamfähigkeit • Zielgerichtete und systematische Arbeitsweise
Inhalt:	Informationsgewinnung und -bewertung • Nutzung von Referenzdatenbanken • Literatursuche anhand konkreter forschungsbezogener Fragestellungen Multivariate Datenanalyse • Datenverdichtung und Extraktion von Trends und Zusammenhängen aus komplexen Datensätzen. • Basismethoden der Datenanalyse, Klassifizierung und Regression, wie PCA (Hauptkomponenten-analyse), Clusteranalyse, PLS (Partial Least Squares Regression).
Studien-/Prüfungsleistungen:	Klausur 2h, Präsentation
Medienformen:	Ausführlicher Tafelanschrieb, Overhead-Folien,Skriptum, Tischvorlagen, Medienraum mit Software
Literatur:	1. Kessler, W.: Multivariate Datenanalyse für die Pharma-, Bio- und Prozessanalytik, Wiley-VCH, 2007 2. Esbensen, Kim H.: Multivariate Data Analysis – in Practis, CAMO Press AS, 2002 3. Beebe, K., Pell, R., Seasholtz, M.: Chemometrics - A Practical Guide, John Wiley & Sons, 1998 4. Brereton, R. : Chemometrics, Data Analysis for the Laboratory and Chemical Plant, John Wiley & Sons, 2003

ACM12 - Project Oriented Learning 2

Course of studies	Angewandte Chemie Master / Process Analysis & Technology Management Master				
Module	Project Oriented Learning 2				
Abbreviation	ACM-12				
Course(s)	Research Seminar Team Project				
Semester	2				
Person responsible for the module	Prof. Dr. Kandelbauer				
Instructor	Prof. Dr. Kandelbauer, Prof. Dr. Rebner, Prof. Dr. Lehnert, Prof. Dr. Lorenz, Prof. Dr. Baumbach, Prof. Dr. Brecht, Dr. Ostertag				
Language	German, English				
Status within the curriculum	Mandatory in ACM, PATM				
Type of course / WH	Course	L	E	LW	S
	Research Seminar				2
	Team Project			4	
Workload in hours	Course	Class attendance		Study outside of class	Total / CP
	Research Seminar	22,5		22,5	50
	Team Project			100	100
	Total	**22,5**		**122,5**	**150 / 5**
Credit points	5				
Prerequisites for attending this course	See examination regulations				
Recommended knowledge / course work	Physics, chemistry, mathematics				

Module goals / desired outcome	Objective is the education of the students in setting-up, planning and performing a project aiming at the solution of a speficic research question. POL-2 is a continuation of POL-1 (ACM-06) Professional scientific methodological approach: Knowledge • Knowledge on defining, performing and controlling a research project. • Knowledge about and application of tools for practical project management (action items, meeting organisation, work documentation, efficient use of resources, coordination, etc.) • Knowledge on specific scientific and technological methods as well as materials depending on the specific actual research question Skills • Effective use of technical and scientific data bases • Formulating project reports, final project report • Formulating scientific hypotheses • Understanding scientific methodolgy • Planning and performing experiments • Adapting to and applying scientific equipment • Performing accurate measurements • Discussing competently experimental results in the light of the state of the art and comparing own findings to the scientific literature Technical competences • Selecting and applying appropriate scientific methodology depending on the specific research question • Responsibility regarding research planning • Assimiliation of novel research questions, adaptation to / orientation in a new field • Formulating and writing a project report (state of the art) • Discussion of experimental results • Proper presentation and scientifically sound defense of own findings in front of a panel of experts (=councel of supervisors) Social competence • Ability to think conceptually • Working in / managing a project team • Coordinating a project / work organisation • Development and strengthening of team and communication skills
Content	The students will work in teams of 3 to 4 people on a defined research question for which in POL-1 (ACM06) they have prepared a proper state of the art and research plan. The research question is defined by the supervisor at the faculty and will be in accordance with current research activities at the department. The students will perform the necessary scientific and technological experiments based on the state of the art on this research question and their

	research proposal. The students organize their project by themselves and are guided by the supervising professor. The project results will be disseminated as a formal final project report. The results will also be presented at a final oral defense in front of a panel of all supervising professors and a poster presentation will be prepared.
Study and exam requirements	Written seminar paper (= final project report), oral presentation of project status during semester (status meetings), final project defense, poster presentation
Media used	Lecture, board, digital projector, handouts
Literature	Chalmers AF (2007) Wege der Wissenschaft. Einführung in die Wissenschaftstheorie, 6. Auflage, Nachdruck, Springer Patzak G, Rattay G (2004) Projektmanagement, 4. Auflage, Linde International Baguley P (1999) Optimales Projektmanagement, Falken Scientific Original papers, depending on the specific research question H.F. Ebel et al. (2006) Schreiben und Publizieren in den Naturwissenschaften, Wiley-VCH Weinheim.

ACM13 - Master's Thesis

Course of studies	Angewandte Chemie (MSc)				
Module	Master's Thesis				
Abbreviation	ACM-13				
Course(s)	Master Thesis Seminar on topics related to Master Thesis				
Semester	1				
Person responsible for the module	Prof. Dr. Andreas Kandelbauer				
Instructor	All instructors of faculty				
Language	English or German				
Status within the curriculum	Mandatory in ACM				
Type of course / WH	Course	L	E	LW	S
	Master Thesis	-	-		-
	Seminar	-	-	-	2
Workload in hours	Course	Class attendance	Study outside of class	Total	CP
	Master Thesis		840	840	28
	Seminar	30	30	60	2
	Total	**30**	**870**	**900**	**30**
Credit points	30				
Prerequisites for attending this course	See examination regulations				
Recommended knowledge / course work	Successful completion of research project				

Module goals / desired outcome	Knowledge • Ability to do detailed and in-depth research on a defined scientific field of study Skills • 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 Technical competences • Ability to apply modern adequate strategies for finding scientific solutions Social competences: • Ability to promote team work in a research group
Content	Students will work independently on a defined research project, preferably in a research group at the Reutlingen University or at an external research). 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&/orD 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.
Study and exam requirements	Master Thesis: The thesis will be evaluated by the mentoring professor as well as by a second reviewer Seminar on topics related to master's thesis: After completing the master's thesis, students will hold an oral presentation on their work
Media used	Oral presentation, written thesis, digital projector, PowerPoint slides
Literature	Depends on actual research project

ACM14 - Internship semester (Additional Module only for students with 180 ECTS Bachelor's degree)

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. Wolfgang Honnen					
Instructor	All instructors of faculty					
Language	English or German					
Status within the curriculum	Mandatory in PA&TM					
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					

Module goals / desired outcome	Knowledge: • insight into the structure, organization and operations of an industrial company or a research institution Skills: • introduction to the independent processing of specific tasks within projects Competencies: • 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 Social competence: • learning the manners and practices in the work environment • improve the team and communication skills through participation in the working group • intercultural competence acquisition
Content	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. 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.
Study and exam requirements	Continuos assessment, regular reporting, preparation of a project report manuscript, certificate of the internship site
Media used	
Literature	Depends on actual project

PAM4 - Process Analytical Technology I

<table>
<tr><td>Course of studies</td><td colspan="6">Process Analysis and Technology Management (MSc)</td></tr>
<tr><td>Module</td><td colspan="6">Process Analytical Technology I</td></tr>
<tr><td>Abbreviation</td><td colspan="6">PAM4</td></tr>
<tr><td>Course(s)</td><td colspan="6">• Process Spectroscopy and Spectrometry</td></tr>
<tr><td>Semester</td><td colspan="6">1</td></tr>
<tr><td>Person responsible for the module</td><td colspan="6">Prof. Dr. Karsten Rebner</td></tr>
<tr><td>Instructor</td><td colspan="6">Prof. Dr. Karsten Rebner</td></tr>
<tr><td>Language</td><td colspan="6">English</td></tr>
<tr><td>Status within the curriculum</td><td colspan="6">Mandatory</td></tr>
<tr><td rowspan="2">Type of course / WH</td><td>Course</td><td>L</td><td>E</td><td>LW</td><td colspan="2">S</td></tr>
<tr><td>Process Spectroscopy and Spectrometry</td><td>4</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td rowspan="5">Workload in hours</td><td>Course</td><td colspan="2">Class attendance</td><td>Study outside of class</td><td>Total</td><td>CP</td></tr>
<tr><td>Process Spectroscopy and Spectrometry</td><td colspan="2">30</td><td>45</td><td>75</td><td></td></tr>
<tr><td>Optofluidics System Technologies</td><td colspan="2">30</td><td>45</td><td>75</td><td></td></tr>
<tr><td colspan="6"></td></tr>
<tr><td>Total</td><td colspan="2">60</td><td>90</td><td>150</td><td>5</td></tr>
<tr><td>Credit points</td><td colspan="6">5</td></tr>
<tr><td>Prerequisites for attending this course</td><td colspan="6">See examination regulations (Studien- und Prüfungsordnung)</td></tr>
<tr><td>Recommended knowledge / course work</td><td colspan="6">Knowledge of instrumental analysis</td></tr>
</table>

Module goals / desired outcome	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. **General knowledge:** Successful students will obtain • 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. **Skills:** Successful students will be able • 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 **Social competences:** • Ability to work in a self-organized manner and as a member of a team • Ability to do work target-oriented and systematically
Content	• 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	1. Kessler RW (Ed.): Prozessanalytik Strategien und Fallbeispiele aus der industriellen Praxis, Wiley-VCH, 2006 2. Bakeev: Process Analytical Technology: Spectroscopic Tools and Implementation Strategies for the Chemical and Pharmaceutical Industries, Wily-VCH, 2010. 3. Rabus: Optofludics System Technology, De Gruyter, 2014 4. Undey, Low, Menezes, Koch: PAT Applied in Biopharmaceutical Process Development and Manufacturing, CRC Press 2012

PAM5 - Industry-Related Topics (Regulatory Affairs, IP Management

Course of studies	Biomedical Sciences (MSc)				
Module	Industry-Related Topics				
Abbreviation	PAM5				
Course(s)	• 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	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. 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. 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.
Content:	Regulatory affairs • FDA • EMEA • ICH IP Management 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	• 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

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)	• 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						

Module goals / desired outcome	General knowledge: Successful students will obtain • 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 Skills: Successful students will be able • to analyse 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 Social competences: • Ability to work in a self-organized manner and as a member of a team • Ability to do work target-oriented and systematically
Content	The course consists of a lecture and accompanying class exercises as well as practicals, all treating: • 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
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	1. Gründler, P. : Chemical Sensors, Springer, 2007 2. Hauptmann, P.: Sensors: Principles and Applications, Prentice-Hall, 1993 3. Eggins, B. R. : Chemical Sensors and Biosensors, John Wiley & Sons, 2004 4. Niebuhr, J., Lindner G.:Physikalische Messtechnik mit Sensoren, Oldenbourg Verlag, München, 2011 5. Freudenberger, A. : Prozessmesstechnik, Vogel Verlag, Würzburg, 2000.

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
Module goals / desired outcome	**General knowledge:** Successful students will obtain • 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 backround like FTIR, NIR, MIR, MS, GC/MS, MCC/IMS, LC/MS **Skills** Successful students will be able • 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
Content	**Sampling and sample preparation** • Core Principles of Sample System Design • Evalulation 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 **Measuring and Control Technology** • 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	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	PAM11				
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
Module goals / desired outcome	General knowledge Successful students will obtain • 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 metabolics, especially for clinical and diagnostic applications • Profound understanding of technologies and functioning of laboratory investigations, diagnostics and applications Skills: • 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 Social competences: • 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.

Content	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 given. 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, metabolom 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 exemplarely explained and conclusions with respect to regulatory processes at medical and biological processes including fermentation and human health characterization.
Study and exam requirements	Written examination (2h), presentation / assignments
Media used	PowerPoint slides, flip charts, board
Literature	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 Lämmerhofer, M., Weckwerth, W.: Metabolomics in Practice: Successful Strategies to Generate and Analyze Metabolic Data, Wiley-VCH, 2013 Weckwerth, W.: The Handbook of Plant Metabolomics (Molecular Plant Biology), Wiley Blackwill, 2013 Teresa Whei-Mei Fan, Andrew N. Lane: The handbook of metabolomics. Humana Press 2016 Alessandra Sussulini: Metabolomics: From Fundamentals to Clinical Applications (Advances in Experimental Medicine and Biology) 2016 David Beale: Microbial Metabolomics: Applications in Clinical, Environmental, and Industrial Microbiology – Springer, 2016 Scientific publications

BMS1 - Analytical Methods in Biomedical Sciences

Course of studies	Biomedical Sciences (MSc)					
Module	**Analytical Methods in Biomedical Sciences**					
Abbreviation	BMS1					
Course(s)	• 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					
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	See examination regulations					

this course	
Recommended knowledge / course work	Knowledge of biochemistry, bioanalytics, instrumental analytics, chemistry, material science, biology
Module goals / desired outcome	General knowledge Successful students will obtain • 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 Skills: • 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 Social competences: • Ability to prepare and deliver a scientific presentation for a seminar • Ability to do scientific research and to present scientific findings

Content	**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: • Proteomics and metabolomics • Biomoarkers • Pharmaceutical analysis • Clinical laboratory analysis • Selected topics of bioanalysis, e.g. blotting techniques, two-hybrid systems, FRET, Patch Clamp, **Diagnostic Technologies** • 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	• 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

BMS7 - Biomedical Technologies and Regenerative Medicine

<table>
<tr><td>Course of studies</td><td colspan="6">Biomedical Sciences (MSc)</td></tr>
<tr><td>Module</td><td colspan="6">Biomedical Technologies</td></tr>
<tr><td>Abbreviation</td><td colspan="6">BMS7</td></tr>
<tr><td>Course(s)</td><td colspan="6">• Regenerative Medicine
• Biomedical Technologies - Biofabrication</td></tr>
<tr><td>Semester</td><td colspan="6">2</td></tr>
<tr><td>Person responsible for the module</td><td colspan="6">Prof. Dr. Petra Kluger</td></tr>
<tr><td>Instructor</td><td colspan="6">Prof. Dr. Petra Kluger</td></tr>
<tr><td>Language</td><td colspan="6">English</td></tr>
<tr><td>Status within the curriculum</td><td colspan="6">Mandatory</td></tr>
<tr><td rowspan="4">Type of course / WH</td><td>Course</td><td>L</td><td>E</td><td>LW</td><td colspan="2">S</td></tr>
<tr><td>Biomedical Technologies</td><td>2</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>Regenerative Medicine</td><td>2</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td rowspan="4">Workload in hours</td><td>Course</td><td colspan="2">Class attendance</td><td>Study outside of class</td><td>Total</td><td>CP</td></tr>
<tr><td>Biomedical Technologies</td><td colspan="2">30</td><td>45</td><td>75</td><td></td></tr>
<tr><td>Regenerative Medicine</td><td colspan="2">30</td><td>45</td><td>75</td><td></td></tr>
<tr><td>Total</td><td colspan="2">60</td><td>90</td><td>150</td><td>5</td></tr>
<tr><td>Credit points</td><td colspan="6"></td></tr>
<tr><td>Prerequisites for attending this course</td><td colspan="6">See examination regulations</td></tr>
<tr><td>Recommended knowledge / course work</td><td colspan="6">Cell biology, physiology, biomaterials, tissue engineering, biomedical engineering</td></tr>
</table>

Module goals / desired outcome	• students get insight into biofabrication technologies for future perspectives in biomedical engineering • 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 students know: • how to define biofabrication • basic principles for automation, especially for automated cell and tissue culture as well as clinical applications • different biofabrication technologies, their characteristics and their pros & cons • needed properties for a bioink, different materials used as bioink and their limitations • possible applications of these biofabrication technologies in biomedical sciences • how to define regenerative medicine • the characteristics of stem cells and their clinical use • different matrix components and their properties as well as the clinical applications of different matrices • the regulatory framework • key facts concerning the global regenerative medicine market • the state of the art in selected applications and the challenges students improve their ability in: • understanding and use new vocabulary • read, summarize and discuss about scientific topics prepare and present these results and short presentation in teams

Content	**Biomedical Technologies - Biofabrication** • Introduction Biofabrication • Overview of different biofabrication technologies • Lab automation for cell and tissue cultures • Bioinks for scaffold and tissue fabrication **Regenerative Medicine** • 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	• 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)	• *Biomedical* Pharmacology • Advanced Bioanalysis				
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
	Biomedical 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 /	Knowledge of biochemistry, bioanalytics and instrumental analytics,				

course work	biology, fundamentals of pharmacology
Module goals / desired outcome	**General knowledge**: • Profound overview of current bioanalytical techniques relevant for biomedical as well as pharmaceutical research • Understanding of mode of action of drugs **Skills**: • Understanding of drug interaction in the human organism • In-depth knowledge of Pharmaco-kinetics and Pharmaco-dynamics • 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 **Social competences**: • Preparation and presentation of a scientific presentation for a seminar • Ability to do scientific research and present scientific findings
Content	**Analytical Methods in Biomedical Sciences** • DNA structure and isolation • Cloning and sequencing • Advanced polymerase chain reaction • DNA/RNA microarray technology • Karyotype analysis • Personalized medicine • Examples of personalized medicine **Biomedical Pharmacology** • Introduction to pharmaco-kinetics • Introduction to pharmaco-dynamics • Drug interaction • Drug impact on - stomach & gut - blood - blood vessels, kidney - heart - hormones • Neuropharmacology (ataractics, Parkinson's, analgesics)
Study and exam requirements	Written exam (2h)

Media used	Lecture, script for download, board, student presentations, digital projector, handouts
Literature	• 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

ACM14 - Modul anderer Fakultäten, Hochschulen oder Universitäten

<table>
<tr><td>Studiengang:</td><td colspan="6">M.Sc. Angewandte Chemie</td></tr>
<tr><td>Modulbezeichnung:</td><td colspan="6">Modul anderer Fakultäten, Hochschulen oder Universitäten</td></tr>
<tr><td>ggf. Modulniveau</td><td colspan="6"></td></tr>
<tr><td>ggf. Kürzel</td><td colspan="6">ACM14</td></tr>
<tr><td>ggf. Untertitel</td><td colspan="6"></td></tr>
<tr><td>ggf. Lehrveranstaltungen:</td><td colspan="6">Wählbare Module anderer Fakultäten, Hochschulen oder Universitäten mit mindestens 4 SWS bzw. 5 ECTS mit Zustimmung der Prüfungskommission</td></tr>
<tr><td>Studiensemester:</td><td colspan="6">1</td></tr>
<tr><td>Modulverantwortliche(r):</td><td colspan="6">Prof. Dr. habil. Andreas Kandelbauer</td></tr>
<tr><td>Dozent(in):</td><td colspan="6">Siehe jeweilige ausgewählte Lehrveranstaltung(/en)</td></tr>
<tr><td>Sprache:</td><td colspan="6">Deutsch, gegebenenfalls in Englisch</td></tr>
<tr><td>Zuordnung zum Curriculum</td><td colspan="6">Wahlpflichtmodul</td></tr>
<tr><td rowspan="3">Lehrform/SWS:</td><td colspan="3">Lehrveranstaltung</td><td>V</td><td>Ü</td><td>P</td><td>S</td></tr>
<tr><td colspan="3">Aufteilung siehe jeweilige ausgewählte Lehrveranstaltung, Summe 4SWS bzw. 5 ECTS</td><td>2</td><td>2</td><td></td><td></td></tr>
<tr><td colspan="6"></td></tr>
<tr><td rowspan="3">Arbeitsaufwand in Stunden:</td><td>Lehrveranstaltung</td><td>Präsenz</td><td>Eigen-studium</td><td>Summe</td><td colspan="2">CP</td></tr>
<tr><td>Siehe jeweilige ausgewählte Lehrveranstaltung(/en), Summe</td><td>60</td><td>90</td><td>150</td><td colspan="2"></td></tr>
<tr><td>Summe</td><td>60</td><td>90</td><td>150</td><td colspan="2">5</td></tr>
<tr><td>Kreditpunkte:</td><td colspan="6">5</td></tr>
<tr><td>Voraussetzungen für die Teilnahme</td><td colspan="6">Laut Studien- und Prüfungsordnung</td></tr>
<tr><td>Modulziel / Angestrebte Lernergebnisse:</td><td colspan="6">Vertiefung der fachlichen Kompetenzen in der angestrebten Fachrichtung, Details siehe die einzelne Lehrveranstaltung</td></tr>
<tr><td>Inhalt:</td><td colspan="6">Der Katalog an wählbaren Wahlpflichtfächern aus Master-Programmen anderer Fakultäten umfasst beispielsweise (nicht ausschließlich):

• Gewerbl. Rechtsschutz (2SWS) (Mechatronik)
• Requirements Engineering (2SWS) (Masch.bau)
• Ingenieur und Gesellschaft (2SWS) (Masch.bau)
• Industrial Ecology (4SWS) (Production/Logistics Mgt.)
• Internationales Wirtschaftsrecht (2SWS) (dito)
• Gewerbl. Rechtsschutz und Urheberrecht (2SWS) (dito)
• Supply Chain Management (4SWS) (dito)
• System Design and Simulation (4SWS) (dito)
• Industrial Ecology (4SWS) (dito)

Einzelne Lehrveranstaltungen mit weniger als 4 SWS können mit anderen Lehrveranstaltungen kombiniert werden, sodass in Summe die 4 SWS bzw. 5 ECTS erreicht werden</td></tr>
</table>

	Darüber hinaus können weitere Lehrveranstaltungen / Module aus Master-Programmen anderer Hochschulen oder Universitäten nach Zustimmung durch die Prüfungskommission gewählt werden.
Studien-/Prüfungsleistungen:	Siehe jeweilige ausgewählte Lehrveranstaltung
Medienformen:	Siehe jeweilige ausgewählte Lehrveranstaltung
Literatur:	Siehe jeweilige ausgewählte Lehrveranstaltung