Module catalogue

Master of Science Soft Matter and Materials

Content / Modules

Remarks

In general: 1 CP/CP equals 30h total workload,
1 CP equals 10,5h attendance time (14 weeks a 0,75h) per semester

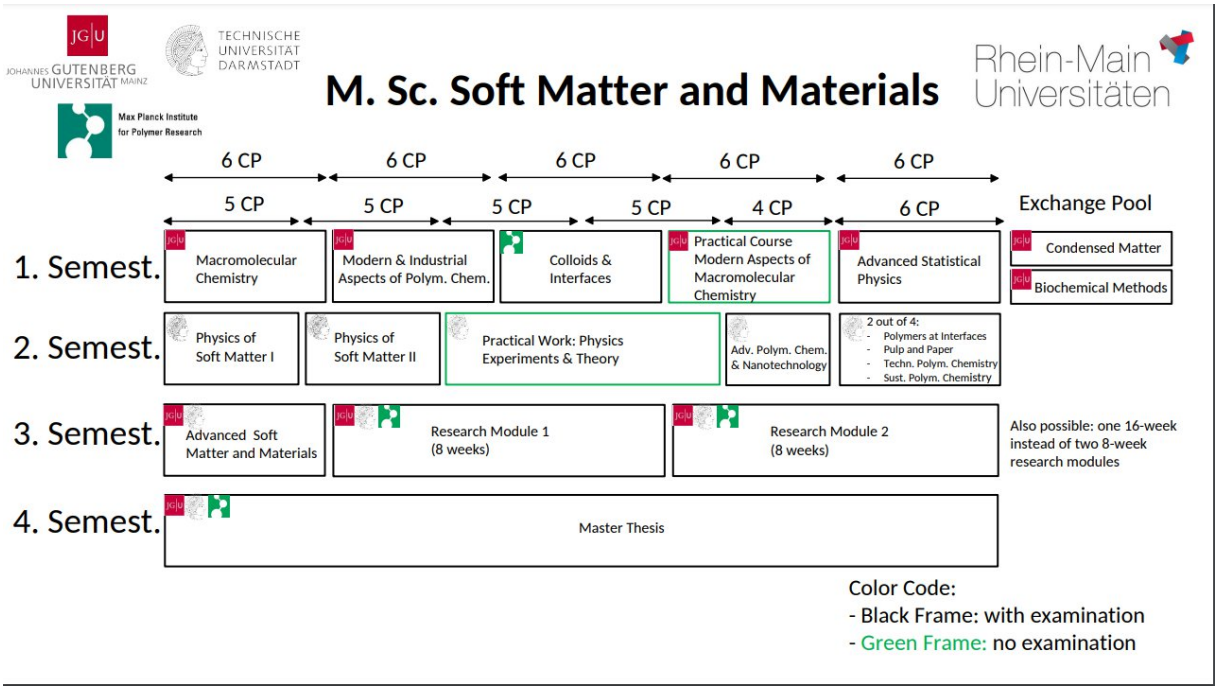
SWH	1	2	3	4
Attendance time	10,5h	21h	31,5h	42h

Abbreviations

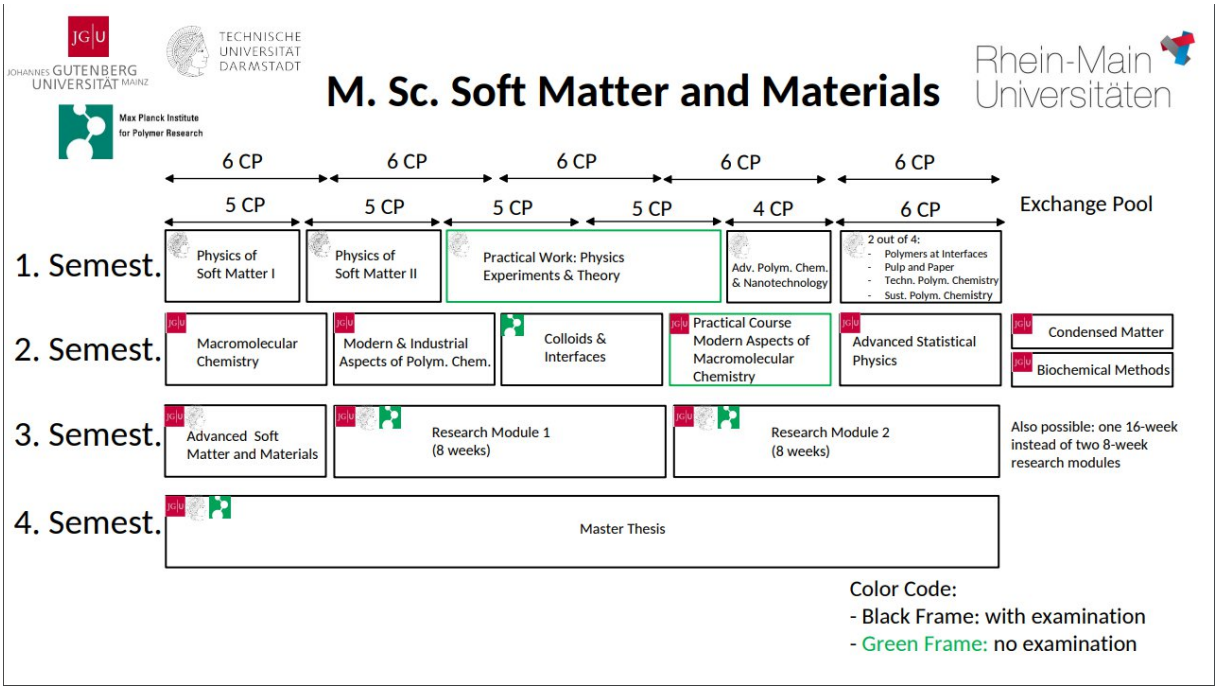
Abbreviation	**Meaning**
AOT	Among Other Things
CP	Credit Points
E	Exercise
E.g	For example
gen.	general
h	hour
incl.	inclusive
IUPAC	International Union of Pure and Applied Chemistry
L	Lecture
LC	Lab course
O	Obligatory/Mandatory
S	Seminar
SWH	Semester-week-hours

Study plan

Start of courses in winter semester, in Mainz:



Start of courses in summer semester, in Darmstadt:



Module Descriptions

Module 1	Macromolecular Chemistry					M.09.032.22_250
Mandatory or elective module	**O**					
Location	JGU Mainz					
Creditpoints (CP) and workload	**6 CP = 180 h**					
Duration of module (according to study plan)	**1 Semester**					
Courses/ Forms of learning	**Type**	**Regular semester** at beginning of study **WS (SS)**	**Degree of obligation**	**Contact hours (SWH)**	**Self-study**	**Creditpoints**
a) Part 1: Synthesis and use of polymers Part 2: Physical chemistry of polymers	L	1 (2)	O	3	103,5 h	4,5
b) Exercises	E	1 (2)	O	1	34,5 h	1,5
In order to complete the module, the following must be completed:						
Attendance						
Active participation	b) according to § 5 para. 3; exercises					
Course achievement(s)						
Module exam	Usually written exam (120 min), otherwise oral exam (30 min)					

Qualification goals/learning outcomes/competencies

The students acquire the basics of polymer chemistry, polymerization types, chain and step growth. An overview of relevant polymer materials as well as key methods of polymer characterization and basic properties of polymers in solution as well as in the solid state is provided.
Students will be able to:
- Reproduce basic physical properties and material properties of polymers and special features of polymers in comparison to other classes of materials, especially to low molecular weight compounds.
- Acquire the basics of polymer chemistry, types of polymerizations, chain and step growth,
- to critically evaluate polymerization methods, both about the achievable molecular weights and with regard to the respective limitations concerning polydispersity,
- to get to know basic characterization methods and to evaluate them with respect to their suitability for specific problems
- to conceptualize and quantitatively discuss the structure and dynamics of macromolecules and to thermodynamically describe macromolecular multicomponent systems.

Contents

Part 1:
General principles: tasks of polymer science, polymer structures, nomenclature.
Polymer synthesis: polycondensation (step growth), Carothers equation, polymerizations with chain growth, radical and ionic methods of polymer synthesis, kinetics, chain transfer, copolymerization, catalytic polymerization, polyinsertion, catalysts (initiators).
Polymerization in heterophase (emulsion, dispersion, suspension).
Polymer modification: cellulose, rubber, polymer analogous reactions.
Controlled and living polymerization processes, ring opening reactions,
solid phase synthesis.

Part 2:
Polymer structure: block copolymers, conformation of macromolecules, errant statistics, RIS model, ideal and real chain statistics, entropy elasticity, Flory exponent and scale laws.
Molecular characterization of polymers in solution: colligative methods, Gelpermeation chromatography, mass spectrometry, static light scattering.
Polymer dynamics: Rouse and Zimm model.
Polymer thermodynamics: Flory-Huggins theory, phase diagrams

Entry requirement(s)	None
Recommended prerequisite(s) for the module or for individual courses of the module	None

Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	Graded 6 CP out of 98 graded CP.
Frequency of the offer	Every semester
Justification of the obligation to be present	
Module officer or person in charge of the module	Prof. Dr. Andreas Walther (JGU – FB 09)
Usability of the module in other study programs	M.Sc. Soft Matter and Materials, B.Sc. und M.Sc. Chemie
Other remarks	Literature: Tieke – Makromolekulare Chemie. Eine Einführung (Wiley). Koltzenburg, Maskos, Nuyken – Polymere: Synthese, Eigenschaften und Anwendungen (Springer) Lechner, Gehrke, Nordmeier – Makromolekulare Chemie (Springer) Seiffert – Physical Chemistry of Polymers: A Conceptual Introduction (DeGruyter)

Module 2	Modern and industrial aspects of polymer materials					M.09.032.22_580
Mandatory or elective module	**O**					
Location	**JGU Mainz**					
Creditpoints (CP) and workload	**6 CP = 180 h**					
Duration of module (according to study plan)	**1 Semester**					
Courses/ Forms of learning	**Type**	**Regular semester** at beginning of study **WS (SS)**	**Degree of obligation**	**Contact hours (SWH)**	**Self-study**	**Creditpoints**
Part 1: Synthesis and use of polymer materials Part 2: Physical chemistry of polymer materials	L	1 (2)	O	3	103,5 h	4,5 CP
Seminar	OS	1 (2)	O	1	34,5 h	1,5 CP
In order to complete the module, the following must be completed:						
Attendance						
Active participation	According to § 5 paragraph 3, successful giving of a lecture in the seminar.					
Course achievement(s)						
Module exam	Usually written exam (120 min) or oral exam (30 min)					

Qualification goals/learning outcomes/competencies

An in-depth look at custom manufacturing and the multi-layered structure and dynamics of polymer systems and materials is provided. The students are able to
- Describe key challenges and approaches to modern and industrial polymer synthesis, and understand current research issues of an academic nature: For example, sequence control, thermoplastic elastomers, composite materials, weak interactions in polymer science, self-assembly, responsive materials, and bioinspired materials design,
- Describe the rheology of polymers in the melt and solution states methodologically, conceptually, and phenomenologically, both qualitatively and quantitatively.
- Reflect the basic characteristics of the structure and dynamics of polymeric solutions, gels, glasses, and crystals.

Contents

Modern methods of polymer synthesis:
- Advanced composite materials, high-performance materials
- Responsive and switchable materials
- Biomimetic concepts in polymer science
- Phase-segregated polymer systems in application, thermoplastic elastomers
- Polymer nanoparticles and self-assembled nanostructures

Fundamentals of rheology:
- viscoelasticity
- complex rheological material properties
- time-temperature superposition
- Rheology of polymer systems: Reptation in melt and solution, rubber elasticity of networks, dynamic glass transition.

Building on this: comprehensive and in each case separate treatment of the structure, dynamics and properties of polymers in the state of melts, semi-dilute solutions, gels, crystals and partial crystals glasses

Entry requirement(s)	None
Recommended prerequisite(s) for the module or for individual courses of the module	None
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	Graded 6 CP out of 98 graded CP.
Frequency of the offer	Winter semester
Justification of the obligation to be present	
Module officer or person in charge of the module	Prof. Dr. Andreas Walther (JGU – FB 09)

Usability of the module in other study programs	M.Sc. Soft Matter and Materials; M.Sc. Chemie; M.Sc. BMC
Other remarks	Literature: Koltzenburg, Maskos, Nuyken – Polymere: Synthese, Eigenschaften und Anwendungen (Springer) Lechner, Gehrke, Nordmeier – Makromolekulare Chemie (Springer) Rubinstein, Colby – Polymer Physics (Oxford University Press)

Module 3	Colloids and interfaces					M.09.032.6003
Mandatory or elective module	**O**					
Location	**MPI-P Mainz**					
Creditpoints (CP) and workload	**6 CP = 180 h**					
Duration of module (according to study plan)	**1 Semester**					
Courses/ Forms of learning	**Type**	**Regular semester** at beginning of study **WS (SS)**	**Degree of obligation**	**Contact hours (SWH)**	**Self-study**	**Creditpoints**
a) Colloid chemistry	L	1 (2)	O	2	69 h	3
b) Physics and chemistry of interfaces	L	1 (2)	O	2	69 h	3
In order to complete the module, the following must be completed:						
Attendance						
Active participation						
Course achievement(s)						
Module exam	a) Usually written exam (60 min) otherwise oral exam (30 min) b) Usually written exam (60 min) otherwise oral exam (30 min)					

Qualification goals/learning outcomes/competencies

Based on basic knowledge from macromolecular and physical chemistry, students have acquired knowledge in the field of colloid and interface research. They are able to reproduce these according to scientific standards and can transfer the concepts to analogous problems. The students are able to integrate the knowledge acquired in the lecture into the already existing knowledge and to reproduce and evaluate it in a larger context. Students know the basic concepts of interfacial science, such as interfacial tension and energy. They are aware of how the shape of liquid surfaces is described in equilibrium and the effect of curvature of liquid surfaces on vapor pressure. You know how surface tension changes in the presence of adsorbing substances. They know how to describe basic wetting phenomena quantitatively. They know how surface charges are formed in aqueous medium and know basic electrokinetic phenomena. The important surface forces are known and the students know about the relevance for the stabilization of dispersions. In addition to the theoretical concepts, they know the methods that can be used to measure the important physicochemical quantities. Different methods for the production of nanoparticles and nanocapsules are familiar. The students know possible applications of colloidal systems.

Contents

The lecture consists of two parts. (1) Fundamentals of Interfacial Science. Topics include liquid surfaces, thermodynamics of interfaces, charged surfaces and electric bilayers, surface forces, contact angle phenomena, solid surfaces and adsorption, modification of surfaces. (2) Colloids and nanoparticles. Topics include surfactants, emulsions, liposomes, polymersomes, foams, emulsion methods, various heterophase polymerization processes, nanoparticles and nanocapsules, and applications of nanoparticles.

Entry requirement(s)	
Recommended prerequisite(s) for the module or for individual courses of the module	Basic knowledge of physical and macromolecular chemistry.
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	Graded 6 CP out of 98 graded CP.
Frequency of the offer	Winter semester
Justification of the obligation to be present	
Module officer or person in charge of the module	Prof. Dr. Hans-Jürgen Butt (MPI-P)
Usability of the module in other study programs	
Other remarks	

Module 4	Practical course - Macromolecular Chemistry	[Module-ID]
Mandatory or elective module	**O**	
Location	**JGU Mainz**	
Creditpoints (CP) and workload	**6 CP = 180 h**	
Duration of module (according to study plan)	**1 Semester**	

Courses/ Forms of learning	Type	Regular semester at beginning of study WS (SS)	Degree of obligation	Contact hours (SWH)	Self-study	Creditpoints
Lab course Macromolecular Chemistry 2	LC	1 (2)	O	6	117 h	6

In order to complete the module, the following must be completed:	
Attendance	Lab course only
Active participation	According to § 5 para. 3 esp. preliminary interview, test protocols
Course achievement(s)	
Module exam	

Qualification goals/learning outcomes/competencies

According to the previous knowledge of the students, practical experiments are selected from the following areas: Polymer synthesis experiments (step growth, chain growth): Radical polymerization, polycondensation, living/controlled polymerization, copolymerization, polymerization in heterophase, networks.
Furthermore, practical experiments on typical physical properties of polymers (solubility, molecular weights, conformation in solution), determination of thermal and mechanical properties of polymers and crystallinity, supramolecular polymerization, DNA nanoscience systems, advanced analytics.

Contents	
Entry requirement(s)	None
Recommended prerequisite(s) for the module or for individual courses of the module	None
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	ungraded
Frequency of the offer	Every semester
Justification of the obligation to be present	Lab course
Module officer or person in charge of the module	Prof. Dr. Andreas Walther (JGU – FB 09)
Usability of the module in other study programs	M.Sc. Soft Matter and Materials, M.Sc. Chemistry
Other remarks	

Module 5	Advanced Statistical Physics					[Module-ID]
Mandatory or elective module	**O**					
Location	**JGU Mainz**					
Creditpoints (CP) and workload	**6 CP = 180 h**					
Duration of module (according to study plan)	**1 Semester**					
Courses/ Forms of learning	**Type**	**Regular semester at beginning of study WS (SS)**	**Degree of obligation**	**Contact hours (SWH)**	**Self-study**	**Creditpoints**
Lecture „Advanced Statistical Physics“	L	1 (2)	O	4	138 h	6
In order to complete the module, the following must be completed:						
Attendance						
Active participation						
Course achievement(s)						
Module exam	Oral exam (30 Min.)					

Qualification goals/learning outcomes/competencies

Learning advanced concepts and applications of statistical physics. To learn central concepts of the physics of systems and materials whose behavior is dominated by large fluctuations, such as E.g. all fluids, many plastics, membranes, and most biomaterials, but also systems outside the natural sciences (E.g. stock exchange). The focus will be on general principles that have overarching importance, such as symmetries, cooperative processes and phase transitions, scales and scale-free, and the concept of coarsening. The concrete material examples are oriented towards the research in Mainz and come for the most part from the field of "soft matter".

Contents

- Fundamentals of a statistical description of complex systems in equilibrium and nonequilibrium:
Linear response and transport, stochastic processes, structure, correlations and scattering.
- Model building: symmetries and conservation laws, concepts of coarsening (reduction of degrees of
degrees of freedom).
- Phase transitions, mean-field approaches, Landau theory, fluctuations and critical exponents,
Scale invariance and renormalization, possibly basic concepts of statistical field theory.

Other topics will be based on instructor preferences. Possibilities are: An in-depth treatment of nonequilibrium thermodynamics, stochastic thermodynamics. Disordered systems and glasses. Basic concepts of hydrodynamics at small Reynolds numbers. Statistical physics of complex soft materials (E.g. polymers, self-assembling systems, membranes, liquid crystals, colloidal systems, charged systems, entangled systems, biomolecules, biomaterials). Interdisciplinary applications of statistical physics (E.g. financial physics).

Entry requirement(s)	None
Recommended prerequisite(s) for the module or for individual courses of the module	None
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	Graded 6 CP out of 98 graded CP.
Frequency of the offer	Winter semester
Justification of the obligation to be present	
Module officer or person in charge of the module	Prof. Dr. Friederike Schmid (JGU - FB08)
Usability of the module in other study programs	M.Sc. Soft Matter and Materials, M. Sc. Physics
Other remarks	Literature: • Chaikin/Lubensky: Principles of Condensed Matter Physics. • Plischke/Bergersen: Equilibrium Statistical Physics. • Landau-Lifshitz: Theoretische Physik Band L und IX. • Goldenfeld: Lectures on phase transitions and the renormalization group.

	• Paul/Baschnagel: Stochastic processes. From physics to finance. • Risken: The Fokker-Planck equation. • Guyon, Hulin, Petit, Mitesu: Physical Hydrodynamics. • de Gennes: Scaling Concepts in Polymer Physics. • Doi/Edwards: The Theory of Polymer Dynamics. • Grosberg/Khokhlov: Statistical Mechanics of Macromolecules. • Rubinstein/Colby: Polymer Physics.

Module 6	Exchange Pool	[Module-ID]
If the competences of module 1 have already been acquired in the previous bachelor's degree program, Module 1 is to be replaced by a module from the following pool: 6.1 Physical Chemistry: Condensed Matter. 6.2 Biochemistry (Biochemistry)		

Module 6.1	Condensed Matter	M.09.032.22_640

Location	**JGU Mainz**
Mandatory or elective module	**EM**
Creditpoints (CP) and workload	**6 CP = 180 h**
Duration of module (according to study plan)	**1 Semester**

Courses/ Forms of learning	Type	Regelsemester at beginning of study WS (SS)	Degree of obligation	Contact hours (SWH)	Self-study	Creditpoints
a) Lecture	L	1 (2)	W	2 SWH	69 h	3 CP
b) Seminar	S	1 (2)	W	2 SWH	69 h	3 CP

In order to complete the module, the following must be completed:	
Attendance	None
Active participation	None
Course achievement(s)	None
Module exam	Usually written exam (120 min.), otherwise oral exam (30 min.)

Qualification goals/learning outcomes/competencies

- Students will be introduced to the physicochemical principles of condensed matter leading to an understanding of the material nature and properties of functional materials, especially at the nanometer scale. The range of suitable topics includes E.g. structure and properties of amorphous and crystalline condensed matter, structure and properties of polymers and colloids, intermolecular interactions and molecular assemblies, nanomaterials. One or more specific topics will be used to develop an in-depth understanding of a research-related condensed matter specialty that will provide a foundation for successfully completing a master's thesis in this or a related field.

Contents

- a) Lecture: Fundamentals of hard and soft condensed matter; intermolecular interactions; structure, dynamics and related characteristic properties of crystalline-hard as well as amorphous-soft matter; scattering from complex matter; electronic and magnetic ordering; relaxation dynamics; energy storage capacity and dissipation, viscoelasticity. The lecture will be offered in digital form via an e-learning platform.
- b) Seminar: in the accompanying seminar the contents of the digital lecture will be deepened in group work, using interactive teaching and forms of learning (here: inverted classroom and just-in-time teaching).

Entry requirement(s)	None
Recommended prerequisite(s) for the module or for individual courses of the module	None
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	Graded 6 out of 98 graded CP.
Frequency of the offer	Winter semester
Justification of the obligation to be present	
Module officer or person in charge of the module	Prof. Dr. Seiffert (JGU - FB09)
Usability of the module in other study programs	M.Sc. Soft Matter and Materials, M. Sc, Chemie, M. Sc. Physik
Other remarks	The module consists of two sections, one on hard matter and one on soft matter. The first is taught by Prof. M. Kläui (FB08), the second is taught by Prof. S. Seiffert (FB09).

Module 6.2	Biochemistry	[Module-ID]
Location	**JGU Mainz**	
Mandatory or elective module	**EM**	
Creditpoints (CP) und Arbeitsaufwand (Workload)	**6 = 180 h**	
Duration of module (according to study plan)	**1 Semester**	

Courses/ Forms of learning	Type	Regular semester at beginning of study WS (SS)	Degree of obligation	Contact hours (SWH)	Self-study	Creditpoints
a) Lecture: Methods of Biochemistry	L	1 (2)	EM	2	69 h	3
b) Seminar to a)	S	1 (2)	EM	2	69 h	3

In order to complete the module, the following must be completed:	
Attendance	
Active participation	according to § 5 para.3 b) The student elaborates and presents a given, current biochemical topic and engages in discussion on the topic.
Course achievement(s)	
Module exam	Usually written examination (120 min.), otherwise oral examination (30 min.) on a) and b)

Qualification goals/learning outcomes/competencies

The students are able to,
- to assign suitable methods to problems from the fields of protein and membrane biochemistry.
- to analyze typical data of these methods.
- to evaluate the results of bioanalytical experiments.
- to understand the limitations of the respective methods based on their physical principles.
- to assess the applicability of the methods to new problems.
- to critically evaluate the significance of the respective experiments in publications in international journals.
- to acquire independently an in-depth knowledge of current topics in biochemical analysis and related fields.
- to analyze and evaluate scientific literature from a scientific point of view.

independently prepare, present and defend a scientific paper on a (given) current biochemical-analytical topic.

Contents

- Methods of protein expression
- Principles and methods of protein isolation and identification
- Immune techniques in biochemistry
- Spectroscopic methods in biochemistry
- Methods of protein structure analysis
- protein stability
- Protein dynamics
- Chemical modification of proteins
- Biochemistry and biophysics of lipid membranes
- Membrane proteins
- In vivo and in vitro studies of protein-protein and protein-lipid interactions
- Microscopic techniques

Expression and protein characterization in vivo

Entry requirement(s)	Basic lecture "Biochemistry" or comparable performance.
Recommended prerequisite(s) for the module or for individual courses of the module	Events with cell biological and physiological content
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	Graded 6 out of 98 graded CP.
Frequency of the offer	1x yearly, in Winter semester

Justification of the obligation to be present	
Module officer or person in charge of the module	Prof. Dr. Dirk Schneider (JGU - FB09)
Usability of the module in other study programs	M.Sc. Soft Matter and Materials, B. Sc. Molecular Biotechnology, M. Sc. Chemistry
Other remarks	A basic understanding of chemical and biological principles, in particular the structure and function of proteins and membranes, is required.

Module 7	Physics of soft matter I	[Module-ID]05-61-3101
Mandatory or elective module	**O**	
Location	**TU Darmstadt**	
Creditpoints (CP) and workload	**5 CP = 150 h**	
Duration of module (according to study plan)	**1 Semester**	

Courses/ Forms of learning	Type	Regular semester at beginning of study WS (SS)	Degree of obligation	Contact hours (SWH)	Self-study	Creditpoints
a) Physics of Soft Matter I	L	2 (1)	O	3	88,5 h	4
b) Exercises	E	2 (1)	O	1	19,5 h	1

In order to complete the module, the following must be completed:	
Attendance	
Active participation	
Course achievement(s)	
Module exam	Usually oral exam (30 min), otherwise written exam (120 min)

Qualification goals/learning outcomes/competencies

The students
- have basic and advanced knowledge of the above topics
- have skills in model building and in the formulation of mathematical-physical approaches and are able to apply and communicate these to tasks in the above-mentioned areas,
- are competent in working independently on problems in the above-mentioned areas and are able to estimate accuracies of observation and analysis,
- are able to embed the technical content in the social context, to critically assess the consequences and to act ethically and responsibly accordingly.

Contents

Phase transitions

Interaction and structure in colloids and polymers

Brownian motion, dynamic scattering experiments

Dynamics in colloids and polymer melts

Self-organization of complex phases

Entry requirement(s)	None
Recommended prerequisite(s) for the module or for individual courses of the module	None
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	Graded 5 out of 98 graded CP.
Frequency of the offer	In Summer semester
Justification of the obligation to be present	
Module officer or person in charge of the module	Prof. Dr. Michael Vogel (TUDa - Fachbereich Physik)
Usability of the module in other study programs	MSc. Soft Matter and Materials (compulsory course)
Other remarks	Literature: Will be specified by lecturer Examples: Strobl: The Physics of Polymers Jones: Soft Condensed Matter Hamley: Introduction to Soft Matter Evans und Wennerstroem: Colloidal Domain

Module 8	Physik der weichen Materie II	[Module-ID] 05-61-3102

	Physics of soft matter II					
Mandatory or elective module	**O**					
Location	**TU Darmstadt**					
Creditpoints (CP) and workload	**5 CP = 150 h**					
Duration of module (according to study plan)	**1 Semester**					
Courses/ Forms of learning	**Type**	**Regular semester at beginning of study WS (SS)**	**Degree of obligation**	**Contact hours (SWH)**	**Self-study**	**Creditpoints**
a) Physics of Soft Matter II	L	2 (1)	O	3	88,5 h	4
b) Exercises	E	2 (1)	O	1	19,5 h	1
In order to complete the module, the following must be completed:						
Attendance						
Active participation						
Course achievement(s)						
Module exam	Usually oral exam (30 min), otherwise written exam (120 min)					

Qualification goals/learning outcomes/competencies
The students - have basic and advanced knowledge of the above topics - have skills in model building and in the formulation of mathematical-physical approaches and are able to apply and communicate these to tasks in the above-mentioned areas, - are competent in working independently on problems in the above-mentioned areas and are able to estimate accuracies of observation and analysis, - are able to embed the technical content in the social context, to critically assess the consequences and to act ethically and responsibly accordingly.
Contents
Liquid crystals, wetting, adsorption of amphiphiles and polymers at interfaces, biological membranes, protein folding and stabilization, Kirkwood-Buff theory, confinement effects, current topics in soft matter physics.

Entry requirement(s)	None
Recommended prerequisite(s) for the module or for individual courses of the module	None
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	Graded 5 out of 98 graded CP.
Frequency of the offer	In summer semester
Justification of the obligation to be present	
Module officer or person in charge of the module	Prof. Dr. Emanuel Schneck (TUDa - Department of Physics)
Usability of the module in other study programs	MSc. Soft Matter and Materials (compulsory course)
Other remarks	Literature: Will be given by lecturer Examples: Strobl: The Physics of Polymers Jones: Soft Condensed Matter Hamley: Introduction to Soft Matter Evans und Wennerstroem: Colloidal Domain

Module 9	Practical Work: Physics Experiments & Theory					[Module-ID] 05-61-3103
Mandatory or elective module	**O**					
Location	**TU Darmstadt**					
Creditpoints (CP) and workload	**10 CP = 300 h**					
Duration of module (according to study plan)	**1 Semester**					
Courses/ Forms of learning	**Type**	**Regular semester at beginning of study WS (SS)**	**Degree of obligation**	**Contact hours (SWH)**	**Self-study**	**Creditpoints**
Practical Work Physics: Experiments & Theory	LC	2 (1)	O	7	226,5 h	10
In order to complete the module, the following must be completed:						
Attendance	Lab course only					
Active participation	According to § 5 para. 3 esp. preliminary interview, test protocols					
Course achievement(s)						
Module exam						

Qualification goals/learning outcomes/competencies

The students
-know and know in-depth techniques in experimentation or simulation, scientific protocol management and are familiar with more complex procedures of data analysis; they acquire in-depth knowledge and measurement and simulation applications in the field of soft matter

-possess skills in the execution of experiments and their analysis, including the critical assessment of experimental uncertainties, as well as basic methodological knowledge for writing a scientific paper,

-are competent to work independently in a limited subject area with selected literature, to critically evaluate the extracted results and to present their knowledge both in the oral preliminary discussion and in the written elaboration; the students are proficient in elementary forms of scientific discussion.

Contents

6 Elective experiments on soft matter experiments and simulations using modern techniques: Liquids, polymers and amphiphiles, and glasses in bulk phase and at interfaces.

Entry requirement(s)	None
Recommended prerequisite(s) for the module or for individual courses of the module	None
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	ungraded
Frequency of the offer	Every semester
Justification of the obligation to be present	
Module officer or person in charge of the module	Prof. Dr. Regine von Klitzing (TUDa - Department of Physics)
Usability of the module in other study programs	M.Sc. Soft Matter and Materials
Other remarks	Literature: Will be specified by instructor(s) Examples: Strobl: The Physics of Polymers Jones: Soft Condensed Matter Hamley: Introduction to Soft Matter

Module 10	Advanced Polymer Chemistry and Polymer Nanotechnology					[Module-ID]
Location	**TU Darmstadt**					
Mandatory or elective module	**O**					
Creditpoints (CP) and workload	**4 CP = 120 h**					
Duration of module (according to study plan)	**1 Semester**					
Courses/ Forms of learning	**Type**	**Regular semester** at beginning of study **WS (SS)**	**Degree of obligation**	**Contact hours (SWH)**	**Self-study**	**Creditpoints**
Advanced Polymer Chemistry and Polymer Nanotechnology	L	2 (1)	O	2	60 h	3
Exercise	E	2 (1)	O	1	15 h	1
In order to complete the module, the following must be completed:						
Attendance						
Active participation						
Course achievement(s)						
Module exam	Written exam (120 min)					

Qualification goals/learning outcomes/competencies

Students will develop an in-depth understanding of the advanced synthetic capabilities of polymer chemistry and the methods used to experimentally demonstrate the architecture and structure of polymers. Students will also be able to correlate important molecular parameters of chain molecules with their properties and the nanostructures they form. In addition, students will learn how to tailor, tune, and utilize polymer self-assembly for applications such as polymer-based drug delivery, nanoscale reaction compartments, and the formation of nanostructured materials.
As part of the tutorial, students will practice their scientific and presentation skills by researching a topic related to the lecture and presenting it in the form of a poster presentation.

Contents

The aim of this lecture is to provide in-depth knowledge in modern synthesis, molecular characterization and nanotechnological applications of macromolecular substances. First, the chain and step growth reactions presented in the Organic Polymer Chemistry lecture will be discussed in mechanistic and kinetic detail. This includes advanced polymerization techniques such as enzyme-catalyzed polymerization. Based on this, current research and development trends in the various polymerization processes are presented and discussed mechanistically and kinetically. The third part of the lecture is devoted to more complex polymer architectures, their targeted preparation, their self-assembly into nanostructured materials, and their application as building blocks for nanotechnology - ranging from block copolymers, through defined branched homopolymers, to hyperbranched polymers and dendrimers.
In the associated tutorial, students conduct a literature review on a current topic in advanced polymer chemistry and polymer nanotechnology, prepare a poster, and present it to their peers.

Entry requirement(s)	None
Recommended prerequisite(s) for the module or for individual courses of the module	None
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	Graded 4 out of 98 graded CP.
Frequency of the offer	Every semester
Justification of the obligation to be present	
Module officer or person in charge of the module	Prof. Dr. Nico Bruns (TUDa - Department of Chemistry)
Usability of the module in other study programs	M.Sc. Soft Matter and Materials
Other remarks	

Module 11	**Compulsory modules**	**[Module-ID]**
Two of the following modules must be chosen: 1. polymers on surfaces 2. chemical technology of pulp and paper 3. sustainable polymer chemistry 4. technical aspects of macromolecular chemistry		
In order to complete the module, the following must be completed:		
Attendance		
Active participation		
Course achievement(s)		
Module exam	Written exam (120 min), consisting of two partial exams, otherwise oral exam (60 min)	
Qualification goals/learning outcomes/competencies		

Module 11.1	Polymers at Interfaces					[Module-ID]
Location	**TU Darmstadt**					
Mandatory or elective module	**EM**					
Creditpoints (CP) and workload	**3 CP = 90 h**					
Duration of module (according to study plan)	**1 Semester**					
Courses/ Forms of learning	**Type**	**Regular semester** at beginning of study **WS (SS)**	**Degree of obligation**	**Contact hours (SWH)**	**Self-study**	**Creditpoints**
Polymers at Interfaces	L	2 (1)	O	2	69 h	3
In order to complete the module, the following must be completed:						
Attendance						
Active participation						
Course achievement(s)						
Module exam	See main modules11					

Qualification goals/learning outcomes/competencies

Polymers at interfaces play an important role in many applications, from functional surfaces, drug delivery systems, particle stabilization, and membranes, to name a few. In this lecture, students will gain insight into various ways to design the chemistry and physics of surfaces in such systems using thin polymer films. In a second part, students will gain insight into modern methods for characterizing such interfaces, which is often a challenge in itself, E.g. due to small amounts of material. With this knowledge you will be able to address research questions and problems in the application of interfaces in the field of medicine, separation or sensing.

Contents

The lecture gives an introduction to the functionalization of interfaces with polymers, the interfacial specific behavior and their characterization. This is E.g. relevant for the design of functional water repellent surfaces or in the field of membranes to enable more efficient separation or sensing. Specifically, the following topics will be addressed:
Polymer functionalization: synthesis of thin polymer layers by grafting from, grafting onto, grafting by different polymerization processes; adsorption of polymers on surfaces; self-assembly of molecules on surfaces; chemical bonding of thin polymer films; polymer brushes; layer-by-layer assembly; polymer networks on surfaces; lithography at interfaces.
Polymer behavior on surfaces: swelling of thin polymer films; switchable surfaces by external stimuli;
Characterization of polymers at surfaces: Introduction to forces at interfaces, electrical double layer; structural characterization (XRR, AFM, SEM); chemical characterization (IR, UV-VIS, wetting, XPS); optical characterization (ellipsometry, plasmon, waveguide-mode spectroscopy, STED); electrochemical characterization (cyclic voltammetry.)

Entry requirement(s)	None
Recommended prerequisite(s) for the module or for individual courses of the module	None
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	Graded 3 out of 98 graded CP.
Frequency of the offer	Every semester
Justification of the obligation to be present	
Module officer or person in charge of the module	Prof. Dr. A. Andrieu-Brunsen (TUDa - Department of Chemistry)
Usability of the module in other study programs	M.Sc. Soft Matter and Materials
Other remarks	

Module 11.2	Chemical Technology of Pulp and Paper	[Module-ID]
Location	**TU Darmstadt**	
Mandatory or elective module	**EM**	
Creditpoints (CP) and workload	**3 CP = 90 h**	
Duration of module (according to study plan)	**1 Semester**	

Courses/ Forms of learning	Type	Regular semester at beginning of study WS (SS)	Degree of obligation	Contact hours (SWH)	Self-study	Creditpoints
Chemical Technology of Pulp and Paper	L	2 (1)	O	2	69 h	3

In order to complete the module, the following must be completed:	
Attendance	
Active participation	
Course achievement(s)	
Module exam	See main module 11

Qualification goals/learning outcomes/competencies

The paper industry is a special key industry that uses a special technology in which colloid chemical and macromolecular processes play the dominant role. In this lecture, students will learn about papermaking from a chemical perspective. On the way from the diluted pulp suspension to the finished paper, the necessities, and modes of action of various chemical auxiliaries are discussed. Students gain comprehensive knowledge in the industrially important area of polymer additives for the paper industry.

Contents

Chapters in this lecture include:
- Polymers as process and functional auxiliaries in papermaking,
- Polymers flocculants, dewatering agents, and fixatives,
- Types and functions of fillers,
- Polymers as dry and wet strength additives in paper,
- Dyes and biocides,
- Chemistry of paper coating and other finishes of paper,
- Treatment of pollutants and effluents,
- Chemical and physicochemical analysis of paper

Entry requirement(s)	None
Recommended prerequisite(s) for the module or for individual courses of the module	The winter semester lecture "Chemical Technology of Paper and Bio-based Fibers" is recommended but not mandatory.
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	Graded 3 out of 98 graded CP.
Frequency of the offer	Every semester
Justification of the obligation to be present	
Module officer or person in charge of the module	Prof. Dr. Markus Biesalski
Usability of the module in other study programs	M.Sc. Soft Matter and Materials
Other remarks	

Module 11.3	Sustainable Polymer Chemistry	[Module-ID]
Mandatory or elective module	**EM**	
Location	**TU Darmstadt**	
Creditpoints (CP) and workload	**3 CP = 90 h**	
Duration of module (according to study plan)	**1 Semester**	

Courses/ Forms of learning	Type	Regular semester at beginning of study WS (SS)	Degree of obligation	Contact hours (SWH)	Self-study	Creditpoints
Sustainable Polymer Chemistry	L	2 (1)	O	2	69 h	3

In order to complete the module, the following must be completed:	
Attendance	
Active participation	
Course achievement(s)	
Module exam	See main module 11

Qualification goals/learning outcomes/competencies

Students develop an in-depth understanding of the environmental concerns of plastics and the potential of polymers for a sustainable future. The course is firmly rooted in the chemistry and technology of polymers. This provides students with the theoretical expertise to develop new concepts for sustainable polymer chemistry and to engage as experts in the societal discourse around polymers and sustainability.

Contents

The aim of this lecture is, on the one hand, to provide in-depth knowledge of the environmental problems associated with plastics and polymers, such as microplastic pollution and marine litter. On the other hand, the lecture will cover the many contributions and opportunities that polymer chemistry offers to solve environmental problems. For example, polymers contribute significantly to the reduction of CO2 emissions in the form of lightweight materials for the automotive and aerospace industries or in the form of high performance insulation materials. In addition, the lecture will detail the synthesis and manufacturing routes for sustainable polymers, including enzymatic polymerizations, as well as bio-based and biodegradable polymers. Finally, the end-of-life cycle of polymers is discussed, including mechanical and chemical recycling strategies, biodegradability, and circular economy.

Entry requirement(s)	None
Recommended prerequisite(s) for the module or for individual courses of the module	None
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	Graded 3 out of 98 graded CP.
Frequency of the offer	Every semester
Justification of the obligation to be present	
Module officer or person in charge of the module	Prof. Dr. Nico Bruns (TUDa - Department of Chemistry)
Usability of the module in other study programs	M.Sc. Soft Matter and Materials
Other remarks	

Module 11.4	Engineering Aspects in Macromolecular Chemistry	[Module-ID]
Mandatory or elective module	**EM**	
Location	**TU Darmstadt**	
Creditpoints (CP) and workload	**3 CP = 90 h**	
Duration of module (according to study plan)	**1 Semester**	

Courses/ Forms of learning	Type	Regular semester at beginning of study WS (SS)	Degree of obligation	Contact hours (SWH)	Self-study	Creditpoints
Engineering Aspects in Macromolecular Chemistry	L	2 (1)	O	2	69 h	3

In order to complete the module, the following must be completed:	
Attendance	
Active participation	
Course achievement(s)	
Module exam	See main module 11

Qualification goals/learning outcomes/competencies

Students will gain an overview of fundamentals and current work in the field of polymer reaction engineering. This includes methods of kinetic investigations, modeling techniques for describing polymerizations on a laboratory and industrial scale, and the application of modeling polymerization reactions in technical practice. As a result, they have the prerequisites for successful employment in companies involved in the design or operation of commercial polymer plants. The often international context in which these companies operate and the fact that in the Anglo-Saxon world these fields of work are taught with the independent subject Polymer Reaction Engineering must be taken into account. Students will be able to describe polymerization processes in models. This includes both laboratory-scale experiments, which focus on the control of the polymer microstructure by the reaction conditions, and the description of technical reactors. Here, students have learned the basic tools, modeling techniques and methodology of application and are able to apply them.

Contents

Polymerization kinetics, methods for determining kinetic coefficients, modeling of polymerization at laboratory and pilot plant scale. Application of modeling in technical practice.

Entry requirement(s)	None
Recommended prerequisite(s) for the module or for individual courses of the module	None
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	Graded 3 out of 98 graded CP.
Frequency of the offer	Every semester
Justification of the obligation to be present	
Module officer or person in charge of the module	Prof. Dr. M. Busch (TUDa - Department of Chemistry)
Usability of the module in other study programs	M.Sc. Soft Matter and Materials
Other remarks	

Module 12	Advanced Soft Matter and Materials	[Module-ID]
Mandatory or elective module	**O**	
Location	**TU Darmstadt und/oder JGU Mainz**	
Creditpoints (CP) and workload	**6 CP = 180 h**	
Duration of module (according to study plan)	**1 Semester**	

Courses/ Forms of learning	Type	Regular semester at beginning of study WS (SS)	Degree of obligation	Contact hours (SWH)	Self-study	Creditpoints
- one module(à 6 CP) - several modules - one module(à 5 CP) and lectures		3	O	4	138 h	6

In order to complete the module, the following must be completed:	
Attendance	
Active participation	
Course achievement(s)	
Module exam	according to the selected events

Qualification goals/learning outcomes/competencies

The students
- have basic and advanced knowledge of the above topics
- have skills in model building and in the formulation of mathematical-physical approaches and are able to apply and communicate these to tasks in the above-mentioned areas,
- are competent in working independently on problems in the above-mentioned areas and are able to estimate accuracies of observation and analysis,
- are able to embed the technical content in the social context, to critically assess the consequences and to act ethically and responsibly accordingly.

If colloquium lectures have been attended, students are
- are able to present technical contexts and to summarize current research results in a trenchant way in writing
- able to embed the professional contents in the social context, to critically assess the consequences and to act ethically and responsibly accordingly.

Contents

Students choose modules with a total of at least 6 credit points on in-depth topics on Soft Matter and Materials from the catalog of events of the participating institutions. The courses available for selection are updated and announced every year.
Instead of a module, the attendance of colloquium lectures can be credited. The lecture series from which lectures may be selected will be updated and announced each semester. Lecture series, can be E.g. institute colloquia or lectures in ongoing GRKs or SFBs. The list of lectures to be heard must be agreed upon in advance with one of the course coordinators in Mainz or Darmstadt. Each lecture must be summarized briefly (approx. 1 page). If 10 summaries are submitted, 1 credit point will be credited.

Entry requirement(s)	None
Recommended prerequisite(s) for the module or for individual courses of the module	None
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	ungraded
Frequency of the offer	Every semester
Justification of the obligation to be present	
Module officer or person in charge of the module	
Usability of the module in other study programs	M.Sc. Soft Matter and Materials
Other remarks	Literature: is specified by lecturer

Module 13	**Research Module**	
The research module consists of either a) two research modules of 12 CP each or b) one research module à 24 CP		

Module 13 a.1	Research Module 1					[Module-ID] 05-21-2780
Location	**TU Darmstadt oder JGU Mainz oder MPI-P Mainz**					
Mandatory or elective module	**EM**					
Creditpoints (CP) and workload	**12 CP = 360 h**					
Duration of module (according to study plan)	**1 Semester**					
Courses/ Forms of learning	**Type**	**Regular semester at beginning of study WS (SS)**	**Degree of obligation**	**Contact hours (SWH)**	**Self-study**	**Creditpoints**
Research Module 1	LC	3	O	8	276 h	12
In order to complete the module, the following must be completed:						
Attendance						
Active participation						
Course achievement(s)						
Module exam	Presentation (15 min.) and written report					

Qualification goals/learning outcomes/competencies

The students know the scientific methodology in research in the subject area of the working group. They are able to deal with problems of the current state of research in a scientifically appropriate manner and to present and discuss their research results orally and in writing according to recognized standards of the subject. They fit into the research group, which is usually composed of staff members with distinctly different cultural backgrounds. They are able to work constructively in an internationally staffed team, taking gender and diversity aspects into account.

Contents

Under the supervision of members of the working group, the students work on a current project from the research topics of the supervising working group. This includes the research of the scientific background, the practical implementation of the project, the presentation and critical discussion of the results in the research seminar of the working group, usually in English, and the written documentation of the project.

Entry requirement(s)	45 CP from the basic phase must have been achieved. Research Module 1 must take place in a different working group than Research Module 2.
Recommended prerequisite(s) for the module or for individual courses of the module	None
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	Graded 12 out of 98 graded CP.
Frequency of the offer	Every semester
Justification of the obligation to be present	
Module officer or person in charge of the module	
Usability of the module in other study programs	M.Sc. Soft Matter and Materials
Other remarks	Literature: Will be specified by supervisor(s) Comment: Research module1 and 2 together replace Research module 3.

Module 13 a.2	Research Module 2					[Module-ID] 05-21-2780
Location	**TU Darmstadt oder JGU Mainz oder MPI-P Mainz**					
Mandatory or elective module	**EM**					
Creditpoints (CP) and workload	**12 CP = 360 h**					
Duration of module (according to study plan)	**1 Semester**					
Courses/ Forms of learning	**Type**	**Regular semester at beginning of study WS (SS)**	**Degree of obligation**	**Contact hours (SWH)**	**Self-study**	**Creditpoints**
Research Module 2	LC	3	O	8	276 h	12
In order to complete the module, the following must be completed:						
Attendance						
Active participation						
Course achievement(s)						
Module exam	Presentation (15 min.) and written report					

Qualification goals/learning outcomes/competencies

The students know the scientific methodology in research in the subject area of the working group. They are able to deal with problems of the current state of research in a scientifically appropriate manner and to present and discuss their research results orally and in writing according to recognized standards of the subject. They fit into the research group, which is usually composed of staff members with distinctly different cultural backgrounds. They are able to work constructively in an internationally staffed team, taking gender and diversity aspects into account.

Contents

Under the supervision of members of the working group, the students work on a current project from the research topics of the supervising working group. This includes the research of the scientific background, the practical implementation of the project, the presentation and critical discussion of the results in the research seminar of the working group, usually in English, and the written documentation of the project.

Entry requirement(s)	45 CP from the basic phase must have been achieved. Research Module 2 must take place in a different working group than Research Module 1.
Recommended prerequisite(s) for the module or for individual courses of the module	None
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	Graded 12 out of 98 graded CP.
Frequency of the offer	Every semester
Justification of the obligation to be present	
Module officer or person in charge of the module	
Usability of the module in other study programs	M.Sc. Soft Matter and Materials
Other remarks	Literature: Will be specified by supervisor(s) Comment: Research module1 and 2 together replace Research module 3.

Module 13 b	Research Module 3					[Module-ID] 05-21-2780
Location	**TU Darmstadt oder JGU Mainz oder MPI-P (Mainz)**					
Mandatory or elective module	**EM**					
Creditpoints (CP) and workload	**24 CP = 720 h**					
Duration of module (according to study plan)	**1 Semester**					
Courses/ Forms of learning	**Type**	**Regular semester at beginning of study WS (SS)**	**Degree of obligation**	**Contact hours (SWH)**	**Self-study**	**Creditpoints**
Research Module 1	LC	3	O	16	552 h	24
In order to complete the module, the following must be completed:						
Attendance						
Active participation						
Course achievement(s)						
Module exam	Interim written report and interim presentation (10 min.) (30% of the final grade) and final written report and final presentation (20 min.) (70% of the final grade).					

Qualification goals/learning outcomes/competencies
The students know the scientific methodology in research in the subject area of the working group. They are able to deal with problems of the current state of research in a scientifically appropriate manner and to present and discuss their research results orally and in writing according to recognized standards of the subject. They fit into the research group, which is usually composed of staff members with distinctly different cultural backgrounds. They are able to work constructively in an internationally staffed team, taking gender and diversity aspects into account.
Contents
Under the supervision of members of the working group, the students work on a current project from the research topics of the supervising working group. This includes the research of the scientific background, the practical implementation of the project, the presentation and critical discussion of the results in the research seminar of the working group, usually in English, and the written documentation of the project.

Entry requirement(s)	45 CP from the basic phase must have been achieved.
Recommended prerequisite(s) for the module or for individual courses of the module	None
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	Graded 24 out of 98 graded CP.
Frequency of the offer	Every semester
Justification of the obligation to be present	
Module officer or person in charge of the module	
Usability of the module in other study programs	M.Sc. Soft Matter and Materials
Other remarks	Literature: Will be specified by supervisor(s) Comment: Research module1 and 2 together replace Research module 3.

Finale module	Master Thesis					A.09.032.6014
Location	**JGU Mainz oder MPI-P Mainz oder TU Darmstadt**					
Mandatory or elective module	**O**					
Creditpoints (CP) and workload	**30 CP = 900 h**					
Duration of module (according to study plan)	**1 Semester**					
	Type	**Regular semester** at beginning of study **WS (SS)**	**Degree of obligation**	**Contact hours (SWH)**	**Self-study**	**Leistungs-punkte**
Master Thesis		4	O			30
In order to complete the module, the following must be completed:						
Attendance						
Active participation						
Course achievement(s)	Talk (30 min)					
Final exams	Master Thesis					

Qualification goals/learning outcomes/competencies

The students are able to work scientifically on a topic in the special field of "Soft Matter and Materials". They are able to introduce this topic in the form of a scientific paper (master thesis), to describe and document their results and to interpret and discuss them in the light of the relevant literature. They are also able to present and defend their master's thesis as a scientific paper, answering questions on the topic as well as on peripheral topics.

Contents

Master thesis: writing of a scientific paper on the topic, consisting of the following parts: Abstract (max. 1 page), introduction including objectives, material & methods as well as results, discussion, bibliography; an appendix may be added to document further primary data.
Oral examination: Presentation of the results as a lecture (30 min) and discussion.

Entry requirement(s)	According to examination regulations
Recommended prerequisite(s) for the module or for individual courses of the module	
Language(s) of instruction and language(s) of examination	English
Weight of the module grade in the overall grade	Graded 30 out of 98 graded CP.
Frequency of the offer	Every semester
Justification of the obligation to be present	
Module officer or person in charge of the module	Working group leaders involved in the study program
Usability of the module in other study programs	
Other remarks	