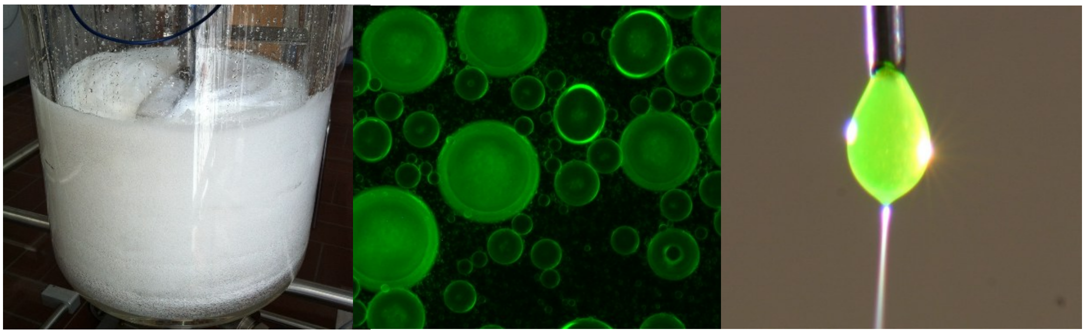
UNIVERSITÄT BAYREUTH

Master Program

Polymer Science

Module Handbook



June 2025

Content

Page

Polymer Science (*Macromolecular Science*) is a prime example of a truly cross-disciplinary innovative area in materials science and one of the fastest growing disciplines. It builds upon the traditional subdivisions of chemistry (organic, inorganic, and physical chemistry) and includes polymer chemistry, colloid science, polymer physics (theoretical and experimental), polymer engineering, and soft matter science. The subject is particularly appealing to students because it deals with modern materials that are commercially important and part of our daily life. Furthermore, based on the predicted growth and innovation power, polymers are the key materials class of the 21st century. *Polymer Science* also represents an area in which the students have high chances of finding employment after graduation. In contrast to the permanent demand of polymer chemistry in industry, *Polymer Science* has traditionally been among the most neglected topics in both undergraduate and graduate education.

Therefore, the *University of Bayreuth (UBT)* has a *strong commitment to teaching Polymer Science and an outstanding, stimulating research environment.* Since the foundation of the University of Bayreuth, polymer and colloid science has been one of the interdisciplinary focus areas with a continuous growth in terms of faculty members and scientific investments. Consequently, the UBT has become one of the leading centers of *Polymer Science* in Germany and Europe with a strong international recognition. More than 20 research groups led by full professors, associate professors, and junior professors are currently involved with various aspects of polymer and colloid science, including bio-based polymers and biomacromolecules.

The two-year *Master Program Polymer Science* focuses on the path from monomers via polymers to functional (polymer) materials and products, and covers, therefore, various disciplines including polymer chemistry, catalysis, colloid chemistry, physical chemistry, polymer physics, polymer processing and engineering, and polymer technology. The program comprises fundamental aspects and latest developments of technological applications of polymeric materials. It is research-oriented and introduces the students at an early stage to the current research topics in *Polymer Science*. This master program is based on faculty members and teaching staff that are very active, well recognized and with long teaching experiences in the different aspects of this area.

The *Master Program Polymer Science* is open to students with a bachelor degree in *chemistry, polymer and colloid chemistry, biochemistry, physics, materials engineering, and related bachelor studies*. It should be pointed out that it is possible for students without prior knowledge of *Polymer Science* to enter the program and participate in both the lectures and the laboratory courses in the first semester. The module concept of combining theoretical with experimental skills, including the documentation of experiments and results, has been proven to be a successful teaching approach. The master program starts yearly during the winter term. It is possible to enter the program in the summer term if sufficient precognition is shown. Applications should be mailed to the coordinator of the *Master Program Polymer Science*.

An overview of the curriculum of the master program offered is shown on page 5 and 6, and will be discussed in more detail in the following.

In the *first semester*, students from different disciplines and backgrounds will be introduced to the fundamentals of *Polymer Science*. Each student has to select four topics from a list of eight recommended modules (*Polymer Synthesis, Physical Chemistry of Polymers, Colloids and Surfaces, Polymer Materials and Technology, Polymer Physics I, Organometallic Chemistry and Polymerization Catalysts, Catalysis and Sustainable Synthesis, and Biomaterials*). Each module, with the exception of *Polymer Physics I*, includes an introductory lecture and a laboratory course to cover the experimental and practical aspects of the subject and teach hands-on skills. After successful completion, the students will have gained the basic theoretical and experimental knowledge which is necessary to specialize and focus on their individual interests.

In the *second semester*, the students will have to select three advanced modules, each comprising lectures and a laboratory course. In order to bring the students as closely as possible to current research, the laboratory course will be held in one of the research groups associated with the master program. Recommended modules are *Polymer Architectures and Functionality, High-performance and Specialty Polymers, Sustainable Polymer Chemistry and Polymer Materials, Advanced Methods in the Physical Chemistry of Polymers, Current Topics in Colloid, Polymer and Interface Science, Polymer Engineering, Polymer Physics II,* and *Catalyst Design*. In addition, students will write and defend a research proposal of a research topic, which could be related to one of the research modules in the third semester or the master thesis in the fourth semester.

In the *third and fourth semester*, two research modules, each of 15 credit points, have to be chosen; this can also be in combination with an assignment abroad and/or in industry. These modules are intended to bring the students closer to independent research. The subject of a master thesis is on a current research topic in *Polymer Science*. The master thesis, with 30 credit points, has a duration of six months, with the main workload in the fourth semester.

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Further information:

Master Program Polymer Science

www.polymerscience.master.uni-bayreuth.de

Bayreuth Graduate School of Mathematical and Natural Sciences
Doctorate Polymer Science

https://www.baynat.uni-bayreuth.de

Focus area Polymer & Colloid Science at the University of Bayreuth

https://www.profilfelder.uni-bayreuth.de/en/advanced-fields/2_polymer_colloid_science

Elite Study Program "Macromolecular Science"

https://www.enb-macromolecular-science.uni-bayreuth.de

At least 120 credit points (CP) have to be achieved in the *Master Program Polymer Science*.

Basic modules P 101 – P 108 Choice: 4 out of 8 modules*	Module P 101 **Polymer Synthesis** 7 CP	Module P 102 **Physical Chemistry of Polymers** 7 CP	Module P 103 **Colloids and Interfaces** 7 CP	Module P 104 **Polymer Materials and Technology** 7 CP
	Module P 105 **Polymer Physics I** 7 CP	Module P 106 **Organometallic Chemistry and Polymerization Catalysts** 7 CP	Module P 107 **Catalysis and Sustainable Synthesis** 7 CP	Module P 108 **Biomaterials** 7 CP

** Students select four from eight suggested modules offered in the winter semester. It is possible to replace one of these modules with a module from master courses in chemistry, biological chemistry, physics, or engineering science.*

Advanced modules P 201 – P 208 Choice: 3 out of 8 modules **	Module P 201 **Polymer Architectures and Functionality** 9 CP	Module P 202 **High-performance and Specialty Polymers** 9 CP	Module P 203 **Advanced Methods in the Physical Chemistry of Polymers** 9 CP	Module P 204 **Current Topics in Colloid, Polymer, and Interface Science** 9 CP
	Module P 205 **Polymer Engineering** 9 CP	Module P 206 **Polymer Physics II** 9 CP	Module P 207 **Catalyst Design** 9 CP	Module P 208 **Sustainable Polymer Chemistry and Polymer Materials** 9 CP

*** Students select three from eight suggested modules offered in the summer semester. It is possible to replace one of these modules with a module from master courses in chemistry, biological chemistry, physics, or engineering science.*

Module	Module P 210 **Research Proposal** 5 CP

Module***	Module P 301 **Advanced Laboratory I** 15 CP P 19 SWS, S 1 SWS	Module P 302 **Advanced Laboratory II** 15 CP P 19 SWS, S 1 SWS

**** These modules can be replaced by a laboratory course at a university abroad and/or an industrial internship. There is the possibility to substitute one module with selected modules or corresponding courses of the master programs of chemistry, biochemistry, physics, or engineering.*

Module	Module P 400 **Master Thesis** 30 CP 900 hours

Compulsory optional modules will be offered as far as possible and subject to demand. They will be announced in an appropriate form by the chairman of the board of coordinators of the *Master Program Polymer Science* at the end of the previous lecture period.

Module P 101: Polymer Synthesis

(Fak225719)

Learning objectives:

The major objective of the module is to provide fundamental knowledge about the different polymerization methods and the theoretical background and polymer terminology. In addition, the students learn about the synthesis and structure-property relation of selected engineering plastics. In the laboratory course, the students learn how to carry out polymerization reactions practically based on selected experiments.

Course units and temporal allocation:

Module P 101 'Polymer Synthesis' is comprised of the following units:

	HPW	Semester
Lectures	2	WS
Laboratory Course	6	WS

This module will be offered by lecturers of macromolecular chemistry.

Course content:

The **lectures** provide a broad knowledge of the basic polymerization techniques, including radical polymerization, cationic and anionic polymerization, polycondensation, and poly-addition. Special emphasis is placed on modern synthetic procedures. In addition, selected polymers for special applications, such as polyurethanes, polycarbonates, and fluoropolymers, will be presented.

The **laboratory course** intensifies the knowledge of the different polymerization techniques in selected experiments from the fields of copolymerization, controlled radical polymerization, anionic polymerization, and polycondensation. The polymers prepared will be characterized by methods such as GPC, MALDI-TOF, and viscosimetry.

Entrance requirements:

None.

Assessment:

A written (or oral) examination on the contents of the lectures and laboratory course after the first semester. This amounts to 60 % of the final grade. A second grade is given for the laboratory course and amounts to 40 % of the final grade. The kind of examination (written or oral) and the date are given at the beginning of the semester.

Work load:

In addition to the 2 HPW for the lectures, 1 hour is planned for individual studies. Accordingly, 3 additional hours are necessary for the preparation of the experiments and the protocol of the 6 HPW laboratory course. Given 15 weeks per semester, this adds up to 180 hours. Together with 30 hours for the preparation of the final examination, a total work load of 210 hours for the whole semester is calculated.

ECTS Credit points: 7

Module P 102: Physical Chemistry of Polymers

(Fak225770)

Learning objectives:

The course will provide knowledge about the structure of macromolecules, the thermodynamics of polymer solutions, the molecular characterization of polymers, and basics of the properties of polymers in the condensed state (melt and solid state) and of their mechanical properties.

Course units and temporal allocation:

Module P 102 'Physical Chemistry of Polymers' is comprised of the following course units:

	HPW	Semester
Lectures	2	WS
Laboratory Course	6	WS

This module will be offered by lecturers of physical chemistry and macromolecular chemistry.

Course content:

The **lectures** will cover the spatial structure of single macromolecules (radius of gyration and segment density distribution of a Gaussian coil), thermodynamics of polymer solutions (Flory-Huggins theory, osmotic pressure, phase diagrams), polymer analytics (osmosis, viscosimetry, scattering methods, chromatography, mass spectrometry), macromolecules in the melt and the solid state (glass transition, crystallization), and basics of mechanical properties (viscoelastic properties, rubbers, rheology).

The **laboratory course** will provide selected experiments on polymer analytics, such as chromatography, mass spectrometry, scattering methods, rheology, and optical and electron microscopy.

Entrance requirements:

None.

Assessment:

A written (or oral) examination on the contents of the lectures and the laboratory course after the first semester amounts to 60 % of the final grade. A second grade is given for the laboratory course and amounts to 40 % of the final grade. The kind of examination (written or oral) and the date are given at the beginning of the semester.

Work load:

In addition to the 2 HPW for the lectures, 1 hour is planned for individual studies. Additionally, 3 hours are necessary for the preparation of the experiments and the protocol of the 6 HPW laboratory course. Given 15 weeks per semester, this adds up to 180 hours. Combined with 30 hours for the preparation of the final examination, a work load of 210 hours for the whole semester is calculated.

ECTS Credit points: 7

Module P 103: Colloids and Interfaces

(Fak225711)

Learning objectives:

The course will provide knowledge about advanced physical chemistry of colloids and interfaces. The surface force dominating colloidal systems will be presented as well wetting phenomena and low-Reynold number hydrodynamics. The analytical technique to characterize colloidal and interfacial properties will be introduced and practically applied by the students.

Course units and temporal allocation:

Module P 104, 'Colloids and Interfaces' is comprised of the following course units:

	HPW	Semester
Lecture	2	WS
Laboratory Course	6	WS

This module will be offered by lecturers of Physical Chemistry II

Course content:

The ***lecture*** will cover: The solid/liquid, liquid/liquid and liquid/gas interface as starting point. The diffuse layer at interfaces will treated in detail, including differential double layer capacitance and Grahame equation. Surface forces, with a special emphasis on van der Waals forces, diffuse layer overlap, depletion forces and steric forces are fundamental for understanding and tuning colloidal interactions and are therefore central to lecture. These topics will be followed by adsorption phenomena at interfaces, including the adsorption of lipids and polymers. Ternary systems and Pickering emulsions represent an important addition for liquid/liquid interfaces and the formulation of colloidal interactions. Wetting phenomena with an emphasis solid/liquid interfaces and real-world systems represent a further topic of the lecture with important practical applications. The DLVO theory and its consequences for colloidal stability will be treated in detail. The final topic will be low-Reynold number hydrodynamics and microfluidics. Throughout the lecture, the analytical methods of colloid and interface science will be introduced, such a electrokinetic methods, scattering techniques, scanning probe techniques or electrochemical and titration techniques.

In the ***laboratory course*** the students will be introduced to the characterization of the interfacial and colloidal systems and familiarize with the concepts introduced in the lecture. The laboratory course will be based on methods, such as impedance spectroscopy, quartz micro balance, microfluidics, optical and scanning probe microscopy.

Entrance requirements:

None.

Assessment:

A written (or oral) examination on the contents of the lecture and the laboratory course after the first semester. This amounts to 4 CP. A second grade is given for the laboratory course and amounts to 3/5 CP. The kind of examination (written or oral) and the date are given at the beginning of the semester.

Workload:

In addition to the 2 HPW for the lecture 2 hours are planned for individual studies. Given 15 weeks per semester this leads to 60 hours workload. For the lab course 120 hours has to be considered. Together with 30 hours for the preparation of the final examination a total workload of 210 hours for the whole semester results.

ECTS Credit points: 7

Module P 104: Polymer Materials and Technology

(Fak225772)

Learning objectives:

This module will provide systematic knowledge about conventional and advanced processing technologies of polymer materials. The objective is to understand the entire process chain starting from the selection of the polymer material, through the processing involved, to the final component in view of the properties desired.

Course units and temporal allocation:

Module P 104 'Polymer Materials and Technology' is comprised of the following units:

	HPW	Semester
Lectures	2	WS
Laboratory Course	6	WS

This module will be offered by lecturers of polymer engineering and macromolecular chemistry

Course content:

The **lectures** provide detailed knowledge of the basic polymer processing techniques, such as injection molding, extrusion, secondary shaping techniques, and general applications. In addition, basic thermal and mechanical characterization methods are reviewed. A special emphasis will be placed on the relationship between processing parameters and the resulting product properties.

In the **laboratory course**, the knowledge about the different processing and characterization techniques is enhanced by experiments using state-of-the-art machines and equipment. Thus, processes such as injection molding and film extrusion are performed and thermal, optical, and mechanical properties will be evaluated regarding the components produced.

Entrance requirements:

None.

Assessment:

A written (or oral) examination on the contents of the lectures and the laboratory course after the first semester. This amounts to 60 % of the final grade. A second grade is given for the laboratory course and amounts to 40 %. The kind of examination (written or oral) and the date are given at the beginning of the semester.

Work load:

In addition to the 2 HPW for the lectures, 1 hour is planned for individual studies. Three additional hours are necessary for the preparation of the experiments and the protocol of the 6 HPW laboratory course. Given 15 weeks per semester, this adds up to 180 hours. Together with 30 hours for the preparation of the final examination, a work load of 210 hours for the whole semester is calculated.

ECTS Credit points: 7

Module P 105: Polymer Physics I

(Fak225773)

Learning objectives:

This module will provide the understanding of fundamental concepts of polymer and soft matter physics. A central goal is the understanding of polymer effects in the light of concepts known from molecular and solid state physics and the interpretation of important experimental results within the framework of reasonably simple physical models.

Course units and temporal allocation:

Module P 105 'Polymer Physics I' is comprised of the following units:

	HPW	Semester
Lectures	3	WS
Exercises	1	WS

This module will be offered by lecturers of theoretical physics and experimental physics.

Course content:

The **lectures** will cover single chain properties, chain models, distribution functions and averages, collective properties, rubber elasticity, rheology, polymer solutions, polymer blends, phase diagrams, block copolymers, structure factor, scattering, experimental techniques, polymer characterization, theoretical models, glass transition, and gelation.

Entrance requirements:

None.

Assessment:

Written (or oral) examination on the contents of the lectures and exercises. The kind of examination (written or oral) and the date are given at the beginning of the semester.

Work load:

Attendance time: 60 hours; pre- and post-preparation: 60 hours; additional time of preparation for examination: 60 hours. Total work load: 180 hours.

ECTS Credit points: 7

Module P 106: Organometallic Chemistry and Polymerization Catalysts

(Fak225774)

Learning objectives:

The students will gain insight into polymerization catalysis and improve their knowledge of organometallic chemistry.

Course units and temporal allocation:

Module P 106 ‘Organometallic Chemistry and Polymerization Catalysts’ is comprised of the following course units:

	HPW	Semester
Lectures	2	WS
Laboratory Course	6	WS

This module will be offered by lecturers of organic and inorganic chemistry.

Course content:

The following topics are discussed during the **lectures**: reactivity of the metal carbon bond, catalytic applications of organometallic compounds, and coordinative polymerizations.

In the **laboratory course**, the students improve skills to work with highly air- and moisture-sensitive compounds and use them in teamwork with PhD students and postdocs to address relevant questions regarding catalysis.

Entrance requirements:

None.

Assessment:

A written examination (an oral examination if fewer than seven students enroll for this course) covering the content of the lectures amounts to 60 % and the quality of the laboratory course to 40 %. The laboratory course assessment results from the quality of the catalyst syntheses and the catalytic experiments. The kind of examination (written or oral) and the date are given at the beginning of the semester.

Work load:

The lectures result in 60 hours work load including lecture preparation and the laboratory course work load is 120 hours. Thirty hours are needed to prepare for the examination.
The overall work load is 210 hours.

ECTS Credit Points: 7

Module P 107: Catalysis and Sustainable Synthesis

(Fak225752)

Learning objectives:

Will provide a deeper understanding of different catalysis aspects for the synthesis of pharmaceuticals, fine chemicals, monomers, and fuels.

Course units and temporal allocation:

Module P 107 'Catalysis and Sustainable Synthesis' is comprised of the following course units:

	HPW	Semester
Lecture	2	WS
Lab course	6	WS

This module will be offered by lecturers of organic chemistry.

Course content:

- **Lecture:** The general catalytic strategies will be discussed by keeping more focus onto photocatalysis, electrocatalysis and thermocatalysis. Basics of all these catalysis aspects will be exemplified along with their application for the synthesis of drug molecules. Additionally, the activation of small molecules such as CO_2, O_2 will be discussed and their applications into organic synthesis will also studied. Furthermore, catalysis for the synthesis of monomers of polymers will be depicted in this course.
- **Lab course:** Individual aspects of catalysis and sustainable synthesis are taught by working on a current research project in one of the participating research groups. The results are summarized in a report and presented in a seminar lecture.

Entrance requirements:

None.

Assessment:

- Graded oral or written examination on the lecture 60%
- Graded lab course with report and seminar presentation 40%

The module grade will only be given after successful completion of both parts.

Work load:

The lecture results in 60 hours work load including lecture preparation, and the laboratory course work load is 120 hours (module with 7 credits). 30 hours are needed to prepare for the examination.
The overall work load is: 210 hours (module 7 credits).

ECTS Credit Points: 7

Module P 108: Biomaterials

(Fak225720)

Learning objectives:

This module focuses on bio-inspired materials and processes. The students will learn about the structure, synthesis, and modification of biopolymers, including biomineralization. Furthermore, the students will gain a comprehensive insight into current research topics and industrial applications. The characterization and analysis of mechanical and structural properties of biomacromolecules also plays an important role in this module.

Course units and temporal allocation:

Module P 108 'Biomaterials' is comprised of the following course units:

	HPW	Semester
Lectures*	2	WS
Laboratory Course	6	WS

This module will be offered by the chair of biomaterials/FAN.

**In winter term the lecture will be given in German. There is the possibility to attend the lecture in Englisch in summer term (Fak615056, lecture "Biomaterials").*

Course content:

A major objective of the **lectures** is the applications of nucleic acids, lipids, and proteins in nanotechnology, pharmacology, and industry. Furthermore, the course deals with the science behind the assembly of macromolecules, their man-made imitations and the biomineralization process. Important characterization methods, such as field-flow fractionation, CD-, UV-, IR- and fluorescence spectroscopy, AFM, EM, HPLC, and mechanical testing are presented. Additionally, molecular and microbiological methods and techniques are introduced.
The **laboratory course** puts the students in a position to apply these methods, for instance, to spider silk, mussel collagens, and yeast proteins.

Entrance requirements:

None.

Assessment:

The module will be evaluated by an oral or written examination (60 %) and the evaluation of the laboratory course consisting of the practical performance and a report (40 %).

Work load:

In addition to the 2 HPW of lecture, 2 more hours are necessary for the preparation and review of the lecture. This will add up to 60 hours for the entire semester. The laboratory course accounts for 120 hours. Furthermore, preparations for the examination are estimated at an additional 30 hours. This results in a total of 210 hours in the semester.

ECTS Credit points: 7

Module P 201: Polymer Architectures and Functionality

(Fak225723)

Learning objectives:

This module will enable the students to design polymers with well-defined structures based on living/controlled polymerization techniques, which are the prerequisite for cutting edge modern research. The students will learn the solution and bulk properties of polymers with selected architectures. Furthermore, students will learn modern techniques for the formulation with the aid of polymers, speciality processing techniques and the creation of advanced functionalities of polymers.

Course units and temporal allocation:

Module P 201 'Polymer Architectures and Functionality' is comprised of the following course units:

	HPW	Semester
Lectures	2	SS
Laboratory Course	8	SS

This module will be offered by lecturers of macromolecular chemistry.

Course content:

The **lectures cover** both macromolecular and polymer architectures. In the first part, the mechanisms of living/controlled polymerizations will be discussed in great detail with respect to the macromolecular engineering for the preparation of architectures, like linear, block, graft, star and dendrimers. The second part will cover details of several polymer architectures (films, particles, fibers) and special polymers and properties.

The associated **laboratory course** will be performed in one of the macromolecular chemistry research groups in collaboration with PhD students and postdocs. It will cover the synthesis and characterization of given polymer structures.

Entrance requirements:

Participation in P101 (Polymer Synthesis) and P102 (Physical Chemistry of Polymers) is recommended.

Assessment:

An oral (or written) examination on the contents of the lectures after the second semester. This examination will amount to 50 % of the grade. The laboratory course will be evaluated by the average of three independent grades: practical performance, a written report, and a seminar, and amount to 50 % of the grade.

Work load:

In addition to the 2 HPW for the lecture, 2 hours are planned for individual studies. Accordingly, 4 additional hours are necessary for the preparation of the experiments and the protocol of the 8 HPW laboratory course. Given 15 weeks per semester, this adds up to 240 hours. Together with 30 hours for the preparation of the final examination, a work load of 270 hours for the whole semester is calculated.

ECTS Credit Points: 9

Module P 202: High-performance and Specialty Polymers

(Fak225725)

Learning objectives:

Organics and polymers have successfully entered and opened up new application fields and replaced other materials during the last few decades. In this module, the students will learn about the design, synthesis, and structure-property relation of high-performance and specialty polymers. Since a number of research groups at the University of Bayreuth are active in this research area, the students will be introduced to cutting-edge science in this field.

Course units and temporal allocation:

Module P 202 'High-performance and Specialty Polymers' is comprised of the following course units:

	HPW	Semester
Lectures	2	SS
Laboratory Course	8	SS

This module will be offered by lecturers of macromolecular chemistry.

Course content:

In the **lectures**, the design, synthesis, and structure-property relation of organic functional materials and specialty polymers will be discussed with respect to advanced applications, such as energy storage, optics, information storage, photovoltaics, organic electronics, photo-lithography, and display technology. Special focus will be laid on the design, synthesis, and properties of conjugated polymers, transition metal- and main group-containing (supra-molecular) polymers.

The associated **laboratory course** will be done in one of the macromolecular chemistry research groups working on high-performance organic materials and specialty polymers. The students will be introduced to the synthesis of new materials as well as their detailed physical characterization and application in devices.

Entrance requirements:

None.

Assessment:

An oral (or written) examination on the contents of the lectures after the second semester. This examination will amount to 50 % of the grade. The laboratory course will be evaluated by the average of three independent grades: practical performance, a written report, and a seminar, and amounts to 50 % of the grade.

Work load:

In addition to the 2 HPW for the lecture, 2 hours are planned for individual studies. Accordingly, 4 additional HPW are necessary for the preparation of the experiments and the protocol of the 8 HPW laboratory course. Given 15 weeks per semester, this adds up to 240 hours. Together with 30 hours for the preparation of the final examination, a work load of 270 hours for the whole semester is calculated.

ECTS Credit Points: 9

Module P 203: Advanced Methods in the Physical Chemistry of Polymers

(Fak225714)

Learning objectives:

The students will be introduced to theoretical and practical knowledge of advanced microscopic tools.

Course units and temporal allocation:

Module P 203 'Advanced Methods in the Physical Chemistry of Polymers' is comprised of the following course units:

	HPW	Semester
Lectures	2	SS
Laboratory Course	8	SS

This module will be offered by lecturers of physical chemistry.

Course content:

The **lectures** will present new complex experimental techniques which can be used in the study of soft matter, such as cryo-transmission electron microscopy, scanning electron microscopy, AFM force spectroscopy, surface force apparatus (SFA), total internal reflection microscopy (TIRM), fluorescence microscopy techniques (e.g. fluorescence correlation spectroscopy), scattering methods (e.g. neutron spin echo techniques (NSE) and grazing incidence small angle x-ray scattering (GISAXS)), and x-ray photon correlation spectroscopy (X-PCS).

The associated **laboratory course** will be done in the physical chemistry research groups and will introduce to the use of advanced scattering and microscopy equipment.

Entrance requirements:

Participation in P102 (Physical Chemistry of Polymers) is recommended.

Assessment:

An oral (or written) examination on the contents of the lectures after the second semester. This examination will amount to 50 % of the grade. The laboratory course will be evaluated by the average of three independent grades: practical performance, a written report, and a seminar, and amount to 50 % of the grade.

Work load:

In addition to the 2 HPW for the lecture, 2 hours are planned for individual studies. Accordingly, 4 additional hours are necessary for the preparation of the experiments and the protocol of the 8 HPW laboratory course. Given 15 weeks per semester this adds up to 240 hours. Together with 30 hours for the preparation of the final examination, a work load of 270 hours for the whole semester is calculated.

***ECTS Credit Points**:* 9

Module P 204: Current Topics in Colloid, Polymer, and Interface Science

(Fak225776)

Learning objectives:

The aim of the course is to present current research areas in the field of the physical chemistry of polymers, colloids, and interfaces.

Course units and temporal allocation:

Module P 204 'Current Topics in Colloid, Polymer, and Interface Science' is comprised of the following course units:

	HPW	Semester
Lectures	2	SS
Laboratory Course	8	SS

This module will be offered by lecturers of physical chemistry.

Course content:

Topics currently treated in the physical chemistry research groups will be presented in four different blocks. The blocks will contain the respective fundamentals and recent results on the subject discussed.

The respective laboratory course can be chosen from the four subjects presented and will be carried out in the PC research groups.

Entrance requirements:

Participation in P103 (Colloids and Surfaces) is recommended.

Assessment:

An oral (or written) examination on the contents of the lectures after the second semester. This examination will amount to 50 % of the grade. The laboratory course will be evaluated by the average of three independent grades: practical performance, a written report, and a seminar, and amount to 50 % of the grade.

Work load:

In addition to the 2 HPW for the lecture, 2 hours are planned for individual studies. Accordingly, 4 additional hours are necessary for the preparation of the experiments and the protocol of the 8 HPW laboratory course. Given 15 weeks per semester, this adds up to 240 hours. Together with 30 hours for the preparation of the final examination, a work load of 270 hours for the whole semester is calculated.

ECTS Credit Points: 9

Module P 205: Polymer Engineering

(Fak225777)

Learning objectives:

The objective of this module is to provide detailed knowledge about the processing and properties of reinforced polymer materials. The lecture will cover various concepts to reinforce polymeric matrices. The students will also obtain an overview about relevant technical applications of these advanced engineering polymers. In addition, the laboratory course will extend their knowledge of polymer engineering.

Course units and temporal allocation:

Module P 205 'Polymer Engineering' is comprised of the following units:

	HPW	Semester
Lectures	2	SS
Laboratory Course	8	SS

This module will be offered by lecturers of polymer engineering.

Course content:

The **lectures** will provide detailed knowledge of the processing and characterization of reinforced polymers with industrial importance. Various reinforcement mechanisms, their fabrication and properties will be taught. Modern material characterization techniques are also discussed with an emphasis on fracture mechanics and the long-term dynamic response of composites.

The associated **laboratory course** will be performed in the polymer engineering research group or in collaboration with other polymer engineering-related groups.

Entrance requirements:

Participation in P104 is recommended.

Assessment:

An oral (or written) examination on the contents of the lectures after the second semester. This examination will amount to 50 % of the grade. The laboratory course will be evaluated by the average of three independent grades: practical performance, a written report, and a seminar, amounting to 50 % of the grade.

Work load:

In addition to the 2 HPW for the lecture, 2 hours are planned for individual studies. Four additional hours are necessary for the preparation of the experiments and the protocol of the 8 HPW laboratory course. Given 15 weeks per semester, this adds up to 240 hours. Together with 30 hours for the preparation of the final examination and talk, a work load of 270 hours for the whole semester is calculated.

ECTS Credit points: 9

Module P 206: Polymer Physics II

(Fak225778)

Learning objectives:

In recent years, organic semiconductors have shown great potential in electronic applications like thin-film transistors, light-emitting diodes, and photovoltaic devices, but also in biosensors due to biocompatibility of many of these compounds. In this module, the students will learn how the fundamental electronic structure of neutral and excited organic semiconductors is related to their optical and macroscopic electronic properties that form the basis for advanced applications in optoelectronic devices and transistors. This knowledge is complemented by the discussion of experimental techniques to study these properties.

Course units and temporal allocation:

Module P 206 ‘Polymer Physics II’ is comprised of the following units:

	HPW	Semester
Lecture I	4	SS
Lecture II or lab course	2	SS

This module will be offered by lecturers of experimental physics.

Course contents:

1. **Organic semiconductors (Lecture I)** with 6 ECTS credit points:

This lecture will cover the fundamentals on electronic structure in neutral and excited organic semiconducting materials, as well as the mechanisms of generation, transport and decay of these excitations with special focus on the intrinsic microscopic structure of these materials (structure-property relation). This knowledge will finally form the basis to understand the operational principles of organic optoelectronic devices and transistors.

2. One course with 3 ECTS credit points from the following list:

- **Foundations of optical spectroscopy (Lecture II)**

  This lecture covers the basic principles of optical spectroscopy and microscopy, selected special spectroscopic techniques, as well as the fundamentals of energy transfer between molecules (FRET).

- **Practical laboratory course**

  Three experiments from the advanced laboratory course of the master program in physics (e.g. OLED, TAS, Thin film processing, biomolecular bonding,…)

Entrance requirements:

None

Assessment:

An oral examination on the contents of each lecture or of lecture I and of the practical laboratory course. Lecture I amounts to 2/3 and lecture II or the practical laboratory course amount to 1/3 of the grade.

Work load:

Attending time: 90 hours; pre- and post-preparation: 90 hours; additional time of preparation for examination: 90 hours. Total work load: 270 hours.

ECTS Credit points: 9

Module P 207: Catalyst Design

(Fak225680)

Learning objectives:

The students gain insight into the field of catalyst design.

Course units and temporal allocation:

Module P 207 'Catalyst Design' is comprised of the following course units:

	HPW	Semester
Lectures	2	SS
Laboratory Course	8	SS

This module will be offered by lecturers of organic and inorganic chemistry.

Course content:

The following topics are discussed during the **lectures**: basics and concepts of catalyst design: explorative coordination chemistry, mechanistic studies, and combinatorial catalysis research.

In the **laboratory course**, the students develop skills to run catalytic experiments and use them in teamwork with PhD students and postdocs to address open, catalysis-relevant, questions.

Entrance requirements:

None.

Assessment:

A written examination (an oral examination if fewer than seven students enroll in this course) covering the content of the lectures amounts to 50 %, and the quality of the lab course to 50%. The laboratory course assessment is based on the quality of the catalyst syntheses and the catalytic experiments.

Work load:

The lectures result in 60 hours of work, including lecture preparation, and the laboratory course work load is 180 hours. Thirty hours are needed to prepare for the examination.
Total work load: 270 hours.

ECTS Credit Points: 9

Module P 208: Sustainable Polymer Chemistry and Polymer Materials

(Fak225779)

Learning objectives:

Polymers contribute significantly to the three pillars of sustainability, which are environment, economy, and society. The students will be exposed to these three pillars of sustainability with the focus on the detailed knowledge about sustainability and sustainable processes in polymer chemistry, polymer applications, and their disposal.
The lecture and the laboratory course will provide the students skills in sustainability in general, biobased polymers biodegradable polymers, light-weight polymer materials, green polymerizations, chemical recycling and microplastics.

Course units and temporal allocation:

Module P 208 ‚sustainable polymer chemistry and polymer materials are comprised of the following units:

	HPW	Semester
Lecture	2	SS
Laboratory Course	8	SS

This module will be offered by lecturers of macromolecular chemistry.

Course content:

The ***lecture*** will cover the basics of sustainability pillars, sustainable polymers from natural resources, biodegradable polymers, lightweight porous and bionic (biomimetic) polymer materials, biocatalysts, green processes for the preparation of monomers, and polymers, recycling of polymers.

The associated ***laboratory course*** will be performed in the macromolecular chemistry research groups or in collaboration with other polymer sustainability-related research groups.

Entrance requirements:

Participation in P101 (Polymer Synthesis) and P102 (Physical Chemistry of Polymers) is recommended.

Assessment:

An oral (or written) examination of the contents of the lecture. This examination will amount to 50 % of the grade. The laboratory course will be evaluated by the average of two independent grades: Practical performance and the written report, and a seminar amounting to 50 % of the grade.

Workload:

In addition to the 2 HPW for the lecture, 2 hours are planned for individual studies. Four additional hours are necessary for the preparation of the experiments and the protocol of the 8 HPW laboratory course. Given 15 weeks per semester, this adds up to 240 hours. Together with 30 hours for the preparation of the final examination and talk, a workload of 270 hours for the whole semester is calculated.

ECTS Credit points: 9

Module 210: Research Proposal

(Fak225726)

Learning objectives:

This module is aimed at acquiring basic knowledge of planning and drafting a scientific project proposal in a specific research area based on the existing knowledge. The students learn to prepare a sound proposal, both written and oral, which helps them in planning their master thesis.

Course units and temporal allocation:

Module P 210 'Research Proposal' is comprised of the following course units:

	HPW	Semester
Writing a research proposal	5	WS/SS
Seminar on research topic	1	WS/SS

This module will be offered by all lecturers of the Master Program Polymer Science.

Course content:

Before starting the master thesis, the students work on a research proposal by selecting a research topic, formulating the state of the art in the literature, identifying the main objectives of the research plan, and explaining the work plan and targets based on the experiments proposed. Additionally, the written research plan will be presented in a seminar in order to improve the capabilities of presentation techniques and scientific discussion. In this way, the students gain the experience of working more independently on research topics and formulating well-focused research proposals.

Entrance requirements:

None.

Assessment:

Written research plan (two-thirds of the total grade) and oral presentation and discussion (one-third of the total grade).

Work load:

A total of 120 hours are envisaged for the written research plan, which covers work on literature research, whereas the seminar on the research proposal including the preparation of the seminar and oral presentation results in 30 hours; the total work load being 150 hours.

ECTS Credit Points: 5

Module P 301 and 302: Advanced Laboratory Module I and II

(Fak225727, Fak225728)

Learning objectives:

The objective of this module is to further enhance the laboratory and science skills of the students in selected advanced fields of *Polymer Science*. The students will be introduced to current research topics investigated in one of the *Polymer Science* research groups at the University of Bayreuth. In addition, the students will improve their ability to work in a team and their skills of presenting their research.

Course units and temporal allocation:

Module P 301 and 302 'Advanced Laboratory Module I and II' are comprised of:

	HPW	Semester
Polymer Science research project	19	WS/SS
Group seminar presentation	1	WS/SS

These modules will be offered by all professors of the Master Program Polymer Science.

Course content:

The course covers a selected topic of current research within one of the research groups involved in the *Master Program Polymer Science*. The module includes experiments in the lab, literature search, participation in group seminars, and the presentation of the research results in the form of a report and a seminar with discussion.

Entrance requirements:

The successful completion of a basic module related to the topic of the Advanced Laboratory Module is highly recommended.

Assessment:

The laboratory experiments will be evaluated by the average of three independent grades: practical performance, a written report, and a seminar.
If a grade is given for a laboratory course at a foreign university, the grade is based on the statement of the supervisor of the host university. An industrial internship does not involve a grade. A statement of successful participation will be needed.

Work load:

A total of 350 hours are projected for the laboratory experiments, and 100 hours for the literature search, the report, and the seminar. This adds up to a total of 450 hours.

ECTS Credit points: 15

Module 400: Master Thesis

(Fak225781)

Learning objectives:

The students work independently on a cutting edge of research project of modern polymer science under the guidance of a lecturer of the master program polymer science and write the results and discussion in the form of a thesis.

Course units and temporal allocation:

Module P 400 ‘Master Thesis’ comprises the following:

	Hours	Semester
Research project and written thesis	900	WS/SS

This module will be offered by all lecturers of the Master Program Polymer Science.

Course content:

The topic of the master thesis is based on a current research activity of the research group selected.

Entrance requirements:

A successful completion of 45 ECTS and the Module P 210 ‘Research Proposal’ (5 ECTS) is required.

Assessment:

The master thesis written and submitted at the end of the research work will be evaluated by two reviewers independently.

Work load:

The master thesis covers literature research, experimental work and the formulation of all results and discussion, amounting to a total work load of 900 hours.

ECTS Credit Points: 30