**Modules for Werkstofftechnik**

Date 17/04/25

# Pflichtmodule

## INW.05559.04 - Polymer Engineering

| INW.05559.04 | 10 CP |
|---|---|
| **Module label** | Polymer Engineering |
| **Module code** | INW.05559.04 |
| **Semester of first implementation** | |
| **Module used in courses of study / semesters** | • Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Pflichtmodule |
| **Responsible person for this module** | |
| **Further responsible persons** | Prof. Dr. Beate Langer |
| **Prerequisites** | |
| **Skills to be acquired in this module** | • The students acquire perspectives for the work as a polymer scientist or polymer engineer.<br>• They receive the basic knowledge on processing of polymer materials and polymer testing.<br>• They will be enabled in practical skills of processing of polymer materials.<br>• They also learn about practical skills in mechanical and physical testing of polymer materials. |
| **Module contents** | This module covers basic topics of polymer engineering. The lecture Polymer Processing gives an overview on the general aspects of polymer processing, i.e. handling of polymers from engineering point of view, the lecture Polymer Testing deepens the view on the characterization methods on macroscopic level. The lab courses Polymer processing and testing accompany the lectures and show the details of performing such experiments.<br>Lectures:<br>1. Lecture Polymer Processing<br>Basics of melt flow, extrusion, injection molding, spinning, foaming, elastomer processing, processing tires, blown film extrusion, recycling of polymer materials<br>2. Lecture Polymer Testing<br>Elastic, visco-elastic and plastic deformation behavior of polymer materials and phenomenological models, quasi-static test methods of polymer materials (tensile, compression, bending), hardness measurement and test methods, charpy impact test, instrumented impact tests as methods for toughness characterizations of polymer materials, fracture mechanics concepts for polymer materials<br>Lab Courses:<br>1. Polymer Processing Lab<br>Extrusion, injection molding, elastomer processing, blown film extrusion<br>2. Polymer Testing Lab<br>Characterization of elastic properties, tensile test, dynamic-mechanical analysis, bend test, ball indentation test, Charpy impact test, drop weight test, tensile impact test |
| **Forms of instruction** | Lecture (2 SWS)<br>Seminar (1 SWS)<br>Practical training (1 SWS)<br>Lecture (2 SWS)<br>Practical training (2 SWS)<br>Course |
| **Languages of instruction** | German, English |
| **Duration (semesters)** | 2 Semester Semester |
| **Module frequency** | jedes Wintersemester |
| **Module capacity** | unlimited |
| **Time of examination** | |
| **Credit points** | 10 CP |

INW.05559.04 10 CP

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|---|---|
| **Share on module final degree** | Course 1: %; Course 2: %; Course 3: %; Course 4: %; Course 5: %; Course 6: %. |
| **Share of module grade on the course of study's final grade** | 1 |

| Examination | Exam prerequisites | Type of examination |
|---|---|---|
| **Course 1** | | |
| **Course 2** | | |
| **Course 3** | | |
| **Course 4** | | |
| **Course 5** | | |
| **Course 6** | | |
| **Final exam of module** | written examination and seminar problem set solutions Polymer Processing, written examination Polymer Testing, completed lab course protocols Polymer Processing, completed lab course protocols Polymer Testing | oral or written examination |
| **Exam repetition information** | | |

| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
|---|---|---|---|---|---|---|---|---|
| **Course 1** | Lecture | Lecture Polymer Processing | 2 | | | | | 0 |
| **Course 2** | Seminar | Seminar Polymer Processing | 1 | | | | | 0 |
| **Course 3** | Practical training | Lab Course Polymer Processing | 1 | | | | | 0 |
| **Course 4** | Lecture | Lecture Polymer Testing | 2 | | | | | 0 |
| **Course 5** | Practical training | Lab Course Polymer Testing | 2 | | | | | 0 |
| **Course 6** | Course | Private study | | | | | | 0 |
| **Workload by module** | | | | | | 300 | | 300 |
| **Total module workload** | | | | | | | | 300 |

## PHY.05548.04 - Basics of Materials and Polymer Physics

| PHY.05548.04 | 10 CP |
|---|---|
| **Module label** | Basics of Materials and Polymer Physics |
| **Module code** | PHY.05548.04 |
| **Semester of first implementation** | |
| **Module used in courses of study / semesters** | • Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Pflichtmodule |
| **Responsible person for this module** | |
| **Further responsible persons** | Dr. Karsten Busse |
| **Prerequisites** | |
| **Skills to be acquired in this module** | • The students learn about the central physical concepts in materials science.<br>• The students learn and train the necessary mathematical skills.<br>• They will be enabled in planning, performing and evaluating scientific experiments using modern instrumentation. This includes error estimation and analysis, recording, evaluating and presenting measurement data and writing a report. |
| **Module contents** | This module covers basic theoretical details of polymer physics and physical chemistry. The lectures Introduction to Materials Physics (1) and Mathematical and Theoretical Concepts for Polymer Science (2) act as refresher or introductional courses for the main mathematical tools and solid state properties. The Lab course Basic Physics and Physical Chemistry Lab give the students the opportunity to get an idea for the handling of characterization experiments.<br>Lectures:<br>1. Introduction to Materials Physics<br>• Atoms and bonds, crystal structures<br>• Structure analysis: microscopy techniques<br>• Basics of scattering (Bragg and crystal structures, wave equation, interference, structure factor)<br>• Phase transitions and phase diagrams<br>• Mechanical properties of solids<br>• Thermal, optical, magnetic, electric and dielectric properties<br>2. Mathematical and Theoretical Concepts for Polymer Science<br>• Mathematical tools (linear algebra, trigonometry, complex numbers, Fourier transformation, delta function)<br>• Calculus: integration, differentiation, solving differential simple equations, applications to reaction kinetics and simple mechanical polymer models<br>• Statistics: distribution functions (mol. weight distributions, averages and moments), data treatment, error handling, linear regression<br>• Diffusion, Brownian motion and random walks; single-chain structure (Gaussian coil, radius of gyration)<br>• Basics of computer simulation techniques (interaction potentials, MD vs. MC)<br>• Introduction to quantum mechanics: Schroedinger equation, wave functions, particle in a box, harmonic oscillator, hydrogen atom, bonding<br>Lab course - Basic Physics and Physical Chemistry Lab:<br>9 experiments are performed. Each experiment consists of 4 hours lab time and private study of basics, writing the protocol and evaluating the experiment. The lab includes a tutorial experiment (radioactivity) that includes an introduction into the Origin software. The list of experiments is subject to changes. Current experiments are:<br>• Viscosity (falling ball viscometer)<br>• Humidity (dew point hygrometer)<br>• RLC oscillator (oscilloscope handling) |

- Diffraction spectrometer (optical spectroscopy)
- Polarimeter and refractometer
- X-ray methods (spectrum of Mo tube, dosimetry)
- Vapor pressure and heat of vaporization (Clausius-Clapeyron)
- Freezing point depression
- Surface tension of liquids
- Solubility diagram of liquids (miscibility gap)

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| **Forms of instruction** | Lecture (1 SWS)<br>Lecture (2 SWS)<br>Practical training (3 SWS)<br>Seminar (1 SWS)<br>Seminar (2 SWS)<br>Course |
| **Languages of instruction** | German, English |
| **Duration (semesters)** | 1 Semester Semester |
| **Module frequency** | jedes Wintersemester |
| **Module capacity** | unlimited |
| **Time of examination** | |
| **Credit points** | 10 CP |
| **Share on module final degree** | Course 1: %; Course 2: %; Course 3: %; Course 4: %; Course 5: %; Course 6: %. |
| **Share of module grade on the course of study's final grade** | 1 |

| Examination | Exam prerequisites | Type of examination |
|---|---|---|
| **Course 1** | | |
| **Course 2** | | |
| **Course 3** | | |
| **Course 4** | | |
| **Course 5** | | |
| **Course 6** | | |
| **Final exam of module** | completed lab course protocols, Seminar problem set solutions | oral or written examination (Materials Physics, mathematical and theoretical concepts) |
| **Exam repetition information** | | |

| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
|---|---|---|---|---|---|---|---|---|
| **Course 1** | Lecture | Lecture Introduction to Materials Physics | 1 | | | | | 0 |
| **Course 2** | Lecture | Lecture Mathematical and Theoretical Concepts for Polymer Science | 2 | | | | | 0 |
| **Course 3** | Practical training | Lab course Basic Physics and Physical Chemistry Lab | 3 | | | | | 0 |
| **Course 4** | Seminar | Seminar Introduction to Materials Physics | 1 | | | | | 0 |
| **Course 5** | Seminar | Seminar Mathematical and Theoretical Concepts for Polymer Science | 2 | | | | | 0 |
| **Course 6** | Course | Private Study | | | | | | 0 |

| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
|---|---|---|---|---|---|---|---|---|
| **Workload by module** | | | | | | 300 | | 300 |
| **Total module workload** | | | | | | | | 300 |

## CHE.05560.04 - Polymer Engineering Science

| CHE.05560.04 | 8 CP |
|---|---|
| **Module label** | Polymer Engineering Science |
| **Module code** | CHE.05560.04 |
| **Semester of first implementation** | |
| **Module used in courses of study / semesters** | • Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Pflichtmodule |
| **Responsible person for this module** | |
| **Further responsible persons** | Prof. Dr. Michael Bartke |
| **Prerequisites** | |
| **Skills to be acquired in this module** | • The students acquire perspectives for the work as a polymer engineer.<br>• They study basics of technical/industrial polymerization processes and instrumentation<br>• They receive the theoretical background on basic knowledge of polymerization kinetics, kinetic modeling approaches, design of polymerization reactors and industrial polymerization processes.<br>• They acquire a basic knowledge about physical properties of polymeric materials, including composites. |
| **Module contents** | This module covers advanced topics of polymer engineering. The lectures Polymer Reaction Engineering and Polymeric Materials combine the experience from lab scale to the requirements of industrial application.<br>Lectures:<br>1. Polymer Reaction Engineering<br>• Classification of polyreactions and polymerization processes<br>• Kinetics and kinetic modeling of polymerizations and molecular weight distributions (free-radical, emulsion, coordinative polymerization)<br>• Rheological properties of reaction mixtures<br>• Design and dimensioning of polymerization reactors, heat removal, mixing, non-idealities<br>• Industrial polymerization processes<br>• Seminar topics (Material balances of ideal chemical reactors; Calculation of polymerization kinetics on selected examples; Calculation of molecular weight distributions; Application examples on dimensioning of polymerization reactor; Heat removal calculations for polymerization reactors; examples on non-ideal reactors and selectivity effects)<br>2. Polymeric Materials<br>• Chemical and physical structure, Liquid/melt - solid transition: crystallization / glass transition<br>• Mechanical behaviour: elastic deformation / rubbery-elasticity / visco-elastic behavior of polymeric solids / plastic deformation, Basics of melt flow<br>• Thermal, optical, electrical, acoustic properties of polymers<br>• Polymeric materials: structure, properties, applications:<br>a) Thermoplastics (commodity polymers, polyesters/-amides, high-performance polymers)<br>b) Elastomers<br>c) Thermosets<br>d) Blends and composites<br>• Material balances of ideal chemical reactors<br>• Calculation of polymerization kinetics on selected examples<br>• Calculation of molecular weight distributions<br>Examples on non-ideal reactors and selectivity effects<br>Polymer Computer Modelling |

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| **Forms of instruction** | Lecture (2 SWS)<br>Seminar (2 SWS)<br>Lecture (2 SWS)<br>Seminar (1 SWS)<br>Course |
| **Languages of instruction** | German, English |
| **Duration (semesters)** | 1 Semester Semester |
| **Module frequency** | jedes Wintersemester |
| **Module capacity** | unlimited |
| **Time of examination** | |
| **Credit points** | 8 CP |
| **Share on module final degree** | Course 1: %; Course 2: %; Course 3: %; Course 4: %; Course 5: %. |
| **Share of module grade on the course of study's final grade** | 1 |

| Examination | Exam prerequisites | Type of examination |
|---|---|---|
| **Course 1** | | |
| **Course 2** | | |
| **Course 3** | | |
| **Course 4** | | |
| **Course 5** | | |
| **Final exam of module** | seminar (Polymer Reaction Engineering) problem set solutions, seminar (Polymeric Materials) problem set solutions | oral or written examination |
| **Exam repetition information** | | |

| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
|---|---|---|---|---|---|---|---|---|
| **Course 1** | Lecture | Lecture Polymer Reaction Engineering | 2 | | | | | 0 |
| **Course 2** | Seminar | Seminar Polymer Reaction Engineering | 2 | | | | | 0 |
| **Course 3** | Lecture | Lecture Polymeric Materials | 2 | | | | | 0 |
| **Course 4** | Seminar | Seminar Polymeric Materials | 1 | | | | | 0 |
| **Course 5** | Course | Private study | | | | | | 0 |
| **Workload by module** | | | | | | 240 | | 240 |
| **Total module workload** | | | | | | | | 240 |

## CHE.05562.06 - Polymer Chemistry

| CHE.05562.06 | 10 CP |
|---|---|
| **Module label** | Polymer Chemistry |
| **Module code** | CHE.05562.06 |
| **Semester of first implementation** | |
| **Module used in courses of study / semesters** | • Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Pflichtmodule |
| **Responsible person for this module** | |
| **Further responsible persons** | Prof. Dr. Wolfgang Binder |
| **Prerequisites** | |
| **Skills to be acquired in this module** | • The students can apply their knowledge of basic concepts of polymer synthesis, terminology, synthesis, and characterization of composition and molar mass and distributions.<br>• They deepen their knowledge of basic concepts of organic chemistry and polymer synthesis.<br>• They understand and can qualify the role of synthetic polymers, including the necessities and their recycling strategies in view of modern societal needs and demands.<br>• They learn to handle chemicals safely, basics of organic/polymer synthesis, preparation and purification techniques.<br>• They can apply analytical methods for structural and materials applications.<br>• They learn about writing of scientific reports. |
| **Module contents** | This module covers basic topics of polymer chemistry. The lecture Introduction to Macromolecules gives an overview on the general aspects of polymers and the lecture Organic Chemistry and Polymer Synthesis deepens the view on the basic synthesis and characterization methods. The lab course Basic Chemistry and Polymerization Lab allows the student to perform their first polymerization including all preparative steps like distillation of educts up to precipitation of products.<br>Lectures:<br>1. Introduction to Macromolecules<br>• General introduction and history of polymer science<br>• General principles of polymer synthesis (step growth, chain growth, thermodynamics, kinetics, copolymerization, technical polymerizations, living polymerization)<br>• Reactions with polymers: isomerization, grafting, crosslinking<br>• Basics of polymer characterization: end-group titration/NMR, osmometry, viscosity, chromatography, mass spectrometry, Flory-Huggins theory, polymer additives<br>• Microphase-separated polymers: block copolymers, thin films, amphiphilic polymers in solvents, micelles, polymer crystallization, amorphous state<br>• Polymer materials and their bioprofiles (recycling, degradation, biological asessments)<br>• Applications of polymers in medicine, microelectronics, in society.<br>2. Organic Chemistry and Polymer Synthesis<br>• Basic principles of organic chemistry<br>• Reaction mechanisms in organic chemistry<br>• Principles of homogeneous and heterogeneous catalysis<br>• Basics of solution-state NMR<br>• Free-radical and controlled free-radical polymerizations<br>• Living polymerizations, block copolymer synthesis<br>• Catalytic polymerizations (Ziegler/Natta, metallocene, ROMP)<br>• Polycondensation<br>• Network synthesis/thermosets<br>Lab course:<br>1. Basic Chemistry and Polymerization Lab |

- Basic operations (distillation, recrystallization, precipitation)
- Esterification, amidation, Free-radical polymerization
- Suspension/emulsion polymerization, Resin preparation (amino-, epoxy-resins)

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| **Forms of instruction** | Lecture (1 SWS)<br>Seminar (1 SWS)<br>Lecture (2 SWS)<br>Practical training (5 SWS)<br>Seminar (1 SWS)<br>Course |
| **Languages of instruction** | German, English |
| **Duration (semesters)** | 1 Semester Semester |
| **Module frequency** | jedes Wintersemester |
| **Module capacity** | unlimited |
| **Time of examination** | |
| **Credit points** | 10 CP |
| **Share on module final degree** | Course 1: %; Course 2: %; Course 3: %; Course 4: %; Course 5: %; Course 6: %. |
| **Share of module grade on the course of study's final grade** | 1 |

| Examination | Exam prerequisites | Type of examination |
|---|---|---|
| **Course 1** | | |
| **Course 2** | | |
| **Course 3** | | |
| **Course 4** | | |
| **Course 5** | | |
| **Course 6** | | |
| **Final exam of module** | completed lab course protocols and lab-safety examinations, written examination Macromolecules, Organic Chemistry and Polymer Synthesis I, written examination Macromolecules, Organic Chemistry and Polymer Synthesis II | oral or written examination |
| **Exam repetition information** | | |

| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
|---|---|---|---|---|---|---|---|---|
| **Course 1** | Lecture | Lecture Introduction to Macromolecules | 1 | | | | | 0 |
| **Course 2** | Seminar | Seminar Introduction to Macromolecules | 1 | | | | | 0 |
| **Course 3** | Lecture | Lecture Organic Chemistry and Polymer Synthesis | 2 | | | | | 0 |
| **Course 4** | Practical training | Lab course Basic Chemistry and Polymerization Lab | 5 | | | | | 0 |
| **Course 5** | Seminar | Seminar Organic Chemistry and Polymer Synthesis | 1 | | | | | 0 |
| **Course 6** | Course | Private study | | | | | | 0 |
| **Workload by module** | | | | | | 300 | | 300 |

| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
|---|---|---|---|---|---|---|---|---|
| **Total module workload** | | | | | | | | 300 |

## CHE.05565.02 - Master Thesis (M.Sc.)

| CHE.05565.02 | | | 30 CP |
|---|---|---|---|
| **Module label** | | Master Thesis (M.Sc.) | |
| **Module code** | | CHE.05565.02 | |
| **Semester of first implementation** | | | |
| **Module used in courses of study / semesters** | | • Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Pflichtmodule | |
| **Responsible person for this module** | | | |
| **Further responsible persons** | | Hochschullehrer der Institute Physik oder Chemie bzw. des Fachbereiches der Hochschule Merseburg | |
| **Prerequisites** | | at least 75 Credit Points (75 LP) | |
| **Skills to be acquired in this module** | | • The students will be enabled to carry out independent research.<br>• They will do literature studies and experimental work.<br>• Finally, the students write and defend their thesis. | |
| **Module contents** | | This module covers the main part of the master course: The independent research work on a scientific or engineering based topic. The students must perform literature research, collect and evaluate experimental data, do their own research strategies, and finally present the results including a defense. | |
| **Form of instruction** | | Independent supervised work (30 SWS) | |
| **Languages of instruction** | | German, English | |
| **Duration (semesters)** | | 1 Semester Semester | |
| **Module frequency** | | jedes Semester | |
| **Module capacity** | | unlimited | |
| **Time of examination** | | | |
| **Credit points** | | 30 CP | |
| **Share on module final degree** | | Course 1: %. | |
| **Share of module grade on the course of study's final grade** | | 1 | |
| Examination | Exam prerequisites | | Type of examination |
| **Course 1** | | | |
| **Final exam of module** | | | written Master-Thesis, oral defence |
| **Exam repetition information** | | | |
| **Form of instruction** | Independent supervised work | | |
| **Course name** | Master Thesis | | |
| **SWS** | 30 | | |
| **Workload of compulsory attendance** | | | |
| **Workload of preparation / homework etc** | | | |
| **Workload of independent learning** | | | |
| **Workload (examination and preparation)** | | | |
| **Workload total** | 0 | | |
| **Workload self-arranged work (module-oriented** | 900 | | |
| **Total module workload** | 900 | | |
| **Type of examination** | | | |
| **Frequency** | Summer or winter semester | | |
| **Capacity** | unlimited | | |

## CHE.05558.02 - Introduction to Polymer Research

| CHE.05558.02 | | 15 CP |
|---|---|---|
| **Module label** | Introduction to Polymer Research | |
| **Module code** | CHE.05558.02 | |
| **Semester of first implementation** | | |
| **Module used in courses of study / semesters** | • Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Pflichtmodule | |
| **Responsible person for this module** | | |
| **Further responsible persons** | Prof. Dr. Dariush Hinderberger, Prof. Dr. Beate Langer | |
| **Prerequisites** | | |
| **Skills to be acquired in this module** | • Students will be prepared for independent research.<br>• The project work is their first independent research experience.<br>• The students will learn to give a scientific presentation.<br>• They will become familiar with modern research topics in the field of polymers. | |
| **Module contents** | This module covers advanced topics of polymer science and engineering. The lecture Polymer Colloquium is a ring lecture with local and guest lecturer presenting up to date information on their field of interest. The project work is the first way to perform an independent research at university or industry.<br>Lectures:<br>1. Polymer Colloquium / Ring Lecture<br>• Introduction to database and literature research (block lecture)<br>• Modern methods and developments in polymer chemistry, physics and engineering<br>• New material developments<br>• Latest research activities by leading guest lecturers<br>• Activities in the local research groups (ring lecture)<br>• Interdisciplinary topics from adjacent fields<br>Lab course:<br>1. Lab course Project Work<br>• Participation in a research group at university or in industry<br>• Introduction to independent research<br>• Combining literature and experimental research<br>• Independent preparation of the research report<br>• Oral presentation of the results using PowerPoint | |
| **Forms of instruction** | Lecture (1 SWS)<br>Practical training (10 SWS)<br>Course | |
| **Languages of instruction** | German, English | |
| **Duration (semesters)** | 1 Semester Semester | |
| **Module frequency** | jedes Wintersemester | |
| **Module capacity** | unlimited | |
| **Time of examination** | | |
| **Credit points** | 15 CP | |
| **Share on module final degree** | Course 1: %; Course 2: %; Course 3: %. | |
| **Share of module grade on the course of study's final grade** | 1 | |
| Examination | Exam prerequisites | Type of examination |
| **Course 1** | | |
| **Course 2** | | |

| Examination | | | Exam prerequisites | | | Type of examination | | |
|---|---|---|---|---|---|---|---|---|
| **Course 3** | | | | | | | | |
| **Final exam of module** | | | oral presentation in the group seminar | | | written examination (report) | | |
| **Exam repetition information** | | | | | | | | |
| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
| **Course 1** | Lecture | Lecture Polymer Colloquium / Ring Lecture | 1 | | | | | 0 |
| **Course 2** | Practical training | Lab Course Project Work | 10 | | | | | 0 |
| **Course 3** | Course | Private Study | | | | | | 0 |
| **Workload by module** | | | | | | 450 | | 450 |
| **Total module workload** | | | | | | | | 450 |

## CHE.05561.04 - Polymer Physical Chemistry

| CHE.05561.04 | 10 CP |
|---|---|
| **Module label** | Polymer Physical Chemistry |
| **Module code** | CHE.05561.04 |
| **Semester of first implementation** | |
| **Module used in courses of study / semesters** | • Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Pflichtmodule |
| **Responsible person for this module** | |
| **Further responsible persons** | Prof. Dr. Dariush Hinderberger |
| **Prerequisites** | |
| **Skills to be acquired in this module** | • The students obtain basics of the physical chemistry of polymers and their characterization methods.<br>• The overview of analytical techniques for polymers enables the students for their practical application.<br>• They learn to perform basic polymer analyses using different techniques.<br>• Finally, they improve their capabilities in writing of scientific reports. |
| **Module contents** | This module covers basic topics of polymer physical chemistry. The lectures Instrumental Analytics of Polymers, Physical Chemistry and Polymer Characterization give an overview over the broad spectrum of characterization methods from different approaches. The lab courses Instrumental Analytics of Polymers Lab and Polymer Characterization Lab accompany the lectures and show the examples of the different characterization methods.<br>Lectures:<br>1. Instrumental Analytics of Polymers<br>• Basic principles of analytical chemistry<br>• Statistical treatment of analytical data<br>• Special chromatographic techniques for the investigation of polymers and polymer additives<br>• Principles and instrumental parameters in molecule spectroscopy (IR- and Raman spectroscopy)<br>• Thermal analytical methods for the characterization of chemical and physical properties of polymers<br>2. Physical Chemistry<br>• Phenomenological thermodynamics: Gibbs free energy, enthalphy, chemical potentials<br>• Chemical and phase equilibrium, thermodynamics of mixtures<br>• Chemical kinetics<br>• Basics of statistical thermodynamics<br>3. Polymer Characterization<br>• Determination of molecular masses and distributions<br>• Thermodynamics of polymer solutions, colligative properties<br>• Viscosity and diffusion<br>• DSC, DMA, TMA<br>• Principles of chromatography<br>• Characterization of non-linear polymers<br>• Microstructure analysis by NMR<br>• Electrospray GC-MS, MALDI-TOF<br>• End-group titration<br>Lab courses:<br>1. Instrumental Analytics of Polymers Lab e.g.<br>• Extraction of additives and analysis of extracts and residual monomers by GC/MS<br>• Elastomer characterization by TGA |

- Qualitative analysis of polymers and copolymers by FTIR spectroscopy (MIR or NIR)
- Mn of polymers by vapour pressure osmometry or membrane osmometry

2. Polymer Characterization Lab e.g.

- static light scattering
- Dynamic light scattering
- Wide-angle X-ray scattering
- CMC determination
- Gel permeation chromatography (GPC/SEC)
- End-group titration
- Intrinsic viscosity
- Solubility of polymers
- Mass spectrometry of polymers (ESI and MALDI TOF)

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| **Forms of instruction** | Lecture (1 SWS)<br>Practical training (1 SWS)<br>Lecture (2 SWS)<br>Seminar (1 SWS)<br>Lecture (1 SWS)<br>Seminar (1 SWS)<br>Practical training (2 SWS)<br>Course |
| **Languages of instruction** | German, English |
| **Duration (semesters)** | 2 Semester Semester |
| **Module frequency** | jedes Wintersemester |
| **Module capacity** | unlimited |
| **Time of examination** | |
| **Credit points** | 10 CP |
| **Share on module final degree** | Course 1: %; Course 2: %; Course 3: %; Course 4: %; Course 5: %; Course 6: %; Course 7: %; Course 8: %. |
| **Share of module grade on the course of study's final grade** | 1 |

| Examination | Exam prerequisites | Type of examination |
|---|---|---|
| **Course 1** | | |
| **Course 2** | | |
| **Course 3** | | |
| **Course 4** | | |
| **Course 5** | | |
| **Course 6** | | |
| **Course 7** | | |
| **Course 8** | | |
| **Final exam of module** | completed lab course protocols, written examination and seminar problem set solutions "Physical Chemistry", written examination and seminar problem set solutions "Polymer Characterization", written examination and completed lab course protocols "Instrumental Analytics of Polymers" | oral or written examination (Instrumental Analytics, Physical Chemistry, Polymer Characterization) |
| **Exam repetition information** | | |

| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
|---|---|---|---|---|---|---|---|---|
| **Course 1** | Lecture | Lecture Instrumental Analytics of Polymers | 1 | | | | | 0 |
| **Course 2** | Practical training | Lab course Instrumental Analytics of Polymers | 1 | | | | | 0 |

| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
|---|---|---|---|---|---|---|---|---|
| **Course 3** | Lecture | Lecture Physical Chemistry | 2 | | | | | 0 |
| **Course 4** | Seminar | Seminar Physical Chemistry | 1 | | | | | 0 |
| **Course 5** | Lecture | Lecture Polymer Characterization | 1 | | | | | 0 |
| **Course 6** | Seminar | Seminar Polymer Characterization | 1 | | | | | 0 |
| **Course 7** | Practical training | Lab course Polymer Characterization | 2 | | | | | 0 |
| **Course 8** | Course | Private study | | | | | | 0 |
| **Workload by module** | | | | | | 300 | | 300 |
| **Total module workload** | | | | | | | | 300 |

## PHY.05563.03 - Polymer Physics

| PHY.05563.03 | 10 CP |
|---|---|
| **Module label** | Polymer Physics |
| **Module code** | PHY.05563.03 |
| **Semester of first implementation** | |
| **Module used in courses of study / semesters** | • Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Pflichtmodule |
| **Responsible person for this module** | |
| **Further responsible persons** | Prof. Dr. Kay Saalwächter |
| **Prerequisites** | |
| **Skills to be acquired in this module** | • The students become acquainted with the fundamental concepts of experimental polymer physics.<br>• They learn and apply the theoretical fundamentals and the experimental physical methods used to characterize and investigate polymer materials.<br>• They gain practical experience with basic methods in experimental polymer physics.<br>• They will understand the properties of polymer surfaces.<br>• They receive the knowledge on methods and technologies to modify and analyze polymer surfaces. |
| **Module contents** | This module covers basic topics of polymer physics. The lectures Introduction to Polymer Physics and Polymer Surface Science give an overview over the broad spectrum of physical aspects of polymeric samples. The lab course Polymer Physical Lab accompanies the lectures and show the examples of the different characterization methods.<br>Lectures:<br>1. Introduction to Polymer Physics<br>• Structure of single chains (ideal vs. real chains, scattering, semidilute solutions and melts)<br>• Mechanical properties of polymers (liquids vs. solids, rubber elasticity, viscoelasticity, relaxation processes in polymer melts, Debye relaxation, flow behavior, time-temperature superposition and glass transition)<br>• Molecular structure and weight distributions (chemical structure, architecture, polymerization processes, determination of structures and molecular weights)<br>• Microscopic models for polymer dynamics (viscosity and diffusion, Rouse model, entanglements and reptation)<br>• Thermodynamics of solutions and melts (dilute and semidilute solutions, Flory-Huggins theory, kinetics of phase separation, block copolymers, semicrystalline polymers)<br>2. Polymer Surface Science<br>• Surface vs. bulk<br>• Surface composition and ordering<br>• Dynamic surface processes (adsorption, desorption, diffusion)<br>• Surface tension<br>• Surface analysis (XPS, SIMS, SEM, AFM)<br>• Surface modification by deposition (wet processes, dry processes, CVD, PE-CVD, PVD), polymer film growth<br>• Surface modification and functionalization (wet and dry etching, grafting, plasma treatment)<br>• Polymer in lithography<br>• Technical applications for surface modification<br>Lab course:<br>1. Lab course Polymer Physical Lab e.g.<br>• Rheology/mechanical spectroscopy<br>• DSC<br>• Polarization microscopy |

| | |
|---|---|
| **Forms of instruction** | Lecture (3 SWS)<br>Lecture (2 SWS)<br>Practical training (1 SWS)<br>Seminar (1 SWS)<br>Course |
| **Languages of instruction** | German, English |
| **Duration (semesters)** | 1 Semester Semester |
| **Module frequency** | jedes Sommersemester |
| **Module capacity** | unlimited |
| **Time of examination** | |
| **Credit points** | 10 CP |
| **Share on module final degree** | Course 1: %; Course 2: %; Course 3: %; Course 4: %; Course 5: %. |
| **Share of module grade on the course of study's final grade** | 1 |

| Examination | Exam prerequisites | Type of examination |
|---|---|---|
| **Course 1** | | |
| **Course 2** | | |
| **Course 3** | | |
| **Course 4** | | |
| **Course 5** | | |
| **Final exam of module** | completed lab course protocols, written examination and seminar problem set solutions `Polymer Physics`, written examination `Polymer Surface Science` | oral examination |
| **Exam repetition information** | | |

| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
|---|---|---|---|---|---|---|---|---|
| **Course 1** | Lecture | Lecture Introduction to Polymer Physics | 3 | | | | | 0 |
| **Course 2** | Lecture | Lecture Polymer Surface Science | 2 | | | | | 0 |
| **Course 3** | Practical training | Lab Course Polymer Physics Lab | 1 | | | | | 0 |
| **Course 4** | Seminar | Seminar Introduction to Polymer Physics | 1 | | | | | 0 |
| **Course 5** | Course | Private study | | | | | | 0 |
| **Workload by module** | | | | | | 300 | | 300 |
| **Total module workload** | | | | | | | | 300 |

# Polymer Engineering

## INW.05570.04 - Polymer Engineering Focus

| INW.05570.04 | 7 CP |
|---|---|
| **Module label** | Polymer Engineering Focus |
| **Module code** | INW.05570.04 |
| **Semester of first implementation** | |
| **Module used in courses of study / semesters** | • Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Polymer Engineering |
| **Responsible person for this module** | |
| **Further responsible persons** | Prof. Dr.-Ing. Maik Feldmann |
| **Prerequisites** | |
| **Skills to be acquired in this module** | • The students acquire perspectives for the work as a polymer scientist or polymer engineer.<br>• They receive knowledge on applying polymers for different part specifications.<br>• The advanced knowledge on elastomeric materials enables them to work in industry.<br>• They obtain advanced knowledge on preparation and properties of elastomers.<br>• They can use their practical skills in polymer/elastomer preparation and characterization. |
| **Module contents** | This module covers advanced topics of polymer engineering. The lectures Polymers in Industry and Elastomeric Materials connect the scientific approach to polymers with the industrial requirements and development methods. The lab course Elastomeric Materials Lab accompany the lectures and show the details of industrial processes. The research seminar deepens the view on industrial projects, which cannot be performed in a lab.<br>Lectures:<br>1. Polymers in Industry<br>Overview in application areas of polymers/thermoplastics and other materials in various components with respect to the industrial background. Specification and requirements for material and processing technology. Consideration of requirements and costs, overview of typical applications in various industries such as automotive, construction, packaging, electronics, recycling, and aerospace.<br>2. Elastomeric Materials<br>Structure, production, and properties of elastomeric materials; technical elastomers and their components (polymers, filler, crosslinking agents, additives), influence of additives on rheological and thermodynamic behavior, preparation of rubber mixtures, testing of elastomeric materials, damage analysis.<br>Lab courses and Seminars:<br>1. Elastomeric Materials Lab<br>Content items: compounding of rubber mixtures, vulcanization, vulcametry, determination of mechanical properties of elastomeric materials<br>2. Research Seminar<br>Student presentation of research results from the literature from the polymer engineering field |
| **Forms of instruction** | Lecture (2 SWS)<br>Lecture (2 SWS)<br>Practical training (2 SWS)<br>Seminar (1 SWS)<br>Course |
| **Languages of instruction** | German, English |
| **Duration (semesters)** | 1 Semester Semester |
| **Module frequency** | jedes Wintersemester |
| **Module capacity** | unlimited |
| **Time of examination** | |

INW.05570.04 7 CP

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Credit points** | | | 7 CP | | | | | |
| **Share on module final degree** | | | Course 1: %; Course 2: %; Course 3: %; Course 4: %; Course 5: %. | | | | | |
| **Share of module grade on the course of study's final grade** | | | 1 | | | | | |
| Examination | | | Exam prerequisites | | | Type of examination | | |
| **Course 1** | | | | | | | | |
| **Course 2** | | | | | | | | |
| **Course 3** | | | | | | | | |
| **Course 4** | | | | | | | | |
| **Course 5** | | | | | | | | |
| **Final exam of module** | | | completed lab course protocols, written examination (Polymers in Industry), written examination (Elastomeric Materials), seminar (Research seminar) participation | | | oral examination (presentation) | | |
| **Exam repetition information** | | | | | | | | |
| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
| **Course 1** | Lecture | Lecture Polymers in Industry | 2 | | | | | 0 |
| **Course 2** | Lecture | Lecture Elastomeric Materials | 2 | | | | | 0 |
| **Course 3** | Practical training | Lab course Elastomeric Materials | 2 | | | | | 0 |
| **Course 4** | Seminar | Research Seminar | 1 | | | | | 0 |
| **Course 5** | Course | Private study | | | | | | 0 |
| **Workload by module** | | | | | | 210 | | 210 |
| **Total module workload** | | | | | | | | 210 |

## INW.05571.03 - Advanced Polymer Engineering

| INW.05571.03 | 10 CP |
|---|---|
| **Module label** | Advanced Polymer Engineering |
| **Module code** | INW.05571.03 |
| **Semester of first implementation** | |
| **Module used in courses of study / semesters** | • Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Polymer Engineering |
| **Responsible person for this module** | |
| **Further responsible persons** | Prof. Dr. Mario Beiner |
| **Prerequisites** | |
| **Skills to be acquired in this module** | • Students acquire typical knowledge for the work as a polymer engineers.<br>• They receive advanced knowledge on processing polymer blends and composites.<br>• They will have practical skills for processing polymer blends and composites.<br>• Students can practically apply basic principles of advanced structure characterization techniques. |
| **Module contents** | This module covers advanced methods of polymer processing (lecture 1: Processing of polymer blends and composites) and polymer characterization on macroscopic level (lecture 2: Polymer Structure and Morphology). The Lab courses Processing of polymer blends and composites and Polymer Structure and Morphology give the students the opportunity to perform their own polymer processing experiments and X-ray investigations.<br>Lectures:<br>1. Processing of polymer blends and composites<br>• Techniques of modifying of polymers, creation of blends, compounds and master batches, compatibility and incompatibility of blends, special aspects of blend technology, influence of process parameters, technology of polymer composites: nano, micro and macro composites, manufacturing by different forms of composite components (particles, lamellas, short, long and endless fibers), special aspects of composites technology<br>2. Polymer Structure and Morphology<br>• Scattering techniques: basic principles & general aspects, primary scattering and interference, comparison x-rays and neutrons, radiation sources and detectors<br>• X-ray diffraction (WAXS): typical setups, diffraction by crystals, Braggs law and Laue condition, Miller indices, Structure factor and lattice factor, scattering of amorphous materials and liquids<br>• Small-angle X-ray scattering (SAXS): typical setups, application to semi-crystalline and self-assembled polymers, Guinier law and application to disordered systems<br>• Imaging techniques: light microscopy, atomic force microscopy, electron microscopy techniques<br>1. Lab Course: Processing of polymer blends and composites<br>Practical exercises to special aspects by processing polymer blends and composites, Polymer orientation experiments after extrusion, effect of thermal treatment<br>2. Lab Course: Polymer Structure and Morphology<br>Practical exercises in imaging techniques, X-ray experiments with 1- and 2-dim detectors, AFM investigations on thin films |
| **Forms of instruction** | Lecture (2 SWS)<br>Seminar (1 SWS)<br>Lecture (2 SWS)<br>Practical training (2 SWS)<br>Practical training (1 SWS)<br>Course |

INW.05571.03 10 CP

| | |
|---|---|
| **Languages of instruction** | German, English |
| **Duration (semesters)** | 1 Semester Semester |
| **Module frequency** | jedes Sommersemester |
| **Module capacity** | unlimited |
| **Time of examination** | |
| **Credit points** | 10 CP |
| **Share on module final degree** | Course 1: %; Course 2: %; Course 3: %; Course 4: %; Course 5: %; Course 6: %. |
| **Share of module grade on the course of study's final grade** | 1 |

| Examination | Exam prerequisites | Type of examination |
|---|---|---|
| **Course 1** | | |
| **Course 2** | | |
| **Course 3** | | |
| **Course 4** | | |
| **Course 5** | | |
| **Course 6** | | |
| **Final exam of module** | completed lab course protocols (Processing of polymer blends and composites), completed lab course protocols (Polymer Structure and Morphology) | oral or written examination (Processing of polymers, Polymer structure) |
| **Exam repetition information** | | |

| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
|---|---|---|---|---|---|---|---|---|
| **Course 1** | Lecture | Lecture Processing of polymer blends and composites | 2 | | | | | 0 |
| **Course 2** | Seminar | Seminar Processing of polymer blends and composites | 1 | | | | | 0 |
| **Course 3** | Lecture | Lecture Polymer Structure and Morphology | 2 | | | | | 0 |
| **Course 4** | Practical training | Lab Processing of polymer blends and composites | 2 | | | | | 0 |
| **Course 5** | Practical training | Lab Polymer Structure and Morphology | 1 | | | | | 0 |
| **Course 6** | Course | Private Study | | | | | | 0 |
| **Workload by module** | | | | | | 300 | | 300 |
| **Total module workload** | | | | | | | | 300 |

# Polymer Science *

## PHY.05568.05 - Polymer Science Focus

| PHY.05568.05 | 7 CP |
|---|---|
| **Module label** | Polymer Science Focus |
| **Module code** | PHY.05568.05 |
| **Semester of first implementation** | |
| **Module used in courses of study / semesters** | • Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Polymer Physics<br>• Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Polymer Science * |
| **Responsible person for this module** | |
| **Further responsible persons** | Prof. Dr. Kay Saalwächter |
| **Prerequisites** | |
| **Skills to be acquired in this module** | • The students become familiar with recent developments and modern research topics and methods in synthesis, characterization and properties of polymers and composite materials.<br>• They learn to give a presentation based on literature work. |
| **Module contents** | This module covers advanced topics of polymer physics and chemistry with state of the art examples. New approaches from literature and other groups will be presented and discussed. The research seminar deepens the view on new approaches.<br>Lectures:<br>1. Modern Concepts of Polymer and Biopolymer Synthesis<br>Special topics in current synthetic polymer chemistry research:<br>• Modern concepts of controlled and living polymerization techniques<br>• Star block copolymers, dendrimers, hyper branched polymers, graft copolymers<br>• Organic-inorganic hybrid materials<br>• Polymerization in alternative reaction media (ionic liquids, supercritical solvents)<br>• Click-chemistry, IPN, semi-IPN, graft polymerization<br>• New industrially synthesized polymers (e.g., s-PS, s-PP)<br>• Biochemical methods: enzymatic polymerizations<br>• Modifications and degradation of biopolymers<br>• Special analytical tools for the analysis of biopolymers<br>• Biopolymer applications<br>2. Modern Physical Polymer Science<br>Special topics in current physical polymer research:<br>• Block copolymers and polymer nanostructures<br>• Crystallization of polymers<br>• Nanocomposites<br>• Polymer dynamics<br>• Modern scattering techniques<br>• Polymers in electronics and optics<br>• Principles and applications of magnetic resonance techniques<br>Seminar:<br>1. Research seminar<br>• Student presentation of research results from the literature from the fields of polymer chemistry of physics |
| **Forms of instruction** | Lecture (2 SWS)<br>Seminar (1 SWS) |

| | |
|---|---|
| | Lecture (2 SWS)<br>Seminar (1 SWS)<br>Seminar (1 SWS)<br>Course |
| **Languages of instruction** | German, English |
| **Duration (semesters)** | 1 Semester Semester |
| **Module frequency** | jedes Wintersemester |
| **Module capacity** | unlimited |
| **Time of examination** | |
| **Credit points** | 7 CP |
| **Share on module final degree** | Course 1: %; Course 2: %; Course 3: %; Course 4: %; Course 5: %; Course 6: %. |
| **Share of module grade on the course of study's final grade** | 1 |

| Examination | Exam prerequisites | Type of examination |
|---|---|---|
| **Course 1** | | |
| **Course 2** | | |
| **Course 3** | | |
| **Course 4** | | |
| **Course 5** | | |
| **Course 6** | | |
| **Final exam of module** | oral or written examination Modern Concepts of Polymer and Biopolymer Synthesis, oral or written examination Modern Physical Polymer Science, seminar (Research seminar) participation | oral examination (presentation) |
| **Exam repetition information** | | |

| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
|---|---|---|---|---|---|---|---|---|
| **Course 1** | Lecture | Lecture Modern Concepts of Polymer and Biopolymer Synthesis | 2 | | | | | 0 |
| **Course 2** | Seminar | Seminar Modern Concepts of Polymer and Biopolymer Synthesis | 1 | | | | | 0 |
| **Course 3** | Lecture | Lecture Modern Physical Polymer Science | 2 | | | | | 0 |
| **Course 4** | Seminar | Seminar Modern Physical Polymer Science | 1 | | | | | 0 |
| **Course 5** | Seminar | Research seminar | 1 | | | | | 0 |
| **Course 6** | Course | Private study | | | | | | 0 |
| **Workload by module** | | | | | | 210 | | 210 |
| **Total module workload** | | | | | | | | 210 |

## CHE.05564.06 - Advanced Polymer Chemistry

| CHE.05564.06 | 10 CP |
|---|---|
| **Module label** | Advanced Polymer Chemistry |
| **Module code** | CHE.05564.06 |
| **Semester of first implementation** | |
| **Module used in courses of study / semesters** | • Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Polymer Science * |
| **Responsible person for this module** | |
| **Further responsible persons** | Prof. Dr. Wolfgang Binder |
| **Prerequisites** | |
| **Skills to be acquired in this module** | • Student gain fundamentals in advanced theoretical and practical knowledge of polymerization techniques.<br>• They will be enabled to carry out special living/controlled and catalytic polymerizations, enzymatic and biological polymer synthesis, and preparation of polymer/drug conjugates.<br>• They learn to use advanced characterization techniques and in vivo and in vitro testing of polymers. |
| **Module contents** | This module covers advanced methods of polymer synthesis (lecture 1: Advanced Polymer Synthesis) and polymer characterization on molecular level (lecture 2: Polymer Analytics). The Lab course Polymer Synthesis Lab gives the students the opportunity to perform their own syntheses.<br>Lecture:<br>1. Advanced Polymer Synthesis<br>• Detailed description of standard polymerization techniques like living polymerization methods (CRP, LCCP, living anionic polymerization), ring opening polymerization ROP, ROMP), polymer analogous reactions for tailoring polymer properties, emulsion polymerization<br>• Detailed description of how to achieve advanced polymeric materials, variation of polymeric architectures, e.g., synthesis of block copolymers, grafted polymers, supramolecular polymers,vitrimeric polymers, design of shape memory polymers<br>• Polymers in energy engineering<br>• Polymer degradation and novel recycling methodologies<br>• Polymers and their use in microelectronics<br>• Polymers and their application in medicine<br>• Biopolymers, their biosynthesis and their technological use.<br>• Description of the main analytical techniques in polymer science, with a detailed study of NMR, GPC and MS techniques, discussion of practical application of techniques to polymer molecules<br>2. Polymer Analytics<br>• Description and practical experience in thermal, mechanical and stability-analysis of polymers (DSC, TGA, DTMA, melt-rheology).<br>• NMR-spectroscopy: solution NMR, basic techniques, sensitivity, heteronuclear-NMR, basic 2D-techniques, relaxation in marcomolecules, training and discussion of chemical shift analysis, spin/spin-coupling patterns, coupling constants in relation to chemical structure, isotopic patterns and molecular weight, determination of exact chemical structures, discussion of 2D-COSY-spectroscopy and practical analysis<br>• MS-analytical methods (MALDI-TOF; ESI-TOF; TOF/TOF) for the analytics of synthetic and biopolymers<br>• Advanced GPC/HLPC chromatography: 2D-methods in relation to polarity and coupling techniques, influence of solvents and columns, interpretation of elution times<br>Lab course:<br>1. Polymer Synthesis Lab<br>• Independent personal execution of polymerization experiments. The |

method (Ionic polymerization, Living polymerization (ATRP, NMP, LCCP)) will vary due to lab capacity.
- Multiple step polymerization techniques are performed, e.g. to obtain polymers with special magnetic and electric properties, solution properties, or general block copolymers
- Analytics of polymers (structural analytics and materials analytics such as NMR, MS-, SEC, TGA, DSC, melt-rheology, 3D printing)

| | |
|---|---|
| **Forms of instruction** | Lecture (1 SWS)<br>Seminar (1 SWS)<br>Practical training (5 SWS)<br>Lecture (1 SWS)<br>Course |
| **Languages of instruction** | German, English |
| **Duration (semesters)** | 1 Semester Semester |
| **Module frequency** | jedes Sommersemester |
| **Module capacity** | unlimited |
| **Time of examination** | |
| **Credit points** | 10 CP |
| **Share on module final degree** | Course 1: %; Course 2: %; Course 3: %; Course 4: %; Course 5: %. |
| **Share of module grade on the course of study's final grade** | 1 |

| Examination | Exam prerequisites | Type of examination |
|---|---|---|
| **Course 1** | | |
| **Course 2** | | |
| **Course 3** | | |
| **Course 4** | | |
| **Course 5** | | |
| **Final exam of module** | completed lab course protocols and lab-safety examinations, seminar problem set solutions | oral or written examination (Advanced Polymer Synthesis, Polymer Analytics) |
| **Exam repetition information** | | |

| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
|---|---|---|---|---|---|---|---|---|
| **Course 1** | Lecture | Lecture Advanced Polymer Synthesis | 1 | | | | | 0 |
| **Course 2** | Seminar | Seminar Advanced Polymer Synthesis | 1 | | | | | 0 |
| **Course 3** | Practical training | Lab course Polymer Synthesis | 5 | | | | | 0 |
| **Course 4** | Lecture | Lecture Polymer Analytics | 1 | | | | | 0 |
| **Course 5** | Course | Private study | | | | | | 0 |
| **Workload by module** | | | | | | 300 | | 300 |
| **Total module workload** | | | | | | | | 300 |

## PHY.05566.05 - Advanced Polymer Physics

| PHY.05566.05 | 10 CP |
|---|---|
| **Module label** | Advanced Polymer Physics |
| **Module code** | PHY.05566.05 |
| **Semester of first implementation** | |
| **Module used in courses of study / semesters** | • Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Polymer Physics<br>• Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Polymer Science * |
| **Responsible person for this module** | |
| **Further responsible persons** | Prof. Dr. Kay Saalwächter |
| **Prerequisites** | |
| **Skills to be acquired in this module** | • The students deepen their background knowledge in polymer physics.<br>• They will be familiar with fundamental principles of soft-matter physics.<br>• They gain experience in advanced concepts of experimental or theoretical polymer physics. |
| **Module contents** | This module covers advanced experimental and theoretical details of polymer physics. Beside basic lecture (Soft Condensed Matter Physics), the students can focus on either experimental (Polymer Structure and Morphology) or more theoretical approaches (Polymer Theory). The Lab courses Advanced Polymer Physics Lab and Polymer Structure and Morphology give the students the opportunity to perform their own characterization experiments.<br>Lectures:<br>1. Soft Condensed Matter Physics<br>• Structure and dynamics of liquids (existence, pair correlation function, glass transition)<br>• Liquid crystals (classification, structure and defects in nematics, nematic-to-isotropic phase transition, elastic properties and Fredericks-transition)<br>• Surfactants: supramolecular structures and self-organization (micelles and membranes)<br>• Colloidal dispersions: heterogeneous systems (Brownian motion, forces between colloids, colloidal phase transitions)<br>• Polymers (conformations: ideal chains, rubber elasticity, introduction into semicrystalline polymers)<br>2a. (either) Polymer Structure and Morphology<br>• Scattering techniques: basic principles & general aspects, primary scattering and interference, comparison x-rays and neutrons, radiation sources and detectors<br>• X-ray diffraction (WAXS): typical setups, diffraction by crystals, Braggs law and Laue condition, Miller indices, Structure factor and lattice factor, scattering of amorphous materials and liquids<br>• Small-angle X-ray scattering (SAXS): typical setups, application to semi-crystalline and self-assembled polymers, Guinier law and application to disordered systems<br>• Imaging techniques: light microscopy, atomic force microscopy, electron microscopy techniques<br>2b. (or) Polymer Theory<br>• Conformational statistics of polymers<br>• Flory-Huggins theory for solutions and blends<br>• Self-consistent field theory<br>• Random phase approximation<br>• Polymer networks<br>• Scaling theory of polymers<br>• Theories of polymer dynamics |

Lab courses:
1. Advanced Polymer Physics Lab

- Experiments using special techniques for physical structure details: Dielectric spectroscopy, low-field NMR, light microscopy, atomic force microscopy, X-ray scattering

2. (optional) Polymer Structure and Morphology

- Practical exercises in imaging techniques, X-ray experiments with 1- and 2-dim detectors, AFM investigations on thin films
- Practical exercises in imaging techniques

| | |
|---|---|
| **Forms of instruction** | Lecture (3 SWS)<br>Lecture (3 SWS)<br>Seminar (1 SWS)<br>Seminar (1 SWS)<br>Practical training (1 SWS)<br>Practical training (1 SWS)<br>Lecture (2 SWS)<br>Lecture (2 SWS)<br>Practical training (1 SWS)<br>Seminar (1 SWS)<br>Course<br>Course |
| **Languages of instruction** | German, English |
| **Duration (semesters)** | 1 Semester Semester |
| **Module frequency** | jedes Sommersemester |
| **Module capacity** | unlimited |
| **Time of examination** | |
| **Credit points** | 10 CP |
| **Share on module final degree** | Course 1: %; Course 2: %; Course 3: %; Course 4: %; Course 5: %; Course 6: %; Course 7: %; Course 8: %; Course 9: %; Course 10: %; Course 11: %; Course 12: %. |
| **Share of module grade on the course of study's final grade** | 1 |

| Examination | Exam prerequisites | Type of examination |
|---|---|---|
| **Course 1** | | |
| **Course 2** | | |
| **Course 3** | | |
| **Course 4** | | |
| **Course 5** | | |
| **Course 6** | | |
| **Course 7** | | |
| **Course 8** | | |
| **Course 9** | | |
| **Course 10** | | |
| **Course 11** | | |
| **Course 12** | | |
| **Final exam of module** | completed lab course protocols, seminar (Soft Condensed Matter Physics) problem set solutions | oral or written examination (Condensed Matter, Polymer Theory or Polymer Structure) |
| **Exam repetition information** | | |

| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
|---|---|---|---|---|---|---|---|---|
| **Course 1** | Lecture | Lecture Soft Condensed Matter Physics | 3 | | | | | 0 |
| **Course 2** | Lecture | Lecture Soft | 3 | | | | | 0 |

| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
|---|---|---|---|---|---|---|---|---|
| | | Condensed Matter Physics | | | | | | |
| **Course 3** | Seminar | Seminar Soft Condensed Matter Physics | 1 | | | | | 0 |
| **Course 4** | Seminar | Seminar Soft Condensed Matter Physics | 1 | | | | | 0 |
| **Course 5** | Practical training | Lab course Advanced Polymer Physics | 1 | | | | | 0 |
| **Course 6** | Practical training | Lab Course Advanced Poly.Phys. Lab | 1 | | | | | 0 |
| **Course 7** | Lecture | Lecture Polymer Structure and Morphology | 2 | | | | | 0 |
| **Course 8** | Lecture | Lecture Polymer Theory | 2 | | | | | 0 |
| **Course 9** | Practical training | LabCourse Polymer Structure and Morphology | 1 | | | | | 0 |
| **Course 10** | Seminar | Seminar Polymer Theory | 1 | | | | | 0 |
| **Course 11** | Course | Private study | | | | | | 0 |
| **Course 12** | Course | Private study | | | | | | 0 |
| **Workload by module** | | | | | | 300 | | 300 |
| **Total module workload** | | | | | | | | 300 |

# Polymer Physics

## PHY.05568.05 - Polymer Science Focus

| PHY.05568.05 | 7 CP |
|---|---|
| **Module label** | Polymer Science Focus |
| **Module code** | PHY.05568.05 |
| **Semester of first implementation** | |
| **Module used in courses of study / semesters** | • Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Polymer Physics<br>• Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Polymer Science * |
| **Responsible person for this module** | |
| **Further responsible persons** | Prof. Dr. Kay Saalwächter |
| **Prerequisites** | |
| **Skills to be acquired in this module** | • The students become familiar with recent developments and modern research topics and methods in synthesis, characterization and properties of polymers and composite materials.<br>• They learn to give a presentation based on literature work. |
| **Module contents** | This module covers advanced topics of polymer physics and chemistry with state of the art examples. New approaches from literature and other groups will be presented and discussed. The research seminar deepens the view on new approaches.<br>Lectures:<br>1. Modern Concepts of Polymer and Biopolymer Synthesis<br>Special topics in current synthetic polymer chemistry research:<br>• Modern concepts of controlled and living polymerization techniques<br>• Star block copolymers, dendrimers, hyper branched polymers, graft copolymers<br>• Organic-inorganic hybrid materials<br>• Polymerization in alternative reaction media (ionic liquids, supercritical solvents)<br>• Click-chemistry, IPN, semi-IPN, graft polymerization<br>• New industrially synthesized polymers (e.g., s-PS, s-PP)<br>• Biochemical methods: enzymatic polymerizations<br>• Modifications and degradation of biopolymers<br>• Special analytical tools for the analysis of biopolymers<br>• Biopolymer applications<br>2. Modern Physical Polymer Science<br>Special topics in current physical polymer research:<br>• Block copolymers and polymer nanostructures<br>• Crystallization of polymers<br>• Nanocomposites<br>• Polymer dynamics<br>• Modern scattering techniques<br>• Polymers in electronics and optics<br>• Principles and applications of magnetic resonance techniques<br>Seminar:<br>1. Research seminar<br>• Student presentation of research results from the literature from the fields of polymer chemistry of physics |
| **Forms of instruction** | Lecture (2 SWS)<br>Seminar (1 SWS) |

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| | Lecture (2 SWS)<br>Seminar (1 SWS)<br>Seminar (1 SWS)<br>Course |
| **Languages of instruction** | German, English |
| **Duration (semesters)** | 1 Semester Semester |
| **Module frequency** | jedes Wintersemester |
| **Module capacity** | unlimited |
| **Time of examination** | |
| **Credit points** | 7 CP |
| **Share on module final degree** | Course 1: %; Course 2: %; Course 3: %; Course 4: %; Course 5: %; Course 6: %. |
| **Share of module grade on the course of study's final grade** | 1 |

| Examination | Exam prerequisites | Type of examination |
|---|---|---|
| **Course 1** | | |
| **Course 2** | | |
| **Course 3** | | |
| **Course 4** | | |
| **Course 5** | | |
| **Course 6** | | |
| **Final exam of module** | oral or written examination Modern Concepts of Polymer and Biopolymer Synthesis, oral or written examination Modern Physical Polymer Science, seminar (Research seminar) participation | oral examination (presentation) |
| **Exam repetition information** | | |

| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
|---|---|---|---|---|---|---|---|---|
| **Course 1** | Lecture | Lecture Modern Concepts of Polymer and Biopolymer Synthesis | 2 | | | | | 0 |
| **Course 2** | Seminar | Seminar Modern Concepts of Polymer and Biopolymer Synthesis | 1 | | | | | 0 |
| **Course 3** | Lecture | Lecture Modern Physical Polymer Science | 2 | | | | | 0 |
| **Course 4** | Seminar | Seminar Modern Physical Polymer Science | 1 | | | | | 0 |
| **Course 5** | Seminar | Research seminar | 1 | | | | | 0 |
| **Course 6** | Course | Private study | | | | | | 0 |
| **Workload by module** | | | | | | 210 | | 210 |
| **Total module workload** | | | | | | | | 210 |

## PHY.05566.05 - Advanced Polymer Physics

| PHY.05566.05 | 10 CP |
|---|---|
| **Module label** | Advanced Polymer Physics |
| **Module code** | PHY.05566.05 |
| **Semester of first implementation** | |
| **Module used in courses of study / semesters** | • Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Polymer Physics<br>• Polymer Materials Science (MA120 LP) (Master) > Werkstofftechnik PolymerMaterialScMA120, Version of accreditation valid from WS 2014/15 > Polymer Science * |
| **Responsible person for this module** | |
| **Further responsible persons** | Prof. Dr. Kay Saalwächter |
| **Prerequisites** | |
| **Skills to be acquired in this module** | • The students deepen their background knowledge in polymer physics.<br>• They will be familiar with fundamental principles of soft-matter physics.<br>• They gain experience in advanced concepts of experimental or theoretical polymer physics. |
| **Module contents** | This module covers advanced experimental and theoretical details of polymer physics. Beside basic lecture (Soft Condensed Matter Physics), the students can focus on either experimental (Polymer Structure and Morphology) or more theoretical approaches (Polymer Theory). The Lab courses Advanced Polymer Physics Lab and Polymer Structure and Morphology give the students the opportunity to perform their own characterization experiments.<br>Lectures:<br>1. Soft Condensed Matter Physics<br>• Structure and dynamics of liquids (existence, pair correlation function, glass transition)<br>• Liquid crystals (classification, structure and defects in nematics, nematic-to-isotropic phase transition, elastic properties and Fredericks-transition)<br>• Surfactants: supramolecular structures and self-organization (micelles and membranes)<br>• Colloidal dispersions: heterogeneous systems (Brownian motion, forces between colloids, colloidal phase transitions)<br>• Polymers (conformations: ideal chains, rubber elasticity, introduction into semicrystalline polymers)<br>2a. (either) Polymer Structure and Morphology<br>• Scattering techniques: basic principles & general aspects, primary scattering and interference, comparison x-rays and neutrons, radiation sources and detectors<br>• X-ray diffraction (WAXS): typical setups, diffraction by crystals, Braggs law and Laue condition, Miller indices, Structure factor and lattice factor, scattering of amorphous materials and liquids<br>• Small-angle X-ray scattering (SAXS): typical setups, application to semi-crystalline and self-assembled polymers, Guinier law and application to disordered systems<br>• Imaging techniques: light microscopy, atomic force microscopy, electron microscopy techniques<br>2b. (or) Polymer Theory<br>• Conformational statistics of polymers<br>• Flory-Huggins theory for solutions and blends<br>• Self-consistent field theory<br>• Random phase approximation<br>• Polymer networks<br>• Scaling theory of polymers<br>• Theories of polymer dynamics |

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|---|---|
| | Lab courses:<br>1. Advanced Polymer Physics Lab<br>• Experiments using special techniques for physical structure details: Dielectric spectroscopy, low-field NMR, light microscopy, atomic force microscopy, X-ray scattering<br>2. (optional) Polymer Structure and Morphology<br>• Practical exercises in imaging techniques, X-ray experiments with 1- and 2-dim detectors, AFM investigations on thin films<br>• Practical exercises in imaging techniques |
| **Forms of instruction** | Lecture (3 SWS)<br>Lecture (3 SWS)<br>Seminar (1 SWS)<br>Seminar (1 SWS)<br>Practical training (1 SWS)<br>Practical training (1 SWS)<br>Lecture (2 SWS)<br>Lecture (2 SWS)<br>Practical training (1 SWS)<br>Seminar (1 SWS)<br>Course<br>Course |
| **Languages of instruction** | German, English |
| **Duration (semesters)** | 1 Semester Semester |
| **Module frequency** | jedes Sommersemester |
| **Module capacity** | unlimited |
| **Time of examination** | |
| **Credit points** | 10 CP |
| **Share on module final degree** | Course 1: %; Course 2: %; Course 3: %; Course 4: %; Course 5: %; Course 6: %; Course 7: %; Course 8: %; Course 9: %; Course 10: %; Course 11: %; Course 12: %. |
| **Share of module grade on the course of study's final grade** | 1 |

| Examination | Exam prerequisites | Type of examination |
|---|---|---|
| **Course 1** | | |
| **Course 2** | | |
| **Course 3** | | |
| **Course 4** | | |
| **Course 5** | | |
| **Course 6** | | |
| **Course 7** | | |
| **Course 8** | | |
| **Course 9** | | |
| **Course 10** | | |
| **Course 11** | | |
| **Course 12** | | |
| **Final exam of module** | completed lab course protocols, seminar (Soft Condensed Matter Physics) problem set solutions | oral or written examination (Condensed Matter, Polymer Theory or Polymer Structure) |
| **Exam repetition information** | | |

| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
|---|---|---|---|---|---|---|---|---|
| **Course 1** | Lecture | Lecture Soft Condensed Matter Physics | 3 | | | | | 0 |
| **Course 2** | Lecture | Lecture Soft | 3 | | | | | 0 |

| Module course label | Course type | Course title | SWS | Workload of compulsory attendance | Workload of preparation / homework etc | Workload of independent learning | Workload (examination and preparation) | Sum workload |
|---|---|---|---|---|---|---|---|---|
| | | Condensed Matter Physics | | | | | | |
| **Course 3** | Seminar | Seminar Soft Condensed Matter Physics | 1 | | | | | 0 |
| **Course 4** | Seminar | Seminar Soft Condensed Matter Physics | 1 | | | | | 0 |
| **Course 5** | Practical training | Lab course Advanced Polymer Physics | 1 | | | | | 0 |
| **Course 6** | Practical training | Lab Course Advanced Poly.Phys. Lab | 1 | | | | | 0 |
| **Course 7** | Lecture | Lecture Polymer Structure and Morphology | 2 | | | | | 0 |
| **Course 8** | Lecture | Lecture Polymer Theory | 2 | | | | | 0 |
| **Course 9** | Practical training | LabCourse Polymer Structure and Morphology | 1 | | | | | 0 |
| **Course 10** | Seminar | Seminar Polymer Theory | 1 | | | | | 0 |
| **Course 11** | Course | Private study | | | | | | 0 |
| **Course 12** | Course | Private study | | | | | | 0 |
| **Workload by module** | | | | | | 300 | | 300 |
| **Total module workload** | | | | | | | | 300 |