CONSTRUCTOR UNIVERSITY

Study Program Handbook

Advanced Materials

Molecular Functions, Quantum Systems & Applications

Master of Science

Subject-specific Examination Regulations for Advanced Materials (AdvMat)

The subject-specific examination regulations for AdvMat are defined by this program handbook and are valid only in combination with the General Examination Regulations for Master degree programs (“General Master Policies”).

Upon graduation students in this program will receive a Master of Science (MSc) degree with a scope of 120 ECTS credit points (CP) (for specifics see chapter 3 of this handbook).

Valid for all students starting their studies in Fall 2025

Version	Valid as of	Decision	Details
Fall 2024 - V1	Sep 01, 2025		

Contents

1 Program Overview

1.1 Background

Major advances in technology and related solutions to pressing human problems are generally made possible by novel materials with unique properties tailored to specific applications. Materials science is a rapidly evolving field that is inherently interdisciplinary, encompassing physics, chemistry, and related engineering disciplines. It provides the foundation for understanding and improving many aspects of our daily lives. Relevant examples include the fabrication of nanoparticles and low-dimensional structures that enable the next generation of electronic devices and materials for energy generation, the assembly of supramolecular structures that exploit molecular functions to form smart materials, and the design of tailored quantum systems for next-generation applications and material systems with tuned biophysical functionality. Other classes of materials include semiconductors, carbon fibers, organic light-emitting diodes (OLEDs) and biomaterials. The development of advanced materials is also being greatly accelerated by modern computing resources and algorithms, including big data and artificial intelligence (AI). The development of advanced materials requires researchers to master the relevant scientific tools, to work in and lead interdisciplinary teams, and to utilize available advanced computational methods to succeed in this highly competitive field.

1.2 Concept

The field of materials sciences is experiencing significant growth, encompassing a diverse range of research areas. The Advanced Materials (AdvMat) Master Program at Constructor University deliberately encompasses a range of disciplines, including chemistry, physics, and related computational and engineering subjects. This interdisciplinary approach provides students with a distinctive educational experience. The curriculum includes instruction on molecular functions, quantum systems, and diverse applications, including biomaterials and hybrid materials.

The program integrates innovative computational methodologies, including big data and AI, with experimental laboratory work and research projects. This interdisciplinary approach is achieved through the integration of experts from disparate research domains, who collaborate in joint lectures and research initiatives across various research groups at Constructor University. The program places a strong emphasis on scientific problem solving and conducting research. Consequently, students commence their studies with laboratory rotations, which enable them to gain preliminary experience in diverse research areas. In their second and third semesters, students are guided towards more advanced and independent scientific research. The latter is supported by research collaborations with both internal and external partners.

The combination of modern teaching concepts with co-taught courses by chemists and physicists across the spectrum of materials science and the program's robust research orientation guarantee that graduates receive exemplary training. Moreover, the students will be equipped for successful careers in academia or industry within the rapidly evolving field of materials science. Additionally, the program serves as a nexus for materials science in diverse engineering domains, offering graduates exceptional employment prospects across a multitude of industries.

1.3 Qualification Aims

1.3.1 Educational Aims

The MSc in Advanced Materials is a consecutive research-oriented study program that aims to educate independent scientists, able to pursue successful careers in materials science and related fields, both in academia and industry. To accomplish this, the program emphasizes interdisciplinary approaches, integrating physics and chemistry to address the multifaceted nature of materials research. Consequently, the program not only conveys topical knowledge but also fosters general analytical and problem-solving skills, enhanced by data analysis and AI expertise.

Students will gain experience applying these skills in meaningful research projects and learn how to advance scientific knowledge by developing original research hypotheses and designing, planning, and executing simulations and experiments to test them. They will also gain the scientific rigor to scrutinize, interpret and defend theoretical and experimental results to international scientific standards. A further objective of this program is to equip students with the ability to communicate effectively in an interdisciplinary research environment. This will be achieved by developing and refining their skills in visualizing scientific data, efficiently communicating results and concepts to both scientific and general audiences through oral presentations, written research proposals or scientific publications, and discussing them with their peers.

The freedom to select specific courses in the elective area and to select host groups with specific topics in the research area ensures that students gain expert knowledge in specific subareas of material sciences.

Throughout the MSc program, the students will refine their ability to reflect on their own performance, work in interdisciplinary and diverse teams and act as a responsible, ethical, and effective stakeholder in the scientific community and beyond.

1.3.2 Intended Learning Outcomes

By the end of this program, students will be able to:

1. Explain key concepts for advanced materials, which include structure-property relations, self-assembly, surface and interface processes, thermodynamic limitations, numerical modelling on various scales, and nanoscale effects in low-dimensional materials.
2. Construct innovative research hypotheses and design experiments to test them.
3. Critically examine and creatively apply advanced experimental techniques to obtain reliable data and answer complex scientific questions.
4. Understand and apply common computational tools, algorithms and databases for data processing, analysis and visualization used in materials science.
5. Construct mathematical models and perform computational simulations to generate and test hypotheses in the field of materials science.
6. Critically analyze scientific results, experimental approaches, computational simulations, and research hypothesis from the major fields of materials science.
7. Engage in professional writing and effective scientific communication.
8. Present research using state-of-the-art visualization tools to effectively communicate with scientific and non-scientific audiences.
9. Take responsibility for their own learning, personal and professional development and role in diverse teams, evaluating critical feedback and self-analysis, and adhering to ethical standards.

1.4 Target Audience

The AdvMat MSc program is designed for students with a strong scientific background and quantitative skills holding a bachelor's degree in a relevant discipline, i.e., physics, chemistry or engineering disciplines related to materials science. They should be excited to work in international, interdisciplinary research teams, be prepared to exploit the potential of modern computational techniques including big-data and artificial intelligence, and be proficient in English, the language of education. Moreover, the program aspires to attract international students from a variety of cultural and geographical backgrounds to foster a diverse community with room for exchange and creativity.

1.5 Career Options

There is an increasing worldwide demand for researchers in advanced materials science who are also proficient in data analytics. The MSc program in Advanced Materials will prepare students primarily for careers as independent scientists at the frontiers of research and development in universities, research institutes and industrial laboratories.

The practical components and application relevance in the training allow graduates to directly integrate in and contribute to industrial laboratories, which value the in-flow of cutting-edge knowledge by the graduates. These employers also need trained graduates with a Master of Science degree for administration, technical support, patent offices, service, and sales, to name but a few examples.

Finally, the fact that graduates of the program have learned to communicate with specialists from different fields is a highly demanded qualification in many consulting, policymaking, administration, and governmental jobs. In an increasingly technology-driven world, individuals in decision-making positions need to have sound knowledge on diverse topics such as computing and microelectronics, chemical technology, energy resources and sustainability, all of which are touched upon by an education within Constructor University's graduate program in Advanced Materials.

Graduates can enter the job market, e.g., as Materials Scientist/Engineer, Research and Development (R&D) Scientist, Materials Characterization Specialist, Consultant (Materials Science), or Patent Examiner (Materials Focus). Successful students with more theoretical or computational experience will also be thought after by IT companies and consulting firms.

The Career Services Center supports students in their career development by offering high-quality training, coaching, and networking opportunities. This includes support with CV writing, cover letters, interview preparation, presentations, business etiquette, employer research, and connections with companies. We also host events like the Career Fair, helping students expand their professional networks. Our goal is to guide students toward rewarding careers after graduating from Constructor University. Additionally, we help students and graduates build a lasting global network through our strong alumni community, essential for exploring opportunities in academia, industry, and beyond. For more information, please contact the Career Service Center (https://constructor.university/student-life/career-services) .

1.6 Admission Requirements

The Advanced Materials graduate program requires students to hold bachelor's degree in a relevant discipline, i.e., physics, chemistry or engineering disciplines, the latter need to be related to materials science. Applicants need to prove a strong interest in the contents of the study program in a motivation letter. The general "Admission and Enrollment Policies" of Constructor University apply (see Academic policies | Constructor University). Social commitment as well as extracurricular and voluntary activities during undergraduate studies, e.g., university service, clubs, varsity, social work, etc. will be considered.

Additionally, participants should possess elevated analytical, problem solving and verbal communication skills, which are to be substantiated in recommendation letters.

Study at Constructor University takes place in a highly intercultural environment. It is therefore necessary to be willing to join such a multicultural-international community and work together with students and faculty across various fields of interest at Constructor University.

Admission to Constructor University is selective and based on a candidate's university achievements, recommendations and self-presentation. Students admitted to Constructor University demonstrate exceptional academic achievements, intellectual creativity, and the desire and motivation to make a difference in the world.

The following documents need to be submitted with the application:

- Letter of motivation
- Curriculum vitae (CV)
- Official or certified copies of university transcripts
- Bachelor's degree certificate or equivalent
- Language proficiency test results (minimum score of 90 (TOEFL), 6.5 (IELTS) or 110 (Duolingo)).
- Copy of Passport
- Letter of recommendation.

Formal admission requirements are subject to higher education law and are outlined in the Admission and Enrollment Policy of Constructor University.

For more detailed information about the admission visit:
Application Information | Constructor University

1.7 More information and contacts

For more information on the study program please contact the Study Program Coordinator:

Prof. Dr. Veit Wagner

Professor of Physics

Email: vwagner@constructor.university

or visit our program website: Advanced Materials | Constructor University

For more information on Student Services please visit:
https://constructor.university/student-life/student-services

2 The Curriculum

2.1 The Curriculum at a Glance

The Advanced Materials curriculum is divided into four semesters and takes two years to complete. It is composed of foundation, core, specialization, seminar and research modules, leading to a master's thesis that may be conducted in collaboration with an external partner.

The first semester is a foundational semester, during which students from different educational and cultural backgrounds acquire and consolidate the knowledge in the essential core fields relevant for advanced materials. In parallel, students get first practical experience in scientific research work, thus laying the essential groundwork for their subsequent studies. The second semester focuses on essential knowledge for materials science, such as bottom-up and top-down materials manufacturing and design and relevant mathematical and computational approaches, while further developing scientific research work skills in both, theory and practice. The third semester allows students to gain in-depth knowledge of a specialized field of advanced materials science and training them for complex scientific research tasks and scientific presentations in science and industry. Here, they can select modules that best fit their abilities and interests. It is expected that students will demonstrate the capacity to autonomously organize the preparation of solutions for theoretical and practical scientific problems. During the fourth and final semester, students work on their master's thesis.

The modules are grouped into five areas, as outlined in the Schematic Study Plan (see figure 1).

2.2 Schematic Study Scheme

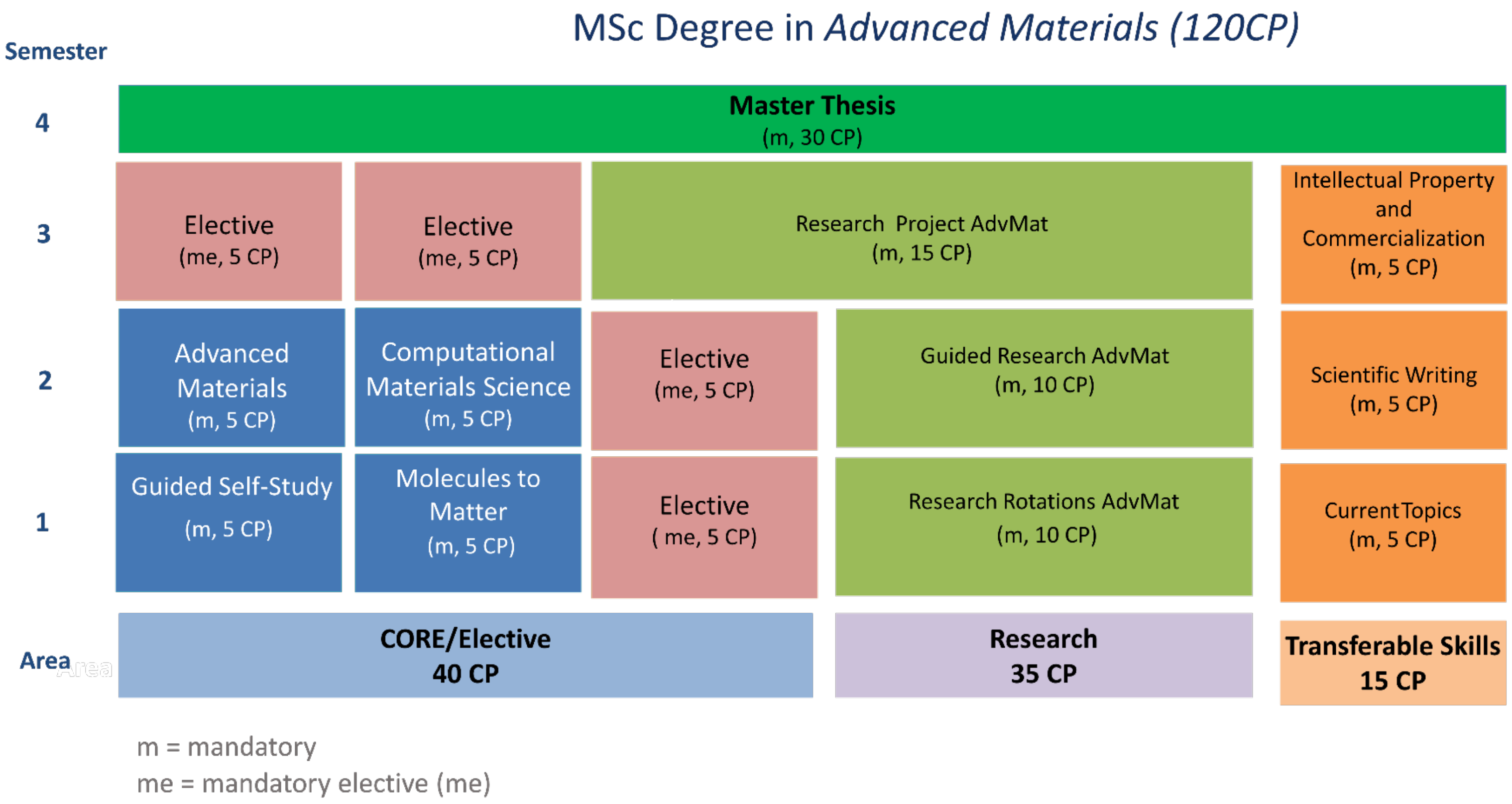

Figure 1. Schematic Study scheme

2.3 Study and Examination Plan

MSc Degree in Advanced Materials Matriculation Fall 2025							
Module Code	**Program-Specific Modules**	**Type**	**Assessment**	**Period[1]**	**Status[2]**	**Semester**	**CP**
Semester 1							**30**
	CORE Area						**10**
XXXX	**Module: Guided Self-Study**				**m**	**1**	**5**
XXXX	Guided Self-Study	Self-Study, Tutorial	Written examination	Examination period			
XXXX	**Module: Molecules to Matter**				**m**	**1**	**5**
XXXX	Molecules to Matter	Lecture	Written examination	Examination period			
	Elective Area				**me**		**5**
	- students choose one module from those listed below						
	Research Area						**10**
XXXX	**Module: Research Rotations AdvMat**				**m**	**1**	**10**
XXXX	Research Rotation AdvMat	Lab	Portfolio Assessment, Project Reports	During semester			
	Transferable Skills Area						**5**
XXXX	**Module: Current Topics**				**m**	**1**	**5**
XXXX	Current Topics	Seminar	Poster presentation	During semester			
Semester 2							**30**
	CORE Area						**10**
XXXX	**Module: Advanced Materials**				**m**	**2**	**5**
XXXX	Advanced Materials	Lecture	Written examination	Examination period			
XXXX	**Module: Computational Materials Science**				**m**	**2**	**5**
XXXX	Computational Materials Science	Lecture	Written examination	Examination period			2.5
	Computational Materials Science-Lab	Lab	Laboratory report	During semester			2.5
	Elective Area				**me**		**5**
	- Students choose a module from those listed below.						
	Research Area				**m**		**10**
XXXX	**Module: Guided Research AdvMat**				**m**	**2**	**10**
XXXX	Guided Research AdvMat	Lab	Project Report	During semester			
	Transferable Skills Area						**5**
XXXX	**Module: Scientific Writing**				**m**	**2**	**5**
XXXX	Scientific Writing	Seminar	Term Paper	During semester			

Semester 3							**30**
	Elective Area				**me**		**10**
	- Students choose two modules from those listed below.						
	Research Area				**m**		**15**
XXXX	**Module: Research Project AdvMat**				**m**	**3**	**15**
XXXX	Research Project AdvMat	Lab	Project Assessment	During semeter			
	Transferable Skills Area						**5**
XXXX	**Module: Intellectual Property and Commercialization**				**m**	**3**	**5**
XXXX	Intellectual Property and Commercialization	Lecture	Oral Examination	Flexible			
Semester 4							**30**
	Master Thesis						**30**
XXXX	**Module: Master Thesis AdvMat**				**m**	**4**	**30**
XXXX	Master Thesis AdvMat		Thesis				
Total CP							**120**

[1] Each lecture period lasts 14 semester weeks and is followed by reading and examination days. Written examinations are centrally scheduled during weeks 15 and 16. For all other assessment types, the timeframes indicated in the above table stipulate

[2] m = mandatory, me = mandatory elective

Elective Area *Students choose 20 CP of manadatory electives*							
XXXX	**Module: Supramolecular Chemistry**				**me**	**1 or 3**	**5**
XXXX	Supramolecular Chemistry	Lecture	Written examination	During semester			
XXXX	**Module: Modern Analytical Methods**				**me**	**1**	**5**
XXXX	Modern Analytical Methods	Lecture	Written examination	Examination period			
XXXX	**Module: Nanoscale Devices**				**me**	**3**	**5**
XXXX	Nanoscale Devices	Lecture	Written examination	Examination period			
XXXX	**Structure Elucidation**				**me**	**2**	**5**
XXXX	Structure Elucidation	Lecture	Written examination	Examination period			
XXXX	**Module: Advanced Statistical and Quantum Physics**				**me**	**2**	**5**
XXXX	Advanced Statistical and Quantum Physics	Lecture	Written examination	Examination period			
XXXX	**Module: Advanced Solid State Physics**				**me**	**3**	**5**
XXXX	Advanced Solid State Physics	Lecture	Project report	During semester			
XXXX	**Module: Optical Characterization of Advanced Materials**				**me**	**3**	**5**
XXXX	Optical Characterization of Advanced Materials	Lecture	Written examination	Examination period			
XXXX	**Module: Applications of Advanced Materials**				**me**	**3**	**5**
XXXX	Applications of Advanced Materials	Lecture	Written examination	Examination period			
Total CP							**40**

Figure 2. Study and examination plan

2.4 Core Area: 20 CP

Modules of the CORE area convey the essential concepts as well as key experimental and computational approaches in materials science. Hence all four Core modules (20 CP) are mandatory (m) to pursue a master's degree in Advanced Materials:

- CORE Module: Guided Self-Study (m, 5 CP)
- CORE Module: Molecules to Matter (m, 5 CP)
- CORE Module: Advanced Materials (m, 5 CP)
- CORE Module: Computational Materials Science (m, 5 CP)

2.5 Research Area: 35 CP

The graduate program in Advanced Materials provides a unique opportunity to conduct research in different scientific areas by providing three stages of research experience (semesters 1-3) with increasing complexity: During the Research Rotations AdvMat (semester 1) students perform three small, supervised tasks in three different research groups, allowing them to explore different methodologies in advanced materials research. The Guided Research (semester 2) is conducted in a single research group allowing for a more complex research project to be addressed under supervision. The Research Project is a 15 CP module, in which students are expected to also design the experimental strategy for their project and to perform experiments more independently. To pursue a master's degree in advanced Materials, all three Research modules (35 CP) need to be taken as mandatory modules (m):

- RESEARCH Module: Research Rotations AdvMat (m, 10 CP)
- RESEARCH Module: Guided Research AdvMat (m, 10 CP)
- RESEARCH Module: Research Project AdvMat (m, 15 CP)

2.6 Transferable Skills Area: 15 CP

In the transferable skills area, three mandatory modules (15 CP) need to be taken. In these modules, the students learn how to present scientific data in oral and written format. Furthermore, they will explore options to secure their intellectual property rights in a scientific setting and for commercialization:

- METHODS Module: Current Topics (m, 5 CP)
- METHODS Module: Scientific Proposal Writing (m, 5 CP)
- METHODS Module: Intellectual Property and Commercialization (m, 5 CP)

2.7 Elective Area: 20 CP

To further deepen their knowledge in selected areas, students may choose elective modules. To fulfil the requirement for a master's degree in Advanced Materials, students need to take four of the following mandatory elective modules (me). To fulfil the credit requirement, any modules can be combined given that the indicated co- or prerequisites are being met:

- ELECTIVES Module: Supramolecular Chemistry (me, 5 CP)
- ELECTIVES Module: Modern Analytical Methods (me, 5 CP)
- ELECTIVES Module: Structure Elucidation (me, 5 CP)
- ELECTIVES Module: Nanoscale Devices (me, 5 CP)
- ELECTIVES Module: Advanced Statistical and Quantum Physics (me, 5 CP)
- ELECTIVES Module: Advanced Solid State Physics (me, 5 CP)
- ELECTIVES Module: Optical Characterization of Advanced Materials (me, 5 CP)
- ELECTIVES Module: Applications of Advanced Materials (me, 5 CP)

2.8 Master thesis 30 CP

In the fourth semester, students conduct independent research in one of the participating research groups. To complete this module, students write a mandatory master thesis guided and supported by their research supervisor, worth of 30 credit points.

- Thesis Module: Master Thesis (m, 30 CP)

3 Advanced Materials Graduate Program Regulations

3.1. Scope of these Regulations

The regulations in this handbook are valid for all students who entered the Advanced Materials graduate program at Constructor University in Fall 2025. In case of conflict between the regulations in this handbook and the general Policies for Master Studies, the latter apply (see Academic policies | Constructor University).

In exceptional cases, certain necessary deviations from the regulations of this study handbook might occur during the course of study (e.g., change of the semester sequence, assessment type, or the teaching mode of courses).

In general, Constructor University reserves therefore the right to change or modify the regulations of the program handbook also after its publication at any time and in its sole discretion.

3.2. Degree

Upon successful completion of the study program, students are awarded a Master of Science (MSc) degree in Advanced Materials.

3.3. Graduation Requirements

In order to graduate, students need to obtain 120 credit points. In addition, the following graduation requirements apply:

- Students need to complete all mandatory components of the program as indicated in chapter 2 of this handbook.

3.4 Other Program-specific Policies & Practices

Close contact and cooperation between program representatives and students are crucial. Therefore, regular meetings are held to continuously evaluate the program, its modules and workshops, supervision, and opportunities. In doing so, the Study Program Chair and the faculty involved gain important insights into students' experiences, demands, and overall impressions of the program. On the module component level, students are asked to complete module component evaluations to ensure that the modules are high-quality and that lecturers can make any necessary changes.

The study program chair intensively uses this feedback and feedback from laboratory heads to improve the learning environment, the program's offering, and its progress. The current program was shaped through input from previous experiences and discussions with several stakeholders, including students and industry practitioners. In exceptional cases, certain necessary deviations from the regulations of this study handbook might occur (e.g., change of the semester sequence, assessment type, or the teaching mode of courses). Constructor University reserves therefore the right to modify the regulations of the program handbook.

4 Modules

4.1 CORE Area (20 CP)

4.1.1 Guided Self- Study

Module Name:	**Guided Self-Study**
Module Code:	-
CP:	5
Frequency:	Annually (Fall)
Year:	1
Semester:	1
Mandatory Status:	Mandatory for AdvMat
Module Components:	1
Program Affiliation:	MSc Advanced Materials (AdvMat)
Module Coordinator(s):	Prof. Dr. Veit Wagner, Prof. Dr. Ulrich Kortz
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	
Seminar:	
Lab:	
Tutorial:	17.5 h
Other:	
Exam Preparation:	20 h
Independent Study:	87.5 h
Hours Total:	125 hours

Module Components	**Number**	**Type**	**CP**
Guided Self-Study	xxxx	Self-Study and Tutorial	5

Module Description

Advanced Materials is inherently and strongly interdisciplinary, and encompasses physics, chemistry, and neighboring engineering disciplines. Successful research in this field necessitates a proper foundation in physics and chemistry as well as relevant mathematical modelling concepts and they are a pre-requisite for the 2nd semester courses of the core area and most other courses in the program. In this “Guided Self-study” module, the students will thus, depending on their academic background, repeat or acquire the necessary knowledge. The content is divided into four broad areas, Inorganic Chemistry, Organic Chemistry, Condensed Matter and Quantum Physics with its own learning goals. These goals are based on the expected knowledge after an undergraduate degree in physics, chemistry or neighboring engineering.

Based on a self-test in all four content areas, each student together with a faculty mentor will build a personalized learning plan selecting the areas of focus requiring revision or additional learning. Since most successful candidates will come with strong expertise in at least one field (i.e., chemistry or physics), usually two areas of focus will require revision or additional learning. The student will then study these topics in an “inverted classroom” setting. Reading materials and other learning materials (videos, exercises) will be provided by the faculty. In addition, regular tutorial sessions will be offered to enable students to discuss the topics. The formation of study groups will be encouraged.

Intended Learning Outcomes

By the end of the module, students will be able to:

1. Inorganic Chemistry
    a. Identify basic types of chemical reactions
    b. Perform stoichiometric calculations
    c. Understand elements and trends in the periodic table
    d. Recognize and discuss basic concepts of chemical bonding
    e. Predict the reactivity of elements and compounds
2. Organic Chemistry
    a. Understand bond strength and angles using knowledge of orbitals
    b. Recognize resonance effects versus inductive effects
    c. Understand basic mechanisms and arrow pushing in organic chemistry
    d. Differentiate some nucleophiles and electrophiles and their orbital connectivity to HOMO and LUMO
    e. Distinguish high and low energy conformations of molecules and recall their value for transition states
3. Condensed Matter Physics
    a. Determine the basic properties of gases and condensed matter based on microscopic and statistical models
    b. Describe the behavior of electrons and analyze how they influence macroscopic and electronic properties of materials
    c. Select basic experimental techniques and procedures needed to study solid state materials
4. Quantum Physics
    a. Describe particle-wave complementarity in quantum mechanics
    b. Present the theoretical foundations of quantum mechanics
    c. Solve quantum mechanics problems of practical relevance using advanced mathematical techniques
    d. Determine the energy levels of quantum systems using algebraic and analytical methods

Indicative Literature

- G.L. Miesler, P.J. Fischer, D.A. Tarr, Inorganic Chemistry, 5th Edition, Pearson, 2013
- J. Clayden, N. Greeves, and S. Warren, Organic Chemistry, Oxford University Press, 2012
- Ch. Kittel, Introduction to Solid State Physics, 8th Edition, Wiley, 2005
- D.J. Griffiths, D.F. Schroeter, Introduction to Quantum Mechanics, 3rd Edition, Cambridge University Press, 2018

Recommendations for Preparation

Review previous knowledge in chemistry and physics.

Entry Requirements

Recommended Knowledge, Abilities or Skills	Ability to obtain knowledge independently
Module Prerequisites	None
Module Co-requisites	None

Usability and Relationships to other Modules

This module provides the basic knowledge necessary to succeed in the core and elective modules and the research area.

Examination Type: Module Examination

Components	Assessment Type	Duration/length	Weight	Scope (ILOs)
Guided Self-study	Written examination	120 minutes (2 x 60 minutes)	100%	All

Module Completion: To pass this module, the module examination(s) must be passed with at least 45%.

4.1.2 Molecules to Matter

Module Name:	Molecules to Matter
Module Code:	-
CP:	5
Frequency:	Annually (Fall)
Year:	1
Semester:	1
Mandatory Status:	Mandatory for AdvMat
Module Components:	1
Program Affiliation:	MSc Advanced Materials (AdvMat)
Module Coordinator(s):	Prof. Dr. Veit Wagner, Prof. Dr. Torsten John
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	35 h
Seminar:	
Lab:	
Tutorial:	
Other:	
Exam Preparation:	20 h
Independent Study:	70 h
Hours Total:	125 hours

Module Components	Number	Type	CP
Molecules to Matter	xxxx	Lecture	5

Module Description

The first part of the course provides foundations as basic knowledge necessary for understanding and describing molecular and nano-scale systems and materials covering fundamental chemical and physical aspects. It emphasizes non-covalent interactions, self-assembly processes, and their role in the design of soft matter systems such as (bio)polymers, membranes, DNA nanostructures, and functional surfaces. Special attention is given to the use of nanocarriers, like liposomes, in drug delivery systems, and the interaction of materials with organic matter. Students will understand how molecular chemistry translates into material properties and applications in fields like nanotechnology, biomaterials, and functional surfaces. The second part provides a survey of the field materials sciences and will start off with an introduction to imaging and characterization techniques. This includes scanning probe microscopies (e.g., STM, AFM, SNOM) and other single molecule detections and analysis techniques (patch clamp, optical tweezers, fluorescence spectroscopy and microscopy). Also, fundamental properties of nanoscale materials (confinement, size dependent properties) will be discussed. The module is rounded of by a short account of methods to create nanostructures at surfaces.

Intended Learning Outcomes

By the end of the module, students will be able to:

1. Explain how given molecules and their functional groups can interact with each other and their surroundings
2. Analyze the role of non-covalent interactions and self-assembly in the formation and stability of molecular systems
3. Evaluate the design and application of nanomaterials, such as nanocarriers and hydrogels, and their interaction with biological matter
4. Determine the basic properties of condensed matter based on microscopic and statistical models
5. Predict the behavior of electrons and analyze how they influence macroscopic and electronic properties of materials
6. Select basic experimental techniques and procedures needed to study solid state materials
7. Communicate in scientific language using advanced field-specific technical terms.

Indicative Literature

- P. Atkins and J. DePaula. Physical Chemistry for the Life Sciences, Oxford University Press, 2015
- B.D. Ratner, A.S. Hoffman, F.J. Schoen, J.E. Lemons, Biomaterials Science: An Introduction to Materials in Medicine, Academic Press, 2014
- Ch. Kittel, Introduction to Solid State Physics, 8th Edition, Wiley, 2005
- R. Waser, Nanoelectronics and Information Technology, 3rd Edition, Wiley, 2012

Recommendations for Preparation

Review basic chemistry, quantum mechanics and statistical concepts.

Entry Requirements

Recommended Knowledge, Abilities or Skills	Basic knowledge in Chemistry and Physics
Module Prerequisites	None
Module Co-requisites	Guided Self-Study

Usability and Relationships to other Modules

This module is conceptionally linked to the Advanced Materials Module, as it focuses on basic materials description and corresponding characterization techniques. The topics introduced in this module will also support the topics discussed in the elective modules or find application in the research courses.

Examination Type: Module Examination

Components	Assessment Type	Duration/length	Weight	Scope (ILOs)
Molecules to Matter	Written examination	120 min	100%	All

Module Completion: To pass this module, the module examination has to be passed with at least 45%.

4.1.3 Advanced Materials

Module Name:	Advanced Materials
Module Code:	-
CP:	5
Frequency:	Annually (Spring)
Year:	1
Semester:	2
Mandatory Status:	Mandatory for AdvMat
Module Components:	1
Program Affiliation:	MSc Advanced Materials (AdvMat)
Module Coordinator(s):	Prof. Dr. Veit Wagner, Prof. Dr. Ulrich Kortz
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	35 h
Seminar:	
Lab:	
Tutorial:	
Other:	
Exam Preparation:	30 h
Independent Study:	60 h
Hours Total:	125 hours

Module Components	Number	Type	CP
Advanced Materials	xxxx	Lecture	5

Module Description

This course provides a survey of the field of Advanced Materials, both from a chemical and physical perspective. After a general introduction to the field, the course will focus in the first part on the (chemical) synthesis of various nanoparticles, including fullerenes and carbon nanotubes as well as metallic, semiconducting and ceramic nanoparticles. Aspects of their structure, properties, and selected applications (catalysis) will also be covered. Finally, nanoporous materials (zeolites) and nanocrystalline materials will be treated. The second part will start off with material growth and its thermodynamics, followed by coating, deposition techniques and characterization of materials. The main part covers nanostructures, magnetic/ferrorelectric crystals, composite and hybrid materials as well as novel material classes, e.g. Metal-organic Frameworks, and 2d-materials like graphene. Directed materials design for tailored properties and quantum systems is discussed including big data and artificial intelligence approaches, as well as related application for intelligent materials.

Intended Learning Outcomes

By the end of the module, students will be able to:

1. Plan methods able to produce nanoparticles
2. Predict surface reactivity and properties of nanoparticles
3. Design materials to achieve targeted properties
4. Choose growth/deposition techniques for given materials
5. Use big data and artificial intelligence approaches in the field of materials science.
6. Communicate in scientific language using advanced field-specific technical terms.

Indicative Literature

- B.D. Fahlman , Materials Chemistry, 4th edition, Springer, 2023
- L.V. Interrante, M. J. Hampden-Smith, Chemistry of Advanced Materials: An Overview, Wiley, 1997
- T. van de Ven, A. Soldera, Advanced Materials, De Gruyter, 2020
- M. Kuno, Introductory Nanoscience: Physical and Chemical Concepts, Garland, 2011
- R. Waser, Nanoelectronics and Information Technology, 3rd Edition, Wiley, 2012

Recommendations for Preparation

Review chemistry, condensed matter, and quantum mechanics concepts.

Entry Requirements

Recommended Knowledge, Abilities or Skills	Physics and Chemistry topics of Guided Self-study course
Module Prerequisites	Molecules to Matter
Module Co-requisites	None

Usability and Relationships to other Modules

This module is conceptionally linked to the Molecules to Matter Module, as it builds upon the previously introduced basic materials description and corresponding characterization techniques. The topics introduced in the Advanced Materials module are core topics of the program and support the topics discussed in the elective modules or find application in the research courses.

Examination Type: Module Examination

Components	Assessment Type	Duration/length	Weight	Scope (ILOs)
Advanced Materials	Written examination	120 min	100%	All

Module Completion: To pass this module, the module examination has to be passed with at least 45%.

4.1.4 Computational Materials Science

Module Name:	Computational Materials Science
Module Code:	-
CP:	5
Frequency:	Annually (Spring)
Year:	1
Semester:	2
Mandatory Status:	Mandatory for AdvMat
Module Components:	2
Program Affiliation:	MSc Advanced Materials (AdvMat)
Module Coordinator(s):	Prof. Dr. Ulrich Kleinekathöfer
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	17.5 h
Seminar:	
Lab:	17.5 h
Tutorial:	
Other:	
Exam Preparation:	20 h
Independent Study:	70 h
Hours Total:	125 hours

Module Components	Number	Type	CP
Computational Materials Science - Lecture	xxxx	Lecture	2.5
Computational Materials Science- Lab	xxxx	Lab	2.5

Module Description

This course provides the conceptual basis and techniques for modeling and simulating material systems at the molecular scale. The fundamental undergirding and applications of the most popular molecular simulation methods will be discussed, including recent developments towards big data analysis and machine learning. Emphasis will be placed on molecular dynamics and quantum mechanical methods such as density functional approaches, using examples from the frontier of computational materials science. Integrated practical work in the computer lab will closely follow the theoretical discussion during the lecture. Computational, hands-on, problem solving using state-of-the-art scientific software packages are performed in self- and supervised-study sessions to support familiarization, experimentation, time for creative thought, and guidance.

Intended Learning Outcomes

By the end of the module, students will be able to:

1. Use the theory and computational techniques of (bio)molecular dynamics simulations in the realm of materials science systems
2. Relate the different computational approaches including machine learning techniques in materials science simulations
3. Evaluate the relevance and value of software packages and machine learning techniques for materials science simulations
4. Apply modern simulation techniques to practical problems with a focus on Materials Science
5. Analyze, visualize and present results obtained from materials simulations
6. Construct a setup for a simulation of a simple materials science system

Indicative Literature

- LeSar, Richard, Introduction to Computational Materials Science: Fundamentals to Applications, Cambridge University Press, 2013
- Alavi, S., P, Molecular Simulations: Fundamentals and Practice, Wiley-VCH, Weinheim, 2020

Recommendations for Preparation

Students taking this course should have some general knowledge of basics physics and chemistry.

Entry Requirements

Recommended Knowledge, Abilities or Skills	Students taking this course should have some general knowledge of basics math, physics and chemistry.
Module Prerequisites	Molecules to Matter Guided Self-Study
Module Co-requisites	None

Usability and Relationships to other Modules

None

Examination Type: Module Component Examination

Components	Assessment Type	Duration/length	Weight	Scope (ILOs)
Computational Materials Science	Written examination	90 minutes	50 %	1,2,3,4
Computational Materials Science – Lab	Laboratory report	10-15 pages	50 %	1,4, 5, 6

Module Completion: To pass this module, both module component examinations must be passed with at least 45%.

4.2 Research Area (35 CP)

4.2.1 Research Rotations AdvMat

Module Name:	**Research Rotations AdvMat**
Module Code:	-
CP:	10
Frequency:	Annually (Fall)
Year:	1
Semester:	1
Mandatory Status:	Mandatory for AdvMat
Number of Module Components:	1
Program Affiliation:	MSc Advanced Materials (AdvMat)
Module Coordinator(s):	Prof. Dr. Veit Wagner, Prof. Dr. Ulrich Kortz
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	
Seminar:	
Lab:	120 h
Tutorial: individual in research groups	10 h
Other:	
Exam Preparation:	
Independent Study:	120 h
Hours Total:	250 hours

Module Components	**Number**	**Type**	**CP**
Research Rotation AdvMat	xxxx	Lab	10

Module Description

This module provides practical training on research methods applied in different areas of Materials Science. This course exposes the student to different experimental and theoretical techniques employed in participating research groups. The research training consists of three units of four weeks each that are conducted in different research groups. The selected combination of units has to fulfill the interdisciplinarity requirement, that in the end, the research rotations module contains at least i) one physics and one chemistry group, or ii) one experimental and one theoretical group. Each unit typically begins with an introduction to the technology or method concerned. The project work will then be conducted under supervision of a research group member. This leads the student to a level of competence with which they can insightfully apply the respective methods to practical, real-life tasks.

Intended Learning Outcomes

By the end of the module, students will be able to:

1. Use current technical/scientific literature
2. Apply scientific knowledge specifically for different subject areas
3. Master specific research methods from different disciplinary fields

4. Consistently apply scientific language to communicate orally and in writing his/her understanding clearly and precisely within a research group

Indicative Literature

The literature is provided individually to each student by the instructor of the respective unit.

Recommendations for Preparation

1. Identify areas or topics of interest and discuss them with your prospective unit supervisors with or before the start of the semester.
2. Students should recap their previous knowledge relevant to prospective unit hosts.
3. Review the University's Code of Academic Integrity and Policy for Safeguarding Good Research Practice.

Entry Requirements

Recommended Knowledge, Abilities or Skills	None
Module Prerequisites	None
Module Co-requisites	Guided Self-Study

Usability and Relationships to other Modules

This module provides additional insights to select a host research group for subsequent Guided Research AdvMat, Research Project AdvMat, and master thesis modules.

Examination Type: Module Component Examination

Components	Assessment Type	Duration/length	Weight	Scope (ILOs)
Research Rotation AdvMat I	Project Report	5-10 pages	33%	All
Research Rotation AdvMat II	Project Report	5-10 pages	33%	All
Research Rotation AdvMat III	Project Report	5-10 pages	34%	All

Module Completion: To pass this module, all module component examinations have to be passed with at least 45%.

4.2.2 Guided Research AdvMat

Module Name:	Guided Research AdvMat
Module Code:	-
CP:	10
Frequency:	Annually (Spring)
Year:	1
Semester:	2
Mandatory Status:	Mandatory for AdvMat
Number of Module Components:	1
Program Affiliation:	MSc Advanced Materials (AdvMat)
Module Coordinator(s):	Prof. Dr. Veit Wagner, Prof. Dr. Ulrich Kortz
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	
Seminar:	20 h
Lab:	140 h
Tutorial:	
Other:	
Exam Preparation:	
Independent Study:	90 h
Hours Total:	250 hours

Module Components	Number	Type	CP
Guided Research AdvMat	xxxx	Lab	10

Module Description

This module aims to provide the student with an understanding and command of materials sciences skills represented by the specific research group. The research can involve experimental and/or theoretical topics. The detailed structure and schedule depend on the specific demands and options of the hosting research group. The Guided Research module realizes a typical start into a new research field scenario. It begins with a literature review about the technologies and methods relevant for the specific sub-area of Advanced Materials. This leads the student to a level of competence, so that they can insightfully plan and apply the respective methods in real-life tasks. The project outcome is a scientific research report (target size: 20 pages), which is usually preceded by a presentation given within the hosts research group allowing for feedback on the project outline and content.

Intended Learning Outcomes

By the end of the module, students will be able to:

1. Use current technical/scientific literature, and distinguish good from second-rate publications
2. Formulate a research project in a research proposal style
3. Apply scientific knowledge specifically on given subject area
4. Apply specific and selected scientific materials science techniques, as required for the project

5. Present of project results for specialists

Indicative Literature

The literature is provided individually to each student by each instructor of the respective research project.

Recommendations for Preparation

Students should recap their previous knowledge relevant to prospective unit hosts.

Review the University's Code of Academic Integrity and Policy for Safeguarding Good Research Practice.

Entry Requirements

Recommended Knowledge, Abilities or Skills	None
Module Prerequisites	Research Rotations AdvMat
Module Co-requisites	None

Usability and Relationships to other Modules

This module provides additional insights to select a host research group for subsequent Research Project AdvMat, and master thesis modules.

Examination Type: Module Examination

Components	Assessment Type	Duration/length	Weight	Scope (ILOs)
Guided Research AdvMat	Project Report	15-25 pages	100%	All

Module Completion: To pass this module, the module examination has to be passed with at least 45%.

4.2.3 Research Project AdvMat

Module Name:	Research Project AdvMat
Module Code:	-
CP:	15
Frequency:	Annually (Fall)
Year:	2
Semester:	3
Mandatory Status:	Mandatory for AdvMat
Number of Module Components:	1
Program Affiliation:	MSc Advanced Materials (AdvMat)
Module Coordinator(s):	Prof. Dr. Veit Wagner, Prof. Dr. Ulrich Kortz
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	
Seminar:	30 h
Lab:	210 h
Tutorial:	
Other:	
Exam Preparation:	
Independent Study:	135 h
Hours Total:	375 hours

Module Components	Number	Type	CP
Research Project AdvMat	xxxx	Lab	15

Module Description

In the Research Project, students will complete a full research cycle, in which the student plans and conducts a research task for a specific sub-area of Advanced Materials. The Research Project can involve experimental and/or theoretical topics. The detailed structure and schedule depend on the specific demands and options of the hosting research group.

Students will consider relevant scientific literature for the planning phase and propose a general research strategy that they need to agree upon with their supervisors. In contrast to the previous research modules, a stronger focus is put on the students' independent planning and performance, accompanied by critical assessment of the obtained results allowing for strategic adjustments if needed.

The project assessment considers all steps of the research cycle, where the main criteria for the project assessment are defined individually for each project, catering to the different natures that these projects may have in different research areas and groups. Overall, the assessment will consider the students' level of acquired independence throughout the project, the active contribution to research strategy development, the quality of the obtained results and their presentation in oral and written form. As formal components, the project assessment always includes an oral presentation of the results in the research group and a scientific research report (target size: 15-25 pages).

Intended Learning Outcomes

By the end of the module, students will be able to:

1. Critically evaluate current technical/scientific literature, and distinguish good from second-rate publications
2. Formulate a research project in a research proposal style
3. Apply scientific knowledge specifically on given subject area
4. Apply specific and selected scientific materials science techniques, as required for the project
5. Critical review scientific results and adjust research tasks accordingly
6. Present of project results for specialists
7. Understand how to plan and manage the time allocated to a presentation
8. Analyze and critique the presentations of their peers

Indicative Literature

Literature is provided individually to each student by each instructor of the respective research project.

Recommendations for Preparation

Students should recap their previous knowledge relevant to prospective unit hosts.

Review the University's Code of Academic Integrity and Policy for Safeguarding Good Research Practice.

Entry Requirements

Recommended Knowledge, Abilities or Skills	**None**
Module Prerequisites	Guided Research AdvMat
Module Co-requisites	None

Usability and Relationships to other Modules

This module provides additional insights to select a host research group for a subsequent master thesis module.

Examination Type: Module Examination

Components	Assessment Type	Duration/length	Weight	Scope (ILOs)
Research Project AdvMat	Project Assessment	15-25 pages	100%	1-8

Module Completion: To pass this module, the module component examination has to be passed with at least 45%.

4.3 Transferable Skills Area (15 CP)

4.3.1 Current Topics

Module Name:	**Current Topics**
Module Code:	-
CP:	5
Frequency:	Annually (Fall)
Year:	1
Semester:	1
Mandatory Status:	Mandatory for AdvMat
Module Components:	1
Program Affiliation:	MSc Advanced Materials (AdvMat)
Module Coordinator(s):	Prof. Dr. Veit Wagner
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	17.5 h
Seminar:	17.5 h
Lab:	
Tutorial:	8 h
Other: Poster Session	2 h
Exam Preparation:	
Independent Study:	80 h
Hours Total:	125 hours

Module Components	**Number**	**Type**	**CP**
Current Topics	xxxx	Seminar	5

Module Description

This module introduces current topics and challenges of Advanced Materials. In the first half of the module, lectures are taught by faculty members and invited experts, presenting selected fields of their research activities and interests in advanced materials sciences. For each field, an overview suitable for general audiences of the scientific background, the motivation and major challenges is provided together with a list of references. This is complemented by an in-depth discussion of the specific research topics.

Each student will then select one research field introduced during the faculty presentations, and they will prepare a scientific poster on a selected topic, which they will present during a conference-style poster session (120 min) at the end of the module. The module will additionally feature tutorials providing the students with the necessary scientific skills to compose and present a poster. In addition, subject matter experts from the research groups will be available for discussion.

Intended Learning Outcomes

By the end of the module, students will be able to:

1. Independently research and analyze scientific literature.

2. Present a scientific research topic in Advanced Materials as a poster suitable for non-scientific or scientific audience.
3. Critically discuss their own and other research data in a poster session.

Indicative Literature

Literature is provided individually by each presenter in the Current Topics module.

Recommendations for Preparation

Read the syllabus and check the web sources of contributing scientists.

Entry Requirements

Recommended Knowledge, Abilities or Skills	None
Module Prerequisites	None
Module Co-requisites	None

Usability and Relationships to other Modules

This module particularly prepares for the Research modules as it introduces the participating faculty members and their respective research fields. This further gives the students a better orientation with respect to which methods are required to master current developments in Advanced Materials research. Finally, it is anticipated that students will select a topic for their poster presentations related to their choice of research groups for the Research Rotations AdvMat.

Examination Type: Module Examination

Components	Assessment Type	Duration/length	Weight	Scope (ILOs)
Current Topics	Poster presentation during poster session	120 min	100%	All

Module achievement: To pass this module, the module examination has to be passed with at least 45%.

4.3.2 Scientific Writing

Module Name:	Scientific Writing
Module Code:	-
CP:	5
Frequency:	Annually (Spring)
Year:	1
Semester:	2
4C-Model:	n/a
Mandatory Status:	Mandatory for QLS and AdvMat
Number of Module Components:	1
Program Affiliation:	MSc Quantitative Life Science
Module Coordinator(s):	Prof Dr Katrin Rosenthal
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	
Seminar:	35 h
Lab:	
Tutorial:	
Other:	
Exam Preparation:	35 h
Independent Study:	55 h
Hours Total:	125 hours

Module Components	Number	Type	CP
Scientific Writing	xxxx	Seminar	5

Module Description

This module is designed to provide students with the skills and knowledge required for effective scientific writing. The module will cover the principles of clear and concise writing, structuring scientific papers and research proposals, presenting data and results, and understanding the submission and publication process. By the end of this module, students will be able to create well-organized, coherent, and persuasive scientific documents. The seminar will enhance critical thinking skills by evaluating scientific arguments and methodologies. The ability to gather relevant information and scientific references will be improved. The seminars provide theoretical foundations and examples of scientific writing with practical sessions for writing and revising texts.

Intended Learning Outcomes

By the end of the module, students will be able to:

1. Understand key components of scientific papers, structure and standards in scientific writing, including abstracts, introductions, methods, results, and discussions and compare different types of scientific documents, such as research articles, reviews, and case studies.
2. Apply principles of effective scientific writing to produce clear and concise sentences and paragraphs and use of appropriate formatting and citation styles in scientific documents.

3. Understand the purpose and importance of scientific writing and scientific communication and understand the publication process and peer review process.
4. Analyze and evaluate data presentation, tables and figures, as well as data interpretation to identify strengths and weaknesses in writing style and structure and evaluate scientific papers for logical flow, clarity, and adherence to conventions.
5. Apply their theoretical knowledge on a writing a short proposal about their own research

Additional Learning Outcomes (Interdisciplinary Skills)

6. Develop strong written communication skills that are applicable in both academic and professional settings.
7. Understand and apply principles of ethical writing, including avoiding plagiarism and ensuring proper attribution.
8. Promote a sense of integrity and responsibility in reporting and discussing scientific findings.

Indicative Literature

- Glasman-Deal H. (2009). Science Research Writing. Imperial College Press.
- Morris J.R., Jehn T.R., Vaughan C., Pantages E., Torello T., Bucheli M., Lohman D., Lue R., Harvard University (2007). A Student's Guide to Writing in the Life Sciences. Harvard University.

Recommendations for Preparation

None.

Entry Requirements

Recommended Knowledge, Abilities or Skills	None
Module Prerequisites	None
Module Co-requisites	None

Usability and Relationships to other Modules

This module provides foundational skills that are widely applicable across various disciplines:

- Writing research papers and theses
- Preparing grant proposals and research funding applications
- Communicating scientific findings
- Enhancing overall academic performance through improved writing and presentation skills

Examination Type: Module Examination

Components	Assessment Type	Duration/length	Weight	Scope (ILOs)
Scientific Writing	Term Paper	5 pages	100%	All

Module completion: To pass this module, the module examination has to be passed with at least 45%.

4.3.3 Intellectual Property and Commercialization

Module Name:	**Intellectual Property and Commercialization**
Module Code:	-
CP:	5
Frequency:	Annually (Fall)
Year:	2
Semester:	3
Mandatory Status:	Mandatory for QLS and AdvMat
Number of Module Components:	1
Program Affiliation:	MSc Quantitative Life Science
Module Coordinator(s):	NN
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	35 h
Seminar:	
Lab:	
Tutorial:	
Other:	
Exam Preparation:	20 h
Independent Study:	70 h
Hours Total:	125 hours

Module Components	Number	Type	CP
Intellectual Property and Commercialization	xxxx	Lecture	5

Module Description

Intellectual property (IP) refers to any form of creation of the mind, and its legal protection ensures that people earn recognition or financial benefit from what they invent or create. This module provides a critical examination of intellectual property (IP) legal aspects exploring the various categories of IP protection available for novel creations. The core focus is on copyright and patents, both granting exclusive rights to inventors for a defined period. We will analyze the criteria for patentability, the different patent types, and the process of patent acquisition. The module will delve into the advantages of patents (including the ability to control the production, sale, and import of inventions) but also explore the limitations of patents (e.g., territorial restrictions and eventual expiration). The module also teaches the various paths to commercialization of IP, including licensing, sale, and establishment of a startup, and it especially focuses on aspects of regulatory affairs, product registration, on the financing, private or public, of any of these options. Finally, it explains the construction of a business plan and a pitch deck, and the selection of the team for a startup. Interactions with, and visits to, initiatives at the University, in the Constructor ecosystem, and in the city-state of Bremen are anticipated to provide an integrated view and help with first steps. By the end, participants will gain a comprehensive understanding of how copyrights and patents can be leveraged to protect inventions and drive innovation. This module is particularly valuable for researchers, aspiring inventors, and those with an entrepreneurial spirit.

Intended Learning Outcomes

By the end of this module, students will be able to:

A. Understand Intellectual Property

1. **Master Intellectual Property:** Comprehend IP concepts, distinguish IP categories, and evaluate their protection mechanisms.
2. **Copyright:** Grasp legal concepts of copyright.
3. **Patent Expertise:** Grasp patent law, including patentability criteria, types, acquisition, enforcement, and impact on innovation.

B. Commercialize Intellectual Property

4. **IP Commercialization:** Explore diverse paths for IP commercialization, identify funding sources, and construct effective business plans.
5. **Entrepreneurial Mindset:** Develop entrepreneurial skills, build high-performing teams, and leverage resources for IP venture success.

C. Achieve Strategic IP Management

6. **IP Strategy:** Analyze real-world case studies to understand IP's role in business strategy, risk management, and competitive advantage.
7. **IP Valuation and Licensing:** Evaluate IP assets, negotiate licenses, and understand the complexities of IP transactions.
8. **IP and Society:** Examine the ethical, legal, and societal implications of IP, considering issues like open innovation and IP policy.

Indicative Literature

- Reingand, N. (ed.), Intellectual Property in Academia: A Practical Guide for Scientists and Engineers, CRC Press, 2011, ISBN-10 1439837007.

Recommendations for Preparation

- The previous modules in the Transferable Skills track, i.e., Scientific Presentations and Scientific Writing, are recommended preparation, while not being strict prerequisites.

Entry Requirements

Recommended Knowledge, Abilities or Skills	
Module Prerequisites	None
Module Co-requisites	None

Usability and Relationships to other Modules

- The module belongs to the Transferable Skills.

Examination Type: Module Examination

Components	Assessment Type	Duration/length	Weight	Scope (ILOs)
Intellectual Property and commercialization	Oral Examination	30 mins	100%	All

Module Completion: To pass this module, the module examination has to be passed with at least 45%.

4.4 Elective Area

4.4.1 Supramolecular Chemistry

Module Name:	Supramolecular Chemistry
Module Code:	-
CP:	5
Frequency:	Annually (Fall)
Year:	1 or 2
Semester:	1 or 3
Mandatory Status:	Mandatory Elective for QLS and AdvMat
Module Components:	1
Program Affiliation:	MSc Quantitative Life Science
Module Coordinator(s):	Prof Dr Anna Tevyashova
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	35 h
Seminar:	
Lab:	
Tutorial:	
Other:	
Exam Preparation:	20 h
Independent Study:	70 h
Hours Total:	125 hours

Module Components	Number	Type	CP
Supramolecular Chemistry	xxxx	Lecture	5

Module Description

The course aims to offer a comprehensive overview and foundational knowledge of supramolecular chemistry, focusing on non-covalent interactions. It covers a wide variety of these interactions, including hydrogen bonding, van der Waals forces, ionic interactions, and π-π stacking. Emphasis is placed on the principles governing these interactions and their roles in different chemical contexts. In drug design and discovery, understanding non-covalent interactions is essential for the rational design of drugs and inhibitors, which depend on specific binding to biological targets. In biomolecular engineering, the ability to manipulate and design supramolecular assemblies facilitates the creation of novel biomaterials and bio-inspired systems. Insights from supramolecular chemistry are also valuable in systems biology for modeling complex biological networks and understanding the emergent properties of biological systems. The principles of self-assembly and molecular recognition are fundamental in nanotechnology for developing nanoscale devices and materials. Furthermore, knowledge of non-covalent interactions enhances the development and application of advanced analytical techniques, such as spectroscopy and chromatography, which are crucial for probing molecular structures and dynamics. Supramolecular chemistry also provides the molecular framework for the quantitative methods essential for analyzing and modeling complex systems.

Intended Learning Outcomes

By the end of the module, students will be able to:

- Account for fundamental concepts, methods and theories within supramolecular chemistry.
- Identify, analyze, and apply non-covalent interactions in diverse chemical contexts.
- Assess the current problems and research in the field.
- Anticipate the importance of supramolecular association within the life sciences and
- Interpret, analyze and evaluate experimental data of supramolecular interaction.

Indicative Literature

- Jonathan W Steed, Jerry L Atwood, Supramolecular Chemistry, 2nd Ed Wiley-Blackwell, 2009, ISBN-13: 978-0470512340

Recommendations for Preparation

To prepare for this course, it is recommended that students have a solid background in basic chemistry, particularly in physical and organic chemistry. Reviewing foundational concepts in these areas will help students grasp the more advanced topics covered in the course. Additionally, reading introductory materials on supramolecular chemistry can provide a useful head start, ensuring that students are well-prepared to engage with the course content.

Entry Requirements

Recommended Knowledge, Abilities or Skills	Knowledge of Organic Chemistry, Inorganic Chemistry, Physical Chemistry and Biochemistry is required.
Module Prerequisites	None
Module Co-requisites	None

Usability and Relationships to other Modules

The course plays a foundational role in understanding complex biological and chemical systems. Its focus on non-covalent interactions provides essential insights into the mechanisms underlying molecular recognition, self-assembly, and catalysts. These principles are critical for successful completion of Computational Life Science, Modeling and Simulation, Advanced Molecular Simulations, as well as Quantitative Experiments in Life Science modules. The principles of supramolecular chemistry are integral to the development of advanced materials.

Examination Type: Module Examination

Components	Assessment Type	Duration/length	Weight	Scope (ILOs)
Supramolecular Chemistry	Written examination	120 min	100%	All

Module Completion: To pass this module, the module examination has to be passed with at least 45%.

4.4.2 Modern Analytical Methods

Module Name:	**Modern Analytical Methods**
Module Code:	-
CP:	5
Frequency:	Annually (Fall)
Year:	1
Semester:	1
Mandatory Status:	Mandatory Elective for AdvMat
Module Components:	1
Program Affiliation:	MSc Advanced Materials (AdvMat)
Module Coordinator(s):	Prof. Dr. Jürgen Fritz
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	35 h
Seminar:	
Lab:	
Tutorial:	
Other:	
Exam Preparation:	20 h
Independent Study:	70 h
Hours Total:	125 hours

Module Components	Number	Type	CP
Modern Analytical Methods	xxxx	Lecture	5

Module Description

Experimental analytical methods are of central importance for any experimental science to confirm or falsify theories, to discover new materials, or to characterize samples. This module gives students an overview of major and current experimental methods to characterize materials and molecules, to investigate their structure, composition and major properties. Students will get a general understanding of the advantages and limitations of different methods, will learn about their underlaying physics, and get an idea of sample preparation, parameters for the operation of instruments, and interpretation of results. When reading scientific publications students will be able to judge the importance, suitability and reliability of the experimental methods used. The course includes discussion on microscopy (optical, electron, and scanning probe microscopy), spectroscopy (UV-Vis, IR), structural and compositional analysis (X-ray diffraction, NMR, mass spectrometry), surface analysis and structuring (ellipsometry, UPS, XPS, microfabrication), and basic methods to characterize electrical properties (electrical conductivity, IV curves). Lectures are complemented by reading assignments from scientific literature and / or homework with sample calculations.

Intended Learning Outcomes

By the end of the module, students will be able to:

1. Familiarize themselves with the physics and instrumentation of major experimental analytical techniques in materials science.
2. To judge on the suitability and reliability of experimental methods used in current literature.
3. Assess the suitability and importance of experimental results of different experimental methods.
4. Select a suitable experimental method to characterize and investigate samples.
5. To support or falsify findings, models or theories in materials science by using the appropriate experimental method.

Indicative Literature

- R. Srinivasan, T. G. Ramesh, G. Umesh, C. S. Sundar, Experimental Techniques in Physics and Material Science: Principles and Methodologies, World Scientific, 2023.

Recommendations for Preparation

Repeat and refresh undergraduate physics (at least first year physics).

Entry Requirements

Recommended Knowledge, Abilities or Skills	1st year physics plus some advanced physics. Exposure to research and some experimental techniques.
Module Prerequisites	None
Module Co-requisites	None

Usability and Relationships to other Modules

Serves as elective for the MSc Advanced Materials graduate program.

Examination Type: Module Examination

Components	Assessment Type	Duration/length	Weight	Scope (ILOs)
Modern Analytical Methods	Written Examination	120 min	100%	All

Module Completion: To pass this module, the module examination has to be passed with at least 45%.

4.4.3 Nanoscale Devices

Module Name:	**Nanoscale Devices**
Module Code:	-
CP:	5
Frequency:	Annually (Fall)
Year:	2
Semester:	3
Mandatory Status:	Mandatory Elective for AdvMat
Module Components:	1
Program Affiliation:	MSc Advanced Materials (AdvMat)
Module Coordinator(s):	Prof. Dr. Mojtaba Joodaki, Prof. Dr. Veit Wagner
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	35 h
Seminar:	
Lab:	
Tutorial:	
Other:	
Exam Preparation:	20 h
Independent Study:	70 h
Hours Total:	125 hours

Module Components	**Number**	**Type**	**CP**
Nanoscale Devices	xxxx	Lecture	5

Module Description

The course focuses on electronic materials and technologies to enable nanoscale devices. It provides basic background for a variety of concepts utilizing advanced electronic materials and novel devices and emphasizes the underlying principles of operation. The course starts from basic semiconductors, their heterostructures and charge carrier properties with related light-matter interaction to introduce standard electronic device concepts, i.e. diodes, transistors, photovoltaic cells and light-emitting devices. Thereafter improved designs by nano-structuring of materials, e.g. for carrier confinement and light propagation management, are introduced and discussed. The course concludes with discussing device concepts utilizing novel non-standard materials as there are 2D-semiconductors, graphene, quantum dots and organic semiconductors.

Intended Learning Outcomes

By the end of the module, students will be able to:

1. Explain basic electronic device operational principals
2. Calculate carrier and light confinement and related device parameter improvements
3. Categorize charge carrier transport regimes
4. Predict beneficial properties offered by novel non-standard materials
5. Communicate in scientific language using advanced field-specific technical terms.

Indicative Literature

- S. M. Sze, K. K. Lee Semiconductor Devices: Physics and Technology, Wiley, 2006.
- R. Waser, Nanoelectronics and Information Technology, 3rd Edition, Wiley, 2012
- M. Joodaki, Selected Advances in Nanoelectronic Devices, Springer, 2013

Recommendations for Preparation

Revise basics of electromagnetism, condensed matter and statistics. Recall semiconductor materials discussed in Advanced Materials.

Entry Requirements

Recommended Knowledge, Abilities or Skills	Basic knowledge in solid state physics
Module Prerequisites	None
Module Co-requisites	None

Usability and Relationships to other Modules

The module benefits from the concepts introduced in Molecules to Matter and Advanced Materials. Topics discussed find application in the research courses.

Examination Type: Module Examination

Components	Assessment Type	Duration	Weight	Scope
Nanoscale Devices	Written examination	120 min	100%	All

Module Completion: To pass this module, the module examination has to be passed with at least 45%.

4.4.4 Structure Elucidation

Module Name:	Structure Elucidation
Module Code:	-
CP:	5
Frequency:	Annually (Spring)
Year:	1
Semester:	2
Mandatory Status:	Mandatory Elective for QLS and AdvMat
Module Components:	1
Program Affiliation:	MSc Quantitative Life Science
Module Coordinator(s):	Prof. Dr. Ulrich Kortz, Prof. Nikolai Kuhnert
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	35 h
Seminar:	
Lab:	
Tutorial:	
Other:	
Exam Preparation:	20 h
Independent Study:	70 h
Hours Total:	125 hours

Module Components	Number	Type	CP
Structure Elucidation	xxxx	Lecture	5

Module Description

Modern Life Science and Material Science operate at the molecular level. The individual chemical structure defines the properties of biomolecules and materials and interactions. Hence it forms the basis of life and of material science. A thorough understanding of instrumental methods used for chemical structure elucidation in solution, in the solid state and in the gas phase, and their application to “known” and novel “unknown” substances is therefore an essential part of both MSc programs.

The module builds on previous knowledge at the Bachelor level and gives an intermediate level introduction and actual exposure to key experimental techniques such as nuclear magnetic resonance (NMR) spectroscopy, single crystal X-ray diffraction, infrared (IR) spectroscopy, mass spectrometry, Mössbauer spectroscopy and electron paramagnetic resonance (EPR) spectroscopy. Typically, a chemical structure elucidation process requires the use of a combination of several experimental techniques, which will be presented to the students along with applied exercises. The module will further introduce more advanced techniques such as multidimensional NMR spectroscopy (homonuclear and heteronuclear) of organic and inorganic compounds, materials, metabolites and proteins, high resolution tandem mass spectrometry, and single crystal as well as powder X-ray diffraction combined with data treatment and molecular visualization using state of the art software.

Intended Learning Outcomes

By the end of the module, students will be able to:

1. Appreciate information content of spectroscopic and diffraction data
2. Predict and propose chemical structures from spectroscopic and diffraction data
3. Predict and deduce spectral data from chemical structures
4. Interpret spectral data and assign signals to molecular features
5. Recommend and rate spectroscopic experiments with a view of solving ambiguous chemical structure problems

Indicative Literature

- Sternhill and Kalman 2D NMR spectroscopy
- Sternhill and Kalmann Solving organic spectroscopic problems
- David W. H. Rankin, Norbert W. Mitzel, Carole A. Morrison: Structural Methods In Molecular Inorganic Chemistry, 2nd edition, Wiley, 2013.

Recommendations for Preparation

Background literature for preparation provided by individual faculty.

Entry Requirements

Recommended Knowledge, Abilities or Skills	Basic knowledge on chemical bonding and spectroscopic techniques (BSc level Analytical Methods and Inorganic Chemistry); Understanding of chemical structure and bonding
Module Prerequisites	Guided self-study
Module Co-requisites	

Usability and Relationships to other Modules

NA

Examination Type: Module Examination

Components	Assessment Type	Duration/length	Weight	Scope (ILOs)
Structure Elucidation	Written Examination	120 min	100%	All

Module Completion: To pass this module, module examination has to be passed with at least 45%.

4.4.5 Advanced Statistical and Quantum Physics

Module Name:	**Advanced Statistical and Quantum Physics**
Module Code:	-
CP:	5
Frequency:	Annually (Spring)
Year:	1
Semester:	2
Mandatory Status:	Mandatory Elective for AdvMat
Module Components:	1
Program Affiliation:	MSc Advanced Materials (AdvMat)
Module Coordinator(s):	Prof. Dr. Peter Schupp, Prof. Dr Sören Petrat
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	35 h
Seminar:	
Lab:	
Tutorial:	
Other:	
Exam Preparation:	20 h
Independent Study:	70 h
Hours Total:	125 hours

Module Components	**Number**	**Type**	**CP**
Advanced Statistical and Quantum Physics	xxxx	Lecture	5

Module Description

This module provides an in-depth introduction to advanced topics in quantum and statistical physics such as: Entropy and information, Boltzmann distribution, quantum statistics, phase transitions, states of matter, Fermi and Bose quantum gases, Bose-Einstein condensation, superfluidity, superconductivity, Ginzburg-Landau and BCS theory; quantum systems, quantum entanglement, coherent states, mixed states, quantum channels, quantum information theory, time dependent perturbation theory, quantization of the light field and light matter interactions including laser theory. A review of basic statistical physics and thermodynamics is included, and lectures are complemented by homework exercises.

Intended Learning Outcomes

By the end of the module, students will be able to:

1. Apply knowledge of quantum mechanics, statistical physics, and many-body interactions in specific fields like super conductivity, lasers and quantum information.
2. Calculate boundary condition for stimulated light emission
3. Break down complex systems into effective interaction of composite (quasi-)particles
4. Communicate in scientific language using advanced field-specific terms.

Indicative Literature

- Silvio R.A. Salinas: Introduction to Statistical Physics, Springer New York, NY (2001)
- John Preskill: Quantum Information and Quantum Computing, available online
- David Tong: Lectures on Topics in Quantum Mechanics, available online
- David Tong: Lectures on Statistical Physics, available online

Recommendations for Preparation

Review of basic quantum mechanics, statistical physics and thermodynamics.

Entry Requirements

Recommended Knowledge, Abilities or Skills	Quantum mechanics and statistical physics at an undergraduate level.
Module Prerequisites	None
Module Co-requisites	None

Usability and Relationships to other Modules

Topics discussed find application in the research courses.

Examination Type: Module Examination

Components	Assessment Type	Duration/length	Weight	Scope (ILOs)
Advanced Statistical and Quantum Physics	Written examination	120 min	100%	All

Module Completion: To pass this module, the module examination has to be passed with at least 45%.

4.4.6 Advanced Solid State Physics

Module Name:	**Advanced Solid State Physics**
Module Code:	-
CP:	5
Frequency:	Annually (Fall)
Year:	2
Semester:	3
Mandatory Status:	Mandatory Elective for AdvMat
Module Components:	1
Program Affiliation:	MSc Advanced Materials (AdvMat)
Module Coordinator(s):	Prof. Dr. Stefan Kettemann
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	35 h
Seminar:	
Lab:	
Tutorial:	
Other:	
Exam Preparation:	
Independent Study:	90 h
Hours Total:	125 hours

Module Components	**Number**	**Type**	**CP**
Advanced Solid State Physics	xxxx	lecture	5

Module Description

This course offers an overview and guideline to derive and understand physical properties of materials in their solid state, such as metals, semiconductors and insulators. An introduction to the theory of emergent phenomena in the solid state is given, including Superconductivity, Bose-Einstein condensation, Magnetism, Anderson Localization, (Fractional) Quantum Hall Effect, Topological Insulator, Kondo Effect and Heavy Fermion physics. The theory of Quantum Phase Transitions between these phases is introduced and reviewed, an introduction to the transport theory of solid state devices is given.

Intended Learning Outcomes

By the end of the module, students will be able to:

1. Explain the theoretical foundations of solid state physics.
2. Apply the concept of emergent phenomena.
3. Derive physical properties of materials in their solid state.
4. Explain a wide range of applications of materials in their solid state
5. Communicate in scientific language using advanced field-specific technical terms

Indicative Literature

- Kittel, C., Introduction to Solid State Physics, New York: Wiley, 2018
- N.W. Ashcroft and N.D. Mermin: Solid State Physics, HRW International Editions, 1976
- Phillips, P., Advanced Solid State Physics, Cambridge University Press, 2012
- Solid State Theory, M. Sigrist, http://www.itp.phys.ethz.ch/education/fs14/sst 2014

Recommendations for Preparation

None

Entry Requirements

Recommended Knowledge, Abilities or Skills	Basic knowledge in solid state physics
Module Prerequisites	Molecules to Matter, Advanced Materials, Advanced Statistical and Quantum Physics
Module Co-requisites	None

Usability and Relationships to other Modules

Examination Type: Module Examination

Components	Assessment Type	Duration/length	Weight	Scope (ILOs)
Advanced Solid State Physics	Project Report	10 pages	100%	All

Module Completion: To pass this module, module examination has to be passed with at least 45%.

4.4.7 Optical Characterization of Advanced Materials

Module Name:	**Optical Characterization of Advanced Materials**
Module Code:	-
CP:	5
Frequency:	Annually (Fall)
Year:	2
Semester:	3
Mandatory Status:	Mandatory Elective for AdvMat
Module Components:	1
Program Affiliation:	MSc Advanced Materials (AdvMat)
Module Coordinator(s):	Prof. Dr. Arnulf Materny
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	35 h
Seminar:	
Lab:	
Tutorial:	
Other:	
Exam Preparation:	20 h
Independent Study:	70 h
Hours Total:	125 hours

Module Components	Number	Type	CP
Optical Characterization of Advanced Materials	xxxx	Lecture	5

Module Description

The module will introduce optical spectroscopy and its application to the characterization of different materials with emphasis on laser spectroscopy. Laser spectroscopy is a fundamental technique used in experimental natural sciences and is of interest for students of Physics, Chemistry, and Life Sciences. Basics concerning spectra, light sources, and spectrometers will be discussed. Additionally, different examples of important spectroscopic techniques will be given, which will enable the student to also understand different spectroscopic techniques not covered by the lectures. Main topics are Advances of Laser Spectroscopy, Fundamentals of Absorption and Emission of Light, Widths and Profiles of Spectral Lines, Fundamentals of Lasers, Doppler-Limited Laser Spectroscopy, High-Resolution Doppler-Free Laser Spectroscopy, Nonlinear Optical Spectroscopy, Femtosecond Time- Resolved Spectroscopy.

Intended Learning Outcomes

By the end of the module, students will be able to:

1. Outline fundamental aspects and instrumentation of optical spectroscopy.
2. Apply optical spectroscopy to investigate molecular and structural properties of different materials.

3. Decide on ideally suited optical spectroscopy techniques for specific problems.
4. Communicate in scientific language using advanced field-specific terms.

Indicative Literature

- Demtröder, W.: Laser Spectroscopy: Basic Concepts and Instrumentation, 3rd ed, Berlin: Springer, 2002
- Hollas, J. Michael: Modern spectroscopy, 4th ed, Chichester: John Wiley & Sons, 2004
- Publications in international journals on specific modern topics as preparation of student presentations

Recommendations for Preparation

Specific preparation is not required. However, active participation including student presentations is a mandatory requirement for achieving the intended learning outcomes.

Entry Requirements

Recommended Knowledge, Abilities or Skills	Basic knowledge in Optics, Quantum Mechanics and Quantum Systems
Module Prerequisites	Guided Self-Study
Module Co-requisites	None

Usability and Relationships to other Modules

Optical spectroscopy is an important technique used to characterize electronic and structural properties of advanced materials. Topics discussed find application in the research courses.

Examination Type: Module Examination

Components	**Assessment Type**	**Duration/length**	**Weight**	**Scope (ILOs)**
Optical Characterization of Advanced Materials	Written examination	120 min	100%	All

Module Completion: To pass this module, the module examination has to be passed with at least 45%.

4.4.8 Applications of Advanced Materials

Module Name:	Applications of Advanced Materials
Module Code:	-
CP:	5
Frequency:	Annually (Fall)
Year:	2
Semester:	3
Mandatory Status:	Mandatory Elective for AdvMat
Module Components:	1
Program Affiliation:	MSc Advanced Materials (AdvMat)
Module Coordinator(s):	Prof. Dr. Gerd-Volker Röschenthaler
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	35 h
Seminar:	
Lab:	
Tutorial:	
Other:	
Exam Preparation:	20 h
Independent Study:	70 h
Hours Total:	125 hours

Module Components	Number	Type	CP
Applications of Advanced Materials	xxxx	Lecture	5

Module Description

The module will introduce high performance materials, its synthesis and application in several industrially important areas, like energy storage devices (e.g. Lithium battery components and beyond), advanced polymers, liquid crystals for computer screens, and OLEDs (Organic Light Emitting Diodes). Since many of these functional materials could contain fluorine and fluorinated building blocks their environmental aspects and smart substitution will be discussed. Special compound characterization, e.g. multi-nuclear NMR spectroscopy will also be part and should be mandatory for students of Physics, Chemistry, and Life Sciences.

Intended Learning Outcomes

By the end of the module, students will be able to:

1. Explain fundamental aspects and strategies in functional materials.
2. List how broad the field of advanced materials is.
3. Decide on the use of functional materials knowing their properties.
4. Make educated guesses for synthetic routes.
5. Analyze the environmental impact of new advanced materials.

Indicative Literature

- Kang Xu, Electrolytes, Interfaces and Interphases: Fundamentals and Applications in Batteries, Royal Society of Chemistry; 1. Edition (12. April 2023).
- E. Lueder, P. Knoll, Sang Hee Lee, Liquid Crystal Displays: Addressing Schemes and Electro-Optical Effects (Wiley in Display Technology), Wiley, 2022.
- Takatoshi Tsujimura, OLED Display Fundamentals and Applications (Wiley-SID Series in Display Technology), 2017.
- K. Deshmukh, C. M. Hussain, Advanced Fluoropolymer Nanocomposites: Fabrication, Processing, Characterization and Applications (Woodhead Publishing Series in Composites Science and Engineering), 2023.
- S. A. Balan, T. A. Bruton, K. G. Hazard, Toward a PFAS-Free Future: Safer Alternatives to Forever Chemicals (Green Chemistry, 81), 2023.

Recommendations for Preparation

Specific preparation is not required. However, students should prepare for active participation including student presentations during class as a mandatory requirement for achieving the intended learning outcomes.

Entry Requirements

Recommended Knowledge, Abilities or Skills	Basic knowledge in Inorganic and Organic Chemistry
Module Prerequisites	None
Module Co-requisites	None

Usability and Relationships to other Modules

The module benefits from the concepts introduced in Molecules to Matter and Advanced Materials. Topics discussed find application in the research courses.

Examination Type: Module Examination

Components	Assessment Type	Duration/length	Weight	Scope (ILOs)
Applications of Advanced Materials	Written examination	120 min	100%	All

Module Completion: To pass this module, the module examination has to be passed with at least 45%.

4.5 Master Thesis

Module Name:	Master Thesis
Module Code:	-
CP:	30
Frequency:	Annually (Spring)
Year:	2
Semester:	4
Mandatory Status:	Mandatory for AdvMat
Number of Module Components:	1
Program Affiliation:	MSc Advanced Materials (AdvMat)
Module Coordinator(s):	Prof. Dr. Veit Wagner, Prof. Dr. Ulrich Kortz
Student Workload	
Asynchronous Self Study:	
Interactive Learning:	
Lecture:	
Seminar:	40 h
Lab:	420 h
Tutorial:	
Other:	
Exam Preparation:	40 h
Independent Study:	250 h
Hours Total:	750 hours

Module Components	Number	Type	CP
Master Thesis	xxxx	Thesis project	30

Module Description

The aim of this module is to train students to motivate, design, carry out and document a research project in one of the areas represented by the research groups of the graduate program. Some familiarity with specific techniques will typically have been acquired in one of the preceding research courses (Research Rotation AdvMat, Guided Research AdvMat or Research Project AdvMat). The thesis topic is determined in mutual agreement with the module instructor. They typically arise from the ongoing research in the instructor’s own research group, but it is also possible for a student to adopt a topic of his/her own choice provided the instructor agrees to supervise it. The thesis work comprises the full cycle of a scientific research endeavor: (i) identifying a relevant open research question, (ii) literature survey to put the planned work in its context and relate it to the state of the art (SoA), (iii) formulate a concrete research objective, (iv) design a research plan including a statement of criteria to evaluate the success of the project, (v) carry out the plan (with the possibility to change the original plan when motivated), (vi) document the results, (vii) analyze the results with respect to the SoA, the original objective, and the success criteria, and (viii) document all of this in a thesis report. All of this work should be done with as much self-guidance as can be reasonably expected. The instructor will likely give substantial guidance for (i) and (iii), whereas the other aspects will be addressed with larger degrees of self-guidance. The project consists of participation in the research group seminar, a thesis report (target size: 30–60 pages, and an oral presentation at the end of the course.

Intended Learning Outcomes

Discipline-Specific Skills (subject area depending on research discipline of the hosting group):

1. Understanding, at a professional level, of a circumscribed segment of the hosting group's research area
2. Ability to apply specific and selected scientific materials science techniques, as required for the project, at a professional level
3. Improve general professional skills
4. Designing and carrying out the full cycle of a scientific research project
5. Formulating a research proposal such that that it could serve as a funding proposal
6. Writing a research thesis such that it could be submitted to a scientific publication venue, or as a project report to a funding agency or industrial client
7. Presentation of project results for specialists and non-specialists

Indicative Literature

None

Recommendations for Preparation

- Students need to recap their knowledge in the specific field of their thesis.
- Identify an area or a topic of interest and discuss this with your prospective supervisor in good time.
- Create a research proposal including a research plan to ensure timely submission.
- Ensure you possess all required technical research skills or can acquire them on time.
- Review the University's Code of Academic Integrity and Policy for Safeguarding Good Research Practice.

Entry Requirements

Recommended Knowledge, Abilities or Skills	Academic writing skills
Module Prerequisites	Research Project AdvMat Molecules to Matter 10 ECTS in Elective area
Module Co-requisites	None

Usability and Relationships to other Modules

The master thesis can build on the courses Guided Research AdvMat and/or Research Project AdvMat, but the students are free to choose a different topic and a different supervisor for the master thesis.

Examination Type: Module Examination

Components	Assessment Type	Duration/length	Weight	Scope (ILOs)
Master Thesis	Thesis	30-60 pages	80%	All
Master Thesis	Oral Examination	20 minutes	20%	All

Module Completion: To pass this module, both module component examinations must be passed with at least 45%.

5 Appendix

5.1 Intended Learning Outcomes Assessment Matrix

MSc Advanced Materials					Guided Self-Study	Molecules to Matter	Advanced Materials	Computational Materials Science	Supramolecular Chemistry	Modern Analytical Methods	Structure Elucidation	Nanoscale Devices	Advanced Statistical and Quantum Physics	Advanced Solid State Physics	Optical Characterization of Advanced Materials	Applications of Advanced Materials	Research Rotations AdvMat	Guided Research AdvMat	Research Project AdvMat	Current Topics	Scientific Writing	Intellectual Property and Commercialization	Master Thesis
Semester					1	1	2	2	1	1	2	2	2	3	3	3	1	2	3	1	2	3	4
Mandatory/ Mandatory elective					m	m	m	m	me	me	me	me	me	me	me	me	m	m	m	m	m	m	m
ECTS Credits					5	5	5	5	5	5	5	5	5	5	5	5	10	10	15	5	5	5	30
	Competencies*																						
Program Learning Outcomes	**A**	**E**	**P**	**S**																			
Explain key concepts for advanced materials, which include structure-property relations, self-assembly, surface and interface processes, thermodynamic limitations, numerical modelling on various scales, and nanoscale effects in low-dimensional materials.	x					x	x	x	x		x	x	x	x									
Construct innovative research hypotheses and design experiments to test them.	x	x																x	x				x
Critically examine and creatively apply advanced experimental techniques to obtain reliable data and answer complex scientific questions.	x	x				x	x			x	x	x			x	x	x	x	x				x
Understand and apply common computational tools, algorithms and databases for data processing, analysis and visualization used in materials science.	x	x						x															
Construct mathematical models and perform computational simulations to generate and test hypotheses in the field of materials science.	x	x						x					x	x									
Scrutinize and critically analyze scientific results, experimental approaches, computational simulations, and research hypothesis from the major fields of materials science.	x	x							x	x	x	x			x	x	x	x	x	x	x	x	x
Engage in professional writing and effective scientific communication.	x	x	x	x														x	x	x	x	x	x
Present research using state-of-the-art visualization tools to effectively communicate with scientific and non-scientific audiences.	x	x	x	x														x	x	x			x
Take responsibility for their own learning, personal and professional development and role in diverse teams, evaluating critical feedback and self-analysis, and adhering to ethical standards.			x	x	x												x	x	x		x	x	x
Assessment Type																							
Written examination					x	x	x	x	x	x	x	x	x		x	x							
Term paper																					x		
Essay																							
Project report														x			x	x					
Poster presentation																				x			
Laboratory report								x															
Program Code																							
Oral examination																						x	x
Presentation																							
Practical Assessments																							
Project Assessments																			x				
Portfolio Assessments																	x						
Master Thesis																							x
Module Achievements																							

*Competencies: A-scientific/academic proficiency; E-competence for qualified employment; P-development of personality; S-competence for engagement in society

Figure 3. Intended Learning Outcomes Assessment- Matrix