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 2025- V1.1		Feb 02, 2026	Implementation of Examination Concept according to policies.
Fall 2025 – V1	Sep 01, 2025		
		Jan 29, 2025	Update of the chapter 3.1 based on the decision of the Academic Senate
		Dec 11, 2024	Originally approved by the Academic Senate

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 master program in Advanced Materials (MSc) 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 master 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 master 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 at Constructor University. 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 master program in Advanced Materials (MSc) 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

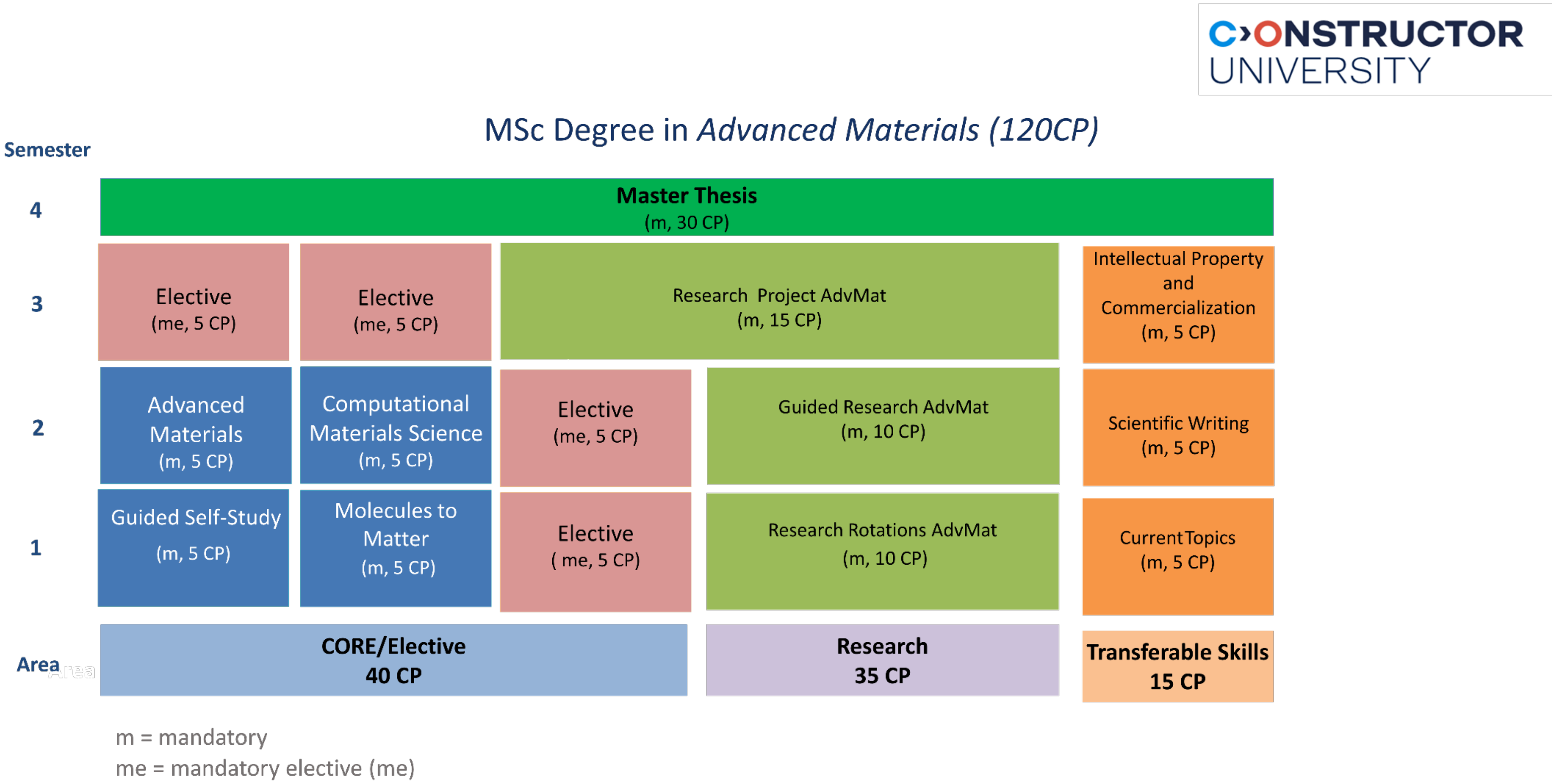

Figure 1. Schematic Study scheme

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**
MAM-CO-01	**Module: Guided Self-Study**				**m**	**1**	**5**
MAM-CO-01-A	Guided Self-Study	Self-Study, Tutorial	Written examination	Examination period			
MAM-CO-02	**Module: Molecules to Matter**				**m**	**1**	**5**
MAM-CO-02-A	Molecules to Matter	Lecture	Written examination	Examination period			
	Elective Area				**me**		**5**
	- students choose one module from those listed below						
	Research Area						**10**
MAM-RES-01	**Module: Research Rotations AdvMat**				**m**	**1**	**10**
MAM-RES-01-A	Research Rotation AdvMat	Lab	Portfolio Assessment, Project Reports	During semester			
	Transferable Skills Area						**5**
MAM-TS-01	**Module: Current Topics**				**m**	**1**	**5**
MAM-TS-01-A	Current Topics	Seminar	Poster presentation	During semester			
Semester 2							**30**
	CORE Area						**10**
MAM-CO-03	**Module: Advanced Materials**				**m**	**2**	**5**
MAM-CO-03-A	Advanced Materials	Lecture	Written examination	Examination period			
MAM-CO-04	**Module: Computational Materials Science**				**m**	**2**	**5**
MAM-CO-04-A	Computational Materials Science	Lecture	Written examination	Examination period			2.5
MAM-CO-04-B	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**
MAM-RES-02	**Module: Guided Research AdvMat**				**m**	**2**	**10**
MAM-RES-02-A	Guided Research AdvMat	Lab	Project Report	During semester			
	Transferable Skills Area						**5**
MQLS-TS-02	**Module: Scientific Writing**				**m**	**2**	**5**
MQLS-TS-02	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**
MAM-RES-03	**Module: Research Project AdvMat**				**m**	**3**	**15**
MAM-RES-03-A	Research Project AdvMat	Lab	Project Assessment	During semeter			
	Transferable Skills Area						**5**
MQLS-TS-03	**Module: Intellectual Property and Commercialization**				**m**	**3**	**5**
MQLS-TS-03	Intellectual Property and Commercialization	Lecture	Oral Examination	Flexible			
Semester 4							**30**
	Master Thesis						**30**
MAM-THE-01	**Module: Master Thesis AdvMat**				**m**	**4**	**30**
MAM-THE-01-A	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

[2] m = mandatory, me = mandatory elective

Elective Area							
Students choose 20 CP of manadatory electives							
MQLS-CHE-01	**Module: Supramolecular Chemistry**				**me**	**1 or 3**	**5**
MQLS-CHE-01	Supramolecular Chemistry	Lecture	Written examination	During semester			
MAM-EL-01	**Module: Modern Analytical Methods**				**me**	**1 or 3**	**5**
MAM-EL-01-A	Modern Analytical Methods	Lecture	Written examination	Examination period			
MAM-EL-02	**Module: Nanoscale Devices**				**me**	**3**	**5**
MAM-EL-02-A	Nanoscale Devices	Lecture	Written examination	Examination period			
MQLS-CHE-02	**Structure Elucidation**				**me**	**2**	**5**
MQLS-CHE-02	Structure Elucidation	Lecture	Written examination	Examination period			
MAM-EL-03	**Module: Advanced Statistical and Quantum Physics**				**me**	**2**	**5**
MAM-EL-03-A	Advanced Statistical and Quantum Physics	Lecture	Written examination	Examination period			
MAM-EL-04	**Module: Advanced Solid State Physics**				**me**	**3**	**5**
MAM-EL-04-A	Advanced Solid State Physics	Lecture	Project report	During semester			
MAM-EL-05	**Module: Optical Characterization of Advanced Materials**				**me**	**3**	**5**
MAM-EL-05-A	Optical Characterization of Advanced Materials	Lecture	Written examination	Examination period			
MAM-EL-06	**Module: Applications of Advanced Materials**				**me**	**3**	**5**
MAM-EL-06-A	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).

Updates to Study Program Handbooks are based on the policies approved by the Academic Senate on substantial and nonsubstantial changes to study programs. Students are integrated in the decision-making process through their respective committee representatives. All students affected by the changes will be properly informed.

In general, Constructor University therefore reserves 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 Examination Concept

According to the Policies for Bachelor and Master studies, modules generally carry at least five ECTS. Each program ensures appropriate examination frequency and organization, justified in an examination concept and regularly reviewed with student involvement.

Constructor University's examination concept follows the principle of Constructive Alignment (Biggs 1996), ensuring that learning outcomes, activities, and assessments are consistently aligned: students learn what is intended, and assessments both measure and shape learning. Where one assessment cannot cover all Intended Learning Outcomes (ILOs) complementary forms could be used (e.g., written exams plus lab reports). Module descriptions map ILOs to assessments.

In specific contexts, such as asynchronous online modules or courses emphasizing student engagement, Module Achievements or other types of formative assessments may support competence-oriented assessment.

Student feedback, embedded in the Quality Assurance System (QAS), systematically monitors workload, competence orientation, and alignment of ILOs and assessments. Student surveys and feedback are regulated in the Policy for student surveys and evaluations.

3.3 Degree

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

3.4 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.

3.5 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	2025-MAM-CO-01
Module ECTS	5
Program Owner	2025-AdvMat-MSc (Advanced Materials)
Module Coordinator	Prof. Dr. Ulrich Kortz Prof. Dr. Veit Wagner

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	1	Mandatory

Student Workload	
Tutorial	17.5
Exam Preparation	20
Independent Study	87.5
Total Hours	**125**

Module Components	**Number**	**Type**	**CP**
Guided Self-Study	MAM-CO-01-A	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.

Recommended Knowledge

- Review previous knowledge in chemistry and physics.
- Ability to obtain knowledge independently

Usability and Relationship to other Modules

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

Intended Learning Outcomes

No	Competence	ILO
1		Inorganic Chemistry
2	Identify	Identify basic types of chemical reactions
3	Perform	Perform stoichiometric calculations
4	Understand	Understand elements and trends in the periodic table
5	Recognize	Recognize and discuss basic concepts of chemical bonding
6	Predict	Predict the reactivity of elements and compounds
7		Organic Chemistry
8	Understand	Understand bond strength and angles using knowledge of orbitals
9	Recognize	Recognize resonance effects versus inductive effects
10	Understand	Understand basic mechanisms and arrow pushing in organic chemistry
11	Differentiate	Differentiate some nucleophiles and electrophiles and their orbital connectivity to HOMO and LUMO
12	Distinguish	Distinguish high and low energy conformations of molecules and recall their value for transition states
13		Condensed Matter Physics
14	Determine	Determine the basic properties of gases and condensed matter based on microscopic and statistical models
15	Describe	Describe the behavior of electrons and analyze how they influence macroscopic and electronic properties of materials
16	Select	Select basic experimental techniques and procedures needed to study solid state materials
17		Quantum Physics

18	Describe	Describe particle-wave complementarity in quantum mechanics
19	Present	Present the theoretical foundations of quantum mechanics
20	Solve	Solve quantum mechanics problems of practical relevance using advanced mathematical techniques
21	Determine	Determine the energy levels of quantum systems using algebraic and analytical methods

Indicative Literature

- 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
- 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

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Module Component	**Examination Type**	**Duration or Length**	**Weight (%)**	**Minimum for Pass**	**ILOs**
Guided Self-Study	Written Examination	120 minutes (2 x 60 minutes)	100	45%	All

Module Achievement

4.1.2 Molecules to Matter

Module Name	Molecules to Matter
Module Code	2025-MAM-CO-02
Module ECTS	5
Program Owner	2025-AdvMat-MSc (Advanced Materials)
Module Coordinator	Prof. Dr. Torsten John Prof. Dr. Veit Wagner

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	1	Mandatory

Student Workload	
Lecture	35
Exam Preparation	20
Independent Study	70
Total Hours	**125**

Module Components	**Number**	**Type**	**CP**
Molecules to Matter	MAM-CO-02	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.

Recommended Knowledge

- Review basic chemistry, quantum mechanics and statistical concepts.

- Basic knowledge in Chemistry and Physics

Usability and Relationship 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.

Intended Learning Outcomes

No	Competence	ILO
1	Explain	Explain how given molecules and their functional groups can interact with each other and their surroundings
2	Analyze	Analyze the role of non-covalent interactions and self-assembly in the formation and stability of molecular systems
3	Evaluate	Evaluate the design and application of nanomaterials, such as nanocarriers and hydrogels, and their interaction with biological matter
4	Determine	Determine the basic properties of condensed matter based on microscopic and statistical models
5	Predict	Predict the behavior of electrons and analyze how they influence macroscopic and electronic properties of materials
6	Select	Select basic experimental techniques and procedures needed to study solid state materials
7	Communicate	Communicate in scientific language using advanced field-specific technical terms

Indicative Literature

- 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
- P. Atkins and J. DePaula. Physical Chemistry for the Life Sciences, Oxford University Press, 2015
- R. Waser, Nanoelectronics and Information Technology, 3rd Edition, Wiley, 2012

Entry Requirements

Prerequisites	None
Co-requisites	2025-MAM-CO-01 Guided Self-Study
Additional Remarks	None

Assessment and Completion

Module Component	Examination Type	Duration or Length	Weight (%)	Minimum for Pass	ILOs
Molecules to Matter	Written Examination	120 Minutes	100	45%	All

Module Achievement

4.1.3 Advanced Materials

Module Name	Advanced Materials
Module Code	2025-MAM-CO-03
Module ECTS	5
Program Owner	2025-AdvMat-MSc (Advanced Materials)
Module Coordinator	Prof. Dr. Ulrich Kortz Prof. Dr. Veit Wagner

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	2	Mandatory

Student Workload	
Lecture	35
Exam Preparation	30
Independent Study	60
Total Hours	**125**

Module Components	Number	Type	CP
Advanced Materials	MAM-CO-03-A	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.

Recommended Knowledge

- Review chemistry, condensed matter, and quantum mechanics concepts.

- Physics and Chemistry topics of Guided

Self-study course

Usability and Relationship 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.

Intended Learning Outcomes

No	Competence	ILO
1	Plan	Plan methods able to produce nanoparticles
2	Predict	Predict surface reactivity and properties of nanoparticles
3	Design	Design materials to achieve targeted properties
4	Choose	Choose growth/deposition techniques for given materials
5	Use	Use big data and artificial intelligence approaches in the field of materials science
6	Communicate	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
- M. Kuno, Introductory Nanoscience: Physical and Chemical Concepts, Garland, 2011
- R. Waser, Nanoelectronics and Information Technology, 3rd Edition, Wiley, 2012
- T. van de Ven, A. Soldera, Advanced Materials, De Gruyter, 2020

Entry Requirements

Prerequisites	2025-MAM-CO-02 Molecules to Matter
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Module Component	Examination Type	Duration or Length	Weight (%)	Minimum for Pass	ILOs

Advanced Materials	Written Examination	120 Minutes	100	45%	All

Module Achievement

4.1.4 Computational Materials Science

Module Name	Computational Materials Science
Module Code	2025-MAM-CO-04
Module ECTS	5
Program Owner	2025-AdvMat-MSc (Advanced Materials)
Module Coordinator	Prof. Dr. Ulrich Kleinekathöfer

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	2	Mandatory

Student Workload	
Lecture	17.5
Laboratory	17.5
Exam Preparation	20
Independent Study	70
Total Hours	**125**

Module Components	**Number**	**Type**	**CP**
Computational Materials Science - Lecture	MAM-CO-04-A	Lecture	2.5
Computational Materials Science- Lab	MAM-CO-04-B	Laboratory	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.

A single assessment type cannot sufficiently test all intended learning outcomes. The laboratory report evaluates experimental skills, whereas the written examination assesses understanding of theoretical knowledge, core principles, and analytical reasoning.

Recommended Knowledge

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

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

Intended Learning Outcomes

No	Competence	ILO
1	Use	Use the theory and computational techniques of (bio)molecular dynamics simulations in the realm of materials science systems
2	Relate	Relate the different computational approaches including machine learning techniques in materials science simulations
3	Evaluate	Evaluate the relevance and value of software packages and machine learning techniques for materials science simulations
4	Apply	Apply modern simulation techniques to practical problems with a focus on Materials Science
5	Analyze	Analyze, visualize and present results obtained from materials simulations
6	Construct	Construct a setup for a simulation of a simple materials science system

Indicative Literature

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

Entry Requirements

Prerequisites	2025-MAM-CO-02 Molecules to Matter 2025-MAM-CO-01 Guided Self-Study
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Module Component	Examination Type	Duration or Length	Weight (%)	Minimum for Pass	ILOs
Computational Materials Science - Lecture	Written Examination	90 minutes	50	45%	1,2,3,4

Computational Materials Science- Lab	Laboratory Report	10-15 pages	50	45%	1,4,5,6

Module Achievement

4.2 Research Area (35 CP)

4.2.1 Research Rotations AdvMat

Module Name	Research Rotations AdvMat
Module Code	2025-MAM-RES-01
Module ECTS	10
Program Owner	2025-AdvMat-MSc (Advanced Materials)
Module Coordinator	Prof. Dr. Ulrich Kortz Prof. Dr. Veit Wagner

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	1	Mandatory

Student Workload	
Laboratory	120
Tutorial	10
Independent Study	120
Total Hours	**250**

Module Components	**Number**	**Type**	**CP**
Research Rotation AdvMat	MAM-RES-01-A	Laboratory	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. The module comprises three major content areas with distinct intended learning outcomes; separate project reports allow each area to be assessed with sufficient depth and validity.

Recommended Knowledge

- Identify areas or topics of interest and discuss them with your prospective unit supervisors with or before the start of the semester.

- 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.

Usability and Relationship 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.

Intended Learning Outcomes

No	Competence	ILO
1	Use	Use current technical/scientific literature
2	Apply	Apply scientific knowledge specifically for different subject areas
3	Master	Master specific research methods from different disciplinary fields
4	Apply	Apply scientific language consistently 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.

Entry Requirements

Prerequisites	None
Co-requisites	2025-MAM-CO-01 Guided Self-Study
Additional Remarks	None

Assessment and Completion

Module Component	Examination Type	Duration or Length	Weight (%)	Minimum for Pass	ILOs
Research Rotation AdvMat	Project Report	3 x (5-10 pages)	100	45%	All

Module Achievement

4.2.2 Guided Research AdvMat

Module Name	Guided Research AdvMat
Module Code	2025-MAM-RES-02
Module ECTS	10
Program Owner	2025-AdvMat-MSc (Advanced Materials)
Module Coordinator	Prof. Dr. Ulrich Kortz Prof. Dr. Veit Wagner

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	2	Mandatory

Student Workload	
Seminar	20
Laboratory	140
Independent Study	90
Total Hours	**250**

Module Components	Number	Type	CP
Guided Research AdvMat	MAM-RES-02-A	Laboratory	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.

Recommended Knowledge

- 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.

Usability and Relationship to other Modules

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

Intended Learning Outcomes

No	Competence	ILO
1	Use	Use current technical/scientific literature, and distinguish good from second-rate publications
2	Formulate	Formulate a research project in a research proposal style
3	Apply	Apply scientific knowledge specifically on given subject area
4	Apply	Apply specific and selected scientific materials science techniques, as required for the project
5	Present	Present of project results for specialists

Indicative Literature

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

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Module Component	Examination Type	Duration or Length	Weight (%)	Minimum for Pass	ILOs
Guided Research AdvMat	Project Report	15-25 pages	100	45%	All

Module Achievement

4.2.3 Research Project AdvMat

Module Name	Research Project AdvMat
Module Code	2025-MAM-RES-03
Module ECTS	15
Program Owner	2025-AdvMat-MSc (Advanced Materials)
Module Coordinator	Prof. Dr. Ulrich Kortz Prof. Dr. Veit Wagner

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	3	Mandatory

Student Workload	
Seminar	30
Laboratory	210
Independent Study	135
Total Hours	**375**

Module Components	Number	Type	CP
Research Project AdvMat	MAM-RES-03-A	Laboratory	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).

Recommended Knowledge

- 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.

Usability and Relationship to other Modules

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

Intended Learning Outcomes

No	Competence	ILO
1	Evaluate	Evaluate critically current technical/scientific literature, and distinguish good from second-rate publications.
2	Formulate	Formulate a research project in a research proposal style
3	Apply	Apply scientific knowledge specifically on given subject area
4	Apply	Apply specific and selected scientific materials science techniques, as required for the project
5	Review	Critical review of scientific results and adjust research tasks accordingly
6	Present	Present of project results for specialists
7	Understand	Understand how to plan and manage the time allocated to a presentation
8	Analyze	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.

Entry Requirements

Prerequisites	2025-MAM-RES-02 Guided Research AdvMat
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Module Component	Examination Type	Duration or Length	Weight (%)	Minimum for Pass	ILOs
Research Project AdvMat	Project Assessment	15-25 pages	100	45%	1-8

Module Achievement

4.3 Transferrable Skills Area (15 CP)

4.3.1 Current Topics

Module Name	Current Topics
Module Code	2025-MAM-TS-01
Module ECTS	5
Program Owner	2025-AdvMat-MSc (Advanced Materials)
Module Coordinator	Prof. Dr. Veit Wagner

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	1	Mandatory

Student Workload	
Lecture	17.5
Seminar	17.5
Tutorial	8
Poster Presentation	2
Independent Study	80
Total Hours	**125**

Module Components	**Number**	**Type**	**CP**
Current Topics	MAM-TS-01-A	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.

Recommended Knowledge

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

Usability and Relationship 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.

Intended Learning Outcomes

No	Competence	ILO
1	Research	Research and analyze scientific literature independently.
2	Present	Present a scientific research topic in Advanced Materials as a poster suitable for non- scientific or scientific audience
3	Discuss	Discuss critically their own and other research data in a poster session.

Indicative Literature

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

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Module Component	Examination Type	Duration or Length	Weight (%)	Minimum for Pass	ILOs
Current Topics	Poster Presentation	120 Minutes	100	45%	All

Module Achievement

4.3.2 Scientific Writing

Module Name	Scientific Writing
Module Code	2025-MQLS-TS-02
Module ECTS	5
Program Owner	2025-QLS-MSc (Quantitative Life Science)
Module Coordinator	Prof. Dr.-Ing Katrin Rosenthal

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	2	Mandatory
2025-QLS-MSc Quantitative Life Science	2	Mandatory

Student Workload	
Seminar	35
Exam Preparation	35
Independent Study	55
Total Hours	**125**

Module Components	Number	Type	CP
Scientific Writing	MQLS-TS-02	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

No	Competence	ILO
1	Understand	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	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	Understand the purpose and importance of scientific writing and scientific communication and understand the publication process and peer review process
4	Analyze	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	Apply their theoretical knowledge on a writing a short proposal about their own research
6		Additional Learning Outcomes (Interdisciplinary Skills)
7	Develop	Develop strong written communication skills that are applicable in both academic and professional settings
8	Understand	Understand and apply principles of ethical writing, including avoiding plagiarism and ensuring proper attribution
9	Promote	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

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Module Component	**Examination Type**	**Duration or Length**	**Weight (%)**	**Minimum for Pass**	**ILOs**
Scientific Writing	Term Paper	5 pages	100	45%	All

Module Achievement

4.3.3 Intellectual Property and Commercialization

Module Name	Intellectual Property and Commercialization
Module Code	2025-MQLS-TS-03
Module ECTS	5
Program Owner	2025-QLS-MSc (Quantitative Life Science)
Module Coordinator	Prof. Dr. Nikolai Kuhnert (SPC) Prof. Dr. Felix Jonas (SPC)

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	3	Mandatory
2025-QLS-MSc Quantitative Life Science	3	Mandatory

Student Workload	
Lecture	35
Exam Preparation	20
Independent Study	70
Total Hours	**125**

Module Components	**Number**	**Type**	**CP**
Intellectual Property and Commercialization	MQLS-TS-03	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.

Recommended Knowledge

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

Usability and Relationship to other Modules

The module belongs to the Transferable Skills.

Intended Learning Outcomes

No	Competence	ILO
1		A. Understand Intellectual Property
2		Master Intellectual Property: Comprehend IP concepts, distinguish IP categories, and evaluate their protection mechanisms
3		Copyright: Grasp legal concepts of copyright
4		Patent Expertise: Grasp patent law, including patentability criteria, types, acquisition, enforcement, and impact on innovation
5		B. Commercialize Intellectual Property
6		IP Commercialization: Explore diverse paths for IP commercialization, identify funding sources, and construct effective business plans
7		Entrepreneurial Mindset: Develop entrepreneurial skills, build high-performing teams, and leverage resources for IP venture success
8		C. Achieve Strategic IP Management
9		IP Strategy: Analyze real-world case studies to understand IP's role in business strategy, risk management, and competitive advantage
10		IP Valuation and Licensing: Evaluate IP assets, negotiate licenses, and understand the complexities of IP transactions
11		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

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Module Component	Examination Type	Duration or Length	Weight (%)	Minimum for Pass	ILOs
Intellectual Property and Commercialization	Oral Examination	30 minutes	100	45%	All

Module Achievement

4.4 Elective Area (20 CP)

4.4.1 Supramolecular Chemistry

Module Name	Supramolecular Chemistry
Module Code	2025-MQLS-CHE-01
Module ECTS	5
Program Owner	2025-QLS-MSc (Quantitative Life Science)
Module Coordinator	Prof. Dr. Anna Tevyashova

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	1	Mandatory Elective
2025-QLS-MSc Quantitative Life Science	1	Mandatory Elective
2025-AdvMat-MSc Advanced Materials	3	Mandatory Elective
2025-QLS-MSc Quantitative Life Science	3	Mandatory Elective

Student Workload	
Lecture	35
Exam Preparation	20
Independent Study	70
Total Hours	**125**

Module Components	Number	Type	CP
Supramolecular Chemistry	MQLS-CHE-01	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 modelling 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 modelling complex systems

Recommended Knowledge

- 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.

- Knowledge of Organic Chemistry, Inorganic Chemistry, Physical Chemistry and Biochemistry is required.

Usability and Relationship 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, Modelling 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.

Intended Learning Outcomes

No	Competence	ILO
1	Account	Account for fundamental concepts, methods and theories within supramolecular chemistry
2	Identify	Identify, analyze, and apply non-covalent interactions in diverse chemical contexts
3	Assess	Assess the current problems and research in the field
4	Anticipate	Anticipate the importance of supramolecular association within the life sciences and
5	Interpret	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

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Module Component	Examination Type	Duration or Length	Weight (%)	Minimum for Pass	ILOs
Supramolecular Chemistry	Written Examination	120 Minutes	100	45%	All

Module Achievement

4.4.2 Modern Analytical Methods

Module Name	Modern Analytical Methods
Module Code	2025-MAM-EL-01
Module ECTS	5
Program Owner	2025-AdvMat-MSc (Advanced Materials)
Module Coordinator	Prof. Dr. Jürgen Fritz

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	1	Mandatory Elective
2025-AdvMat-MSc Advanced Materials	3	Mandatory Elective

Student Workload	
Lecture	35
Exam Preparation	20
Independent Study	70
Total Hours	**125**

Module Components	Number	Type	CP
Modern Analytical Methods	MAM-EL-01-A	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.

Recommended Knowledge

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

- 1st year physics plus some advanced physics. Exposure to research and some experimental techniques.

Usability and Relationship to other Modules

Serves as elective for the MSc Advanced Materials graduate program.

Intended Learning Outcomes

No	Competence	ILO
1	Familiarize	Familiarize themselves with the physics and instrumentation of major experimental analytical techniques in materials science
2	Judge	Judge the suitability and reliability of experimental methods used in current literature.
3	Assess	Assess the suitability and importance of experimental results of different experimental methods
4	Select	Select a suitable experimental method to characterize and investigate samples
5	Validate	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.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Module Component	Examination Type	Duration or Length	Weight (%)	Minimum for Pass	ILOs
Modern Analytical Methods	Written Examination	120 Minutes	100	45%	All

Module Achievement

4.4.3 Nanoscale Devices

Module Name	Nanoscale Devices
Module Code	2025-MAM-EL-02
Module ECTS	5
Program Owner	2025-AdvMat-MSc (Advanced Materials)
Module Coordinator	Prof. Dr. Veit Wagner Prof. Dr.-Ing. Mojtaba Joodaki

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	3	Mandatory Elective

Student Workload	
Lecture	35
Exam Preparation	20
Independent Study	70
Total Hours	**125**

Module Components	Number	Type	CP
Nanoscale Devices	MAM-EL-02-A	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.

Recommended Knowledge

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

- Basic knowledge in solid state physics

Usability and Relationship 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.

Intended Learning Outcomes

No	Competence	ILO
1	Explain	Explain basic electronic device operational principals
2	Calculate	Calculate carrier and light confinement and related device parameter improvements
3	Categorize	Categorize charge carrier transport regimes.
4	Predict	Predict beneficial properties offered by novel non-standard materials
5	Communicate	Communicate in scientific language using advanced field-specific technical terms

Indicative Literature

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

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Module Component	Examination Type	Duration or Length	Weight (%)	Minimum for Pass	ILOs
Nanoscale Devices	Written Examination	120 Minutes	100	45%	All

Module Achievement

4.4.4 Structure Elucidation

Module Name	Structure Elucidation
Module Code	2025-MQLS-CHE-02
Module ECTS	5
Program Owner	2025-QLS-MSc (Quantitative Life Science)
Module Coordinator	Prof. Dr. Nikolai Kuhnert Prof. Dr. Ulrich Kortz

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	2	Mandatory Elective
2025-QLS-MSc Quantitative Life Science	2	Mandatory Elective

Student Workload	
Lecture	35
Exam Preparation	20
Independent Study	70
Total Hours	**125**

Module Components	Number	Type	CP
Structure Elucidation	MQLS-CHE-02	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.

Recommended Knowledge

- Background literature for preparation provided by individual faculty.

- Basic knowledge on chemical bonding and

spectroscopic techniques (BSc level

Analytical Methods and Inorganic Chemistry)

Understanding of chemical structure and

bonding

Intended Learning Outcomes

No	Competence	ILO
1	Appreciate	Appreciate information content of spectroscopic and diffraction data
2	Predict	Predict and propose chemical structures from spectroscopic and diffraction data
3	Predict	Predict and deduce spectral data from chemical structures
4	Interpret	Interpret spectral data and assign signals to molecular features
5	Recommend	Recommend and rate spectroscopic experiments with a view of solving ambiguous chemical structure problems

Indicative Literature

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

Entry Requirements

Prerequisites	2025-MQLS-CO-01 Guided Self-study
Co-requisites	2025-MQLS-CO-03 Experimental Techniques
Additional Remarks	None

Assessment and Completion

Module Component	Examination Type	Duration or Length	Weight (%)	Minimum for Pass	ILOs
Structure Elucidation	Written Examination	120 Minutes	100	45%	All

Module Achievement

4.4.5 Advanced Statistical and Quantum Physics

Module Name	Advanced Statistical and Quantum Physics
Module Code	2025-MAM-EL-03
Module ECTS	5
Program Owner	2025-AdvMat-MSc (Advanced Materials)
Module Coordinator	Prof. Dr. Peter Schupp Prof. Dr. Sören Petrat

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	2	Mandatory Elective

Student Workload	
Lecture	35
Exam Preparation	20
Independent Study	70
Total Hours	**125**

Module Components	**Number**	**Type**	**CP**
Advanced Statistical and Quantum Physics	MAM-EL-03-A	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.

Recommended Knowledge

- Review of basic quantum mechanics, statistical physics and thermodynamics.

- Quantum mechanics and statistical physics at an undergraduate level.

Usability and Relationship to other Modules

Topics discussed find application in the research courses.

Intended Learning Outcomes

No	Competence	ILO
1	Apply	Apply knowledge of quantum mechanics, statistical physics, and many-body interactions in specific fields like super conductivity, lasers and quantum information
2	Calculate	Calculate boundary condition for stimulated light emission
3	Break down	Break down complex systems into effective interaction of composite (quasi-)particles.
4	Communicate	Communicate in scientific language using advanced field-specific terms

Indicative Literature

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

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Module Component	Examination Type	Duration or Length	Weight (%)	Minimum for Pass	ILOs
Advanced Statistical and Quantum Physics	Written Examination	120 Minutes	100	45%	All

Module Achievement

4.4.6 Advanced Solid State Physics

Module Name	Advanced Solid State Physics
Module Code	2025-MAM-EL-04
Module ECTS	5
Program Owner	2025-AdvMat-MSc (Advanced Materials)
Module Coordinator	Prof. Dr. Markus Wenzel

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	3	Mandatory Elective

Student Workload	
Lecture	35
Independent Study	90
Total Hours	**125**

Module Components	Number	Type	CP
Advanced Solid State Physics	MAM-EL-04-A	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.

Recommended Knowledge

Basic knowledge in solid state physics

Intended Learning Outcomes

No	Competence	ILO
1	Explain	Explain the theoretical foundations of solid state physics
2	Apply	Apply the concept of emergent phenomena
3	Derive	Derive physical properties of materials in their solid state
4	Explain	Explain a wide range of applications of materials in their solid state

5	Communicate	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

Entry Requirements

Prerequisites	2025-MAM-CO-02 Molecules to Matter 2025-MAM-CO-03 Advanced Materials 2025-MAM-EL-03 Advanced Statistical and Quantum Physics
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Module Component	**Examination Type**	**Duration or Length**	**Weight (%)**	**Minimum for Pass**	**ILOs**
Advanced Solid State Physics	Project Report	10 pages	100	45%	All

Module Achievement

4.4.7 Optical Characterization of Advanced Materials

Module Name	Optical Characterization of Advanced Materials
Module Code	2025-MAM-EL-05
Module ECTS	5
Program Owner	2025-AdvMat-MSc (Advanced Materials)
Module Coordinator	Prof. Dr. Dr. Arnulf Materny

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	3	Mandatory Elective

Student Workload	
Lecture	35
Exam Preparation	20
Independent Study	70
Total Hours	**125**

Module Components	**Number**	**Type**	**CP**
Optical Characterization of Advanced Materials	MAM-EL-05	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.

Recommended Knowledge

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

- Basic knowledge in Optics, Quantum

Mechanics and Quantum Systems

Usability and Relationship 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.

Intended Learning Outcomes

No	Competence	ILO
1	Outline	Outline fundamental aspects and instrumentation of optical spectroscopy
2	Apply	Apply optical spectroscopy to investigate molecular and structural properties of different materials
3	Decide	Decide on ideally suited optical spectroscopy techniques for specific problems.
4	Communicate	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

Entry Requirements

Prerequisites	2025-MAM-CO-01 Guided Self-Study
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Module Component	Examination Type	Duration or Length	Weight (%)	Minimum for Pass	ILOs
Optical Characterization of Advanced Materials	Written Examination	120 Minutes	100	45%	All

Module Achievement

4.4.8 Applications of Advanced Materials

Module Name	Applications of Advanced Materials
Module Code	2025-MAM-EL-06
Module ECTS	5
Program Owner	2025-AdvMat-MSc (Advanced Materials)
Module Coordinator	Prof. Dr. Gerd-Volker Röschenthaler

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	3	Mandatory Elective

Student Workload	
Lecture	35
Exam Preparation	20
Independent Study	70
Total Hours	**125**

Module Components	**Number**	**Type**	**CP**
Applications of Advanced Materials	MAM-EL-06-A	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.

Recommended Knowledge

- 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.

- Basic knowledge in Inorganic and Organic Chemistry

Usability and Relationship 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.

Intended Learning Outcomes

No	Competence	ILO
1	Explain	Explain fundamental aspects and strategies in functional materials
2	List	List how broad the field of advanced materials is
3	Decide	Decide on the use of functional materials knowing their properties.
4	Make	Make educated guesses for synthetic routes
5	Analyze	Analyze the environmental impact of new advanced materials

Indicative Literature

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

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Module Component	Examination Type	Duration or Length	Weight (%)	Minimum for Pass	ILOs
Applications of Advanced Materials	Written Examination	120 Minutes	100	45%	All

Module Achievement

4.5 Master Thesis (30 CP)

4.5.1 Master Thesis

Module Name	Master Thesis
Module Code	2025-MAM-THE-01
Module ECTS	30
Program Owner	2025-AdvMat-MSc (Advanced Materials)
Module Coordinator	Prof. Dr. Ulrich Kortz Prof. Dr. Veit Wagner

Study Semester		
Program	**Semester**	**Status**
2025-AdvMat-MSc Advanced Materials	4	Mandatory

Student Workload	
Seminar	40
Laboratory	420
Exam Preparation	40
Independent Study	420
Total Hours	**920**

Module Components	**Number**	**Type**	**CP**
Master Thesis	MAM-THE-01-A	Thesis	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.

Recommended Knowledge

- 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.
- Academic writing skills

Usability and Relationship 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.

Intended Learning Outcomes

No	Competence	ILO
1	Understand	Understanding, at a professional level, of a circumscribed segment of the hosting group's research area
2	Able	Able to apply specific and selected scientific materials science techniques, as required for the project, at a professional level
3	Improve	Improve general professional skills.
4	Design	Designing and carrying out the full cycle of a scientific research project
5	Formulate	Formulating a research proposal such that that it could serve as a funding proposal
6	Write	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	Present	Presentation of project results for specialists and non-specialists

Indicative Literature

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Module Component	Examination Type	Duration or Length	Weight (%)	Minimum for Pass	ILOs
Master Thesis	Thesis	30-60 pages. Component 2 assessment: type: Oral Examination. Duration: 20 minutes. weight: 20%.	80	45%	All

Module Achievement

5 Appendix

5.1 Intended Learning Outcomes

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 or 3	1 or 3	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