

# Module Catalogue

for the Subject

# Quantum Technology

as a Bachelor's with 1 major  
with the degree "Bachelor of Science"  
(180 ECTS credits)

Examination regulations version: 2021  
Responsible: Faculty of Physics and Astronomy

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## The subject is divided into

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## Learning Outcomes

German contents and learning outcome available but not translated yet.

### Wissenschaftliche Befähigung

- Die Absolventinnen und Absolventen verstehen die mathematischen, theoretischen und experimentellen Grundlagen der Quantentechnologie und können diese anwenden.
- Die Absolventinnen und Absolventen können unter Anleitung Experimente durchführen, analysieren und die erhaltenen Ergebnisse darstellen und bewerten.
- Die Absolventinnen und Absolventen setzen die erlernten die theoretischen und experimentellen Methoden unter Anleitung zur Erlangung neuer Erkenntnisse in der Quantentechnologie um.
- Die Absolventinnen und Absolventen sind in der Lage, Probleme mit wissenschaftlicher Arbeitsweise und unter Beachtung der Regeln guter wissenschaftlicher Praxis (Dokumentation, Fehleranalyse) zu bearbeiten.
- Die Absolventinnen und Absolventen können ihr Wissen und ihre Erkenntnisse einem Fachpublikum gegenüber darstellen und vertreten.
- Die Absolventinnen und Absolventen können ein breites Grundlagenwissen aus den wichtigsten Teilgebieten der Quantentechnologie sowie tiefergehende Kenntnisse in mindestens einem Teilgebiet abrufen.
- Die Absolventinnen und Absolventen verstehen die wesentlichen Zusammenhänge und Konzepte der einzelnen Teilgebiete der Quantentechnologie.
- Die Absolventinnen und Absolventen sind in der Lage, sich mit Hilfe von Fachliteratur in neue Aufgabengebiete einzuarbeiten, sowie physikalische und technische Methoden weitgehend selbstständig auf konkrete Aufgabenstellungen anzuwenden, Lösungswege zu entwickeln und die Ergebnisse zu interpretieren und zu bewerten.
- Die Absolventinnen und Absolventen besitzen Abstraktionsvermögen, analytisches Denken, Problemlösungskompetenz und die Fähigkeit, komplexe Zusammenhänge zu strukturieren.

### Befähigung zur Aufnahme einer Erwerbstätigkeit

- Die Absolventinnen und Absolventen können ihr Wissen und ihre Erkenntnisse einem Fachpublikum gegenüber darstellen und vertreten.
- Die Absolventinnen und Absolventen sind in der Lage, konstruktiv und zielorientiert in einem heterogenen Team zusammenzuarbeiten, unterschiedliche und abweichende Ansichten produktiv zur Zielerreichung zu nutzen und auftretende Konflikte zu lösen.
- Die Absolventinnen und Absolventen können ihre erworbenen Kompetenzen in unterschiedlichen interkulturellen Kontexten und in international zusammengesetzten Teams anwenden.
- Die Absolventinnen und Absolventen sind in der Lage, Probleme und deren Lösungen zielgruppengerecht und auch in einer Fremdsprache aufzubereiten und darzustellen.
- Die Absolventinnen und Absolventen können physikalische und technische Methoden weitgehend selbstständig auf konkrete Aufgabenstellungen der Quantentechnologie anwenden, Lösungswege entwickeln und die Ergebnisse bewerten und interpretieren.
- Die Absolventinnen und Absolventen kennen die wichtigsten Anforderungen und Arbeitsweisen im industriellen Umfeld der Quantentechnologie.
- Die Absolventinnen und Absolventen kennen die wichtigsten Anforderungen und Arbeitsweisen in Forschung und Entwicklung.
- Die Absolventinnen und Absolventen sind befähigt, komplexe Probleme zu analysieren und zu lösen und sich sehr schnell auch in weniger vertraute Themenkomplexe einzuarbeiten.

### Persönlichkeitsentwicklung

- Die Absolventinnen und Absolventen kennen die Regeln guter wissenschaftlicher Praxis und beachten sie.

- Die Absolventinnen und Absolventen sind in der Lage, ihr Wissen und ihre Erkenntnisse einem Fachpublikum gegenüber darzustellen und zu vertreten.

#### **Befähigung zum gesellschaftlichen Engagement**

- Die Absolventinnen und Absolventen können naturwissenschaftliche Entwicklungen kritisch reflektieren und deren Auswirkungen auf die Wirtschaft, Gesellschaft und die Umwelt erfassen (Technikfolgenabschätzung).
- Die Absolventinnen und Absolventen haben ihr Wissen bezüglich wirtschaftlicher, gesellschaftlicher, naturwissenschaftlicher, kultureller etc. Fragestellungen erweitert und können begründet Position beziehen.
- Die Absolventinnen und Absolventen haben die Bereitschaft und Fähigkeit entwickelt, ihre Kompetenzen in partizipative Prozesse einzubringen und aktiv an Entscheidungen mitzuwirken.

## Abbreviations used

Course types: **E** = field trip, **K** = colloquium, **O** = conversatorium, **P** = placement/lab course, **R** = project, **S** = seminar, **T** = tutorial, **Ü** = exercise, **V** = lecture

Term: **SS** = summer semester, **WS** = winter semester

Methods of grading: **NUM** = numerical grade, **B/NB** = (not) successfully completed

Regulations: **(L)ASPO** = general academic and examination regulations (for teaching-degree programmes), **FSB** = subject-specific provisions, **SFB** = list of modules

Other: **A** = thesis, **LV** = course(s), **PL** = assessment(s), **TN** = participants, **VL** = prerequisite(s)

## Conventions

Unless otherwise stated, courses and assessments will be held in German, assessments will be offered every semester and modules are not creditable for bonus.

## Notes

Should there be the option to choose between several methods of assessment, the lecturer will agree with the module coordinator on the method of assessment to be used in the current semester by two weeks after the start of the course at the latest and will communicate this in the customary manner.

Should the module comprise more than one graded assessment, all assessments will be equally weighted, unless otherwise stated below.

Should the assessment comprise several individual assessments, successful completion of the module will require successful completion of all individual assessments.

## In accordance with

the general regulations governing the degree subject described in this module catalogue:

**ASPO2015**

associated official publications (FSB (subject-specific provisions)/SFB (list of modules)):

**28-Apr-2021 (2021-54)**

This module handbook seeks to render, as accurately as possible, the data that is of statutory relevance according to the examination regulations of the degree subject. However, only the FSB (subject-specific provisions) and SFB (list of modules) in their officially published versions shall be legally binding. In the case of doubt, the provisions on, in particular, module assessments specified in the FSB/SFB shall prevail.



## Compulsory Courses

(118 ECTS credits)

# Quantum Technology

(27 ECTS credits)

Module title		Abbreviation
Introduction to Quantum Technology		11-N-EIN-212-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
7	numerical grade	--
Duration	Module level	Other prerequisites
2 semester	undergraduate	Admission prerequisite to assessment: regular attendance (minimum 85% of sessions).
<b>Contents</b>		
Introduction to the principles of producing, characterising and applying in quantum technology.		
<b>Intended learning outcomes</b>		
The students have knowledge of the fundamental properties, technologies, characterising methods and functions in quantum technology.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (2) + S (2) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
a) talk (30 to 45 minutes) with discussion and b) written examination (approx. 120 minutes) Language of assessment: German and/or English		
<b>Allocation of places</b>		
--		
<b>Additional information</b>		
Registration: If a student registers for the exercises and obtains the qualification for admission to assessment, this will be considered a declaration of will to seek admission to assessment pursuant to Section 20 Subsection 3 Sentence 4 ASPO (general academic and examination regulations). If the module coordinators subsequently find that the student has obtained the qualification for admission to assessment, they will put the student's registration for assessment into effect. Only those students that meet the respective prerequisites can successfully register for an assessment. Students who did not register for an assessment or whose registration for an assessment was not put into effect will not be admitted to the respective assessment. If a student takes an assessment to which he/she has not been admitted, the grade achieved in this assessment will not be considered.		
<b>Workload</b>		
210 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
--		
<b>Module appears in</b>		
Module studies (Bachelor) Orientierungsstudien (2020) Bachelor' degree (1 major) Quantum Technology (2021) exchange program Physics (2023)		

Module title		Abbreviation
Industrial Internship Quantum Technology		11-N-IP-212-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
10	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
Insights into industrial methods, work processes, goals and production methods. Summary of own experiences and tasks in a report and an oral presentation.		
<b>Intended learning outcomes</b>		
The students have knowledge and practical experience of using a variety of industrial technologies with relevance to quantum technology and are able to summarise their experience in a report and an oral presentation.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
P (0) + S (1)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
a) report on practical course (approx. 15 pages) and b) presentation/talk (approx. 45 minutes). Weighted: 1:4 Language of assessment: German and/or English		
<b>Allocation of places</b>		
--		
<b>Additional information</b>		
Registration: If a student registers for the exercises and obtains the qualification for admission to assessment, this will be considered a declaration of will to seek admission to assessment pursuant to Section 20 Subsection 3 Sentence 4 ASPO (general academic and examination regulations). If the module coordinators subsequently find that the student has obtained the qualification for admission to assessment, they will put the student's registration for assessment into effect. Only those students that meet the respective prerequisites can successfully register for an assessment. Students who did not register for an assessment or whose registration for an assessment was not put into effect will not be admitted to the respective assessment. If a student takes an assessment to which he/she has not been admitted, the grade achieved in this assessment will not be considered.		
<b>Workload</b>		
300 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
--		
<b>Module appears in</b>		
Bachelor' degree (1 major) Quantum Technology (2021)		

Module title		Abbreviation
Experimental Chemistry		o8-AC-ExChem-152-mo1
Module coordinator		Module offered by
lecturer of lecture "Experimentalchemie" (Experimental Chemistry)		Institute of Inorganic Chemistry
ECTS	Method of grading	Only after succ. compl. of module(s)
5	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
The module provides an overview of the fundamental knowledge of chemistry. Emphasis is placed on the material and particle level, metals, acid-base reactions, the periodic table, chemical equilibrium and complexometry.		
<b>Intended learning outcomes</b>		
The student understands the principles of the periodic table and can obtain information from it. He/she is proficient in basic models of the structure of matter and can describe them properly. He/she can depict chemical reactions using typical chemical formula language and interpret them by identifying the type of reaction.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (4)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 minutes) Language of assessment: German and/or English		
<b>Allocation of places</b>		
--		
<b>Additional information</b>		
--		
<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
Teaching cycle: every year, winter semester		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
--		
<b>Module appears in</b>		
Bachelor' degree (1 major) Biology (2011) Bachelor' degree (1 major) Physics (2012) Bachelor' degree (1 major) Psychology (2010) Bachelor' degree (1 major) Economathematics (2012) Bachelor' degree (1 major) Romanic Languages (French/Spanish) (2013) Bachelor's degree (1 major, 1 minor) Pedagogy (2011) Bachelor's degree (1 major, 1 minor) Pedagogy (2013) Bachelor's degree (1 major, 1 minor) French Studies (2013) Bachelor's degree (1 major, 1 minor) History (2010) Bachelor's degree (1 major, 1 minor) Pre- and Protohistoric Archaeology (2012) Bachelor's degree (1 major, 1 minor) Spanish Studies (2010) Bachelor's degree (1 major, 1 minor) Political and Social Studies (2013) Bachelor's degree (1 major, 1 minor) English and American Studies (2010)		
Bachelor's with 1 major Quantum Technology (2021)	JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	page 13 / 179

Bachelor's degree (1 major, 1 minor) Russian Language and Culture (2008)  
 Bachelor's degree (1 major, 1 minor) Gallo-Roman philology (2010)  
 Bachelor's degree (1 major, 1 minor) German Language and Literature (2013)  
 Bachelor's degree (1 major, 1 minor) German Language and Literature (2010)  
 Bachelor's degree (1 major, 1 minor) Italian Studies (2010)  
 Bachelor's degree (2 majors) Classical Archaeology (2013)  
 Bachelor's degree (2 majors) Pedagogy (2013)  
 Bachelor's degree (2 majors) Philosophy (2013)  
 Bachelor's degree (2 majors) Special Education (2009)  
 Bachelor's degree (2 majors) Digital Humanities (2012)  
 Bachelor's degree (2 majors) Political and Social Studies (2011)  
 Bachelor's degree (2 majors) Russian Language and Culture (2012)  
 Bachelor's degree (2 majors) European Ethnology (2013)  
 Magister Theologiae Catholic Theology (2013)  
 Bachelor's degree (2 majors) English and American Studies (2009)  
 Bachelor's degree (2 majors) German Language and Literature (2013)  
 Bachelor' degree (1 major) Geography (2015)  
 Bachelor' degree (1 major) Mathematics (2015)  
 Bachelor' degree (1 major) Musicology (2015)  
 Bachelor' degree (1 major) Physics (2015)  
 Bachelor' degree (1 major) Psychology (2015)  
 Bachelor' degree (1 major) Business Management and Economics (2015)  
 Bachelor' degree (1 major) Nanostructure Technology (2015)  
 Bachelor' degree (1 major) Biomedicine (2015)  
 Bachelor' degree (1 major) Music Education (2015)  
 Bachelor' degree (1 major) Computational Mathematics (2015)  
 Bachelor' degree (1 major) Political and Social Studies (2015)  
 Bachelor' degree (1 major) Functional Materials (2015)  
 Bachelor' degree (1 major) Academic Speech Therapy (2015)  
 Bachelor' degree (1 major) Indology/South Asian Studies (2015)  
 Bachelor's degree (1 major, 1 minor) Egyptology (2015)  
 Bachelor's degree (1 major, 1 minor) Pedagogy (2015)  
 Bachelor's degree (1 major, 1 minor) History (2015)  
 Bachelor's degree (1 major, 1 minor) Musicology (2015)  
 Bachelor's degree (1 major, 1 minor) Philosophy (2015)  
 Bachelor's degree (1 major, 1 minor) Pre- and Protohistoric Archaeology (2015)  
 Bachelor's degree (1 major, 1 minor) Ancient World (2015)  
 Bachelor's degree (1 major, 1 minor) Music Education (2015)  
 Bachelor's degree (1 major, 1 minor) Philosophy and Religion (2015)  
 Bachelor's degree (1 major, 1 minor) Theological Studies (2015)  
 Bachelor's degree (1 major, 1 minor) Political and Social Studies (2015)  
 Bachelor's degree (1 major, 1 minor) Russian Language and Culture (2015)  
 Bachelor's degree (1 major, 1 minor) German Language and Literature (2015)  
 Bachelor's degree (2 majors) Egyptology (2015)  
 Bachelor's degree (2 majors) Pedagogy (2015)  
 Bachelor's degree (2 majors) Protestant Theology (2015)  
 Bachelor's degree (2 majors) Musicology (2015)  
 Bachelor's degree (2 majors) Philosophy (2015)  
 Bachelor's degree (2 majors) Special Education (2015)  
 Bachelor's degree (2 majors) Pre- and Protohistoric Archaeology (2015)  
 Bachelor's degree (2 majors) Latin Philology (2015)  
 Bachelor's degree (2 majors) Music Education (2015)  
 Bachelor's degree (2 majors) Philosophy and Religion (2015)

Bachelor's degree (2 majors) Theological Studies (2015)  
 Bachelor's degree (2 majors) Digital Humanities (2015)  
 Bachelor's degree (2 majors) Political and Social Studies (2015)  
 Bachelor's degree (2 majors) Russian Language and Culture (2015)  
 Bachelor's degree (2 majors) Greek Philology (2015)  
 Bachelor's degree (2 majors) European Ethnology (2015)  
 Bachelor's degree (2 majors) Indology/South Asian Studies (2015)  
 Bachelor's degree (2 majors) Ancient Near Eastern Studies (2015)  
 Bachelor's degree (2 majors) Geography (2015)  
 Bachelor's degree (2 majors) French Studies (2015)  
 Bachelor's degree (2 majors) History (2015)  
 Bachelor's degree (2 majors) Sport Science (Focus on health and Pedagogics in Movement) (2015)  
 Bachelor's degree (2 majors) German Language and Literature (2015)  
 Bachelor' degree (1 major) Mathematical Physics (2016)  
 Bachelor's degree (2 majors) Theological Studies (2011)  
 Bachelor's degree (1 major, 1 minor) French Studies (2016)  
 Bachelor's degree (2 majors) French Studies (2016)  
 Bachelor's degree (1 major, 1 minor) Italian Studies (2016)  
 Bachelor's degree (2 majors) Italian Studies (2016)  
 Bachelor's degree (1 major, 1 minor) Spanish Studies (2016)  
 Bachelor's degree (2 majors) Spanish Studies (2016)  
 Bachelor' degree (1 major) Romanic Languages (French/Italian) (2016)  
 Bachelor' degree (1 major) Romanic Languages (French/Spanish) (2016)  
 Bachelor' degree (1 major) Romanic Languages (Italian/Spanish) (2016)  
 Bachelor' degree (1 major) Business Information Systems (2016)  
 Bachelor' degree (1 major) Games Engineering (2016)  
 Bachelor's degree (1 major, 1 minor) English and American Studies (2016)  
 Bachelor's degree (2 majors) English and American Studies (2016)  
 Bachelor' degree (1 major) Media Communication (2016)  
 Bachelor's degree (1 major, 1 minor) Digital Humanities (2016)  
 Bachelor' degree (1 major) Biology (2017)  
 Bachelor's degree (1 major, 1 minor) Geography (2017)  
 Bachelor's degree (1 major, 1 minor) History of Medieval and Modern Art (2017)  
 Bachelor's degree (2 majors) History of Medieval and Modern Art (2017)  
 Bachelor's degree (2 majors) Comparative Indo-European Linguistics (2017)  
 Bachelor' degree (1 major) Aerospace Computer Science (2017)  
 Bachelor' degree (1 major) Modern China (2017)  
 Bachelor's degree (1 major, 1 minor) Museology and material culture (2017)  
 Bachelor' degree (1 major) Economathematics (2017)  
 Bachelor' degree (1 major) Games Engineering (2017)  
 Bachelor' degree (1 major) Computer Science (2017)  
 Bachelor' degree (1 major) Media Communication (2018)  
 Bachelor' degree (1 major) Biomedicine (2018)  
 Bachelor' degree (1 major) Human-Computer Systems (2018)  
 Bachelor's degree (2 majors) Classical Archaeology (2018)  
 Bachelor's degree (1 major, 1 minor) Classical Archaeology (2018)  
 Bachelor's degree (1 major, 1 minor) Digital Humanities (2018)  
 Bachelor's degree (2 majors) Digital Humanities (2018)  
 Bachelor' degree (1 major) Computer Science (2019)  
 Bachelor's degree (1 major, 1 minor) English and American Studies (2019)  
 Bachelor's degree (1 major, 1 minor) Indology/South Asian Studies (2019)  
 Bachelor' degree (1 major) Indology/South Asian Studies (2019)  
 Bachelor' degree (1 major) Business Information Systems (2019)



Bachelor's degree (2 majors) Indology/South Asian Studies (2019)  
 Bachelor' degree (1 major) Business Management and Economics (2019)  
 Bachelor' degree (1 major) Modern China (2019)  
 Bachelor' degree (1 major) Biomedicine (2020)  
 Bachelor' degree (1 major) Pedagogy (2020)  
 Bachelor' degree (1 major) Political and Social Studies (2020)  
 Bachelor' degree (1 major) Business Information Systems (2020)  
 Bachelor's degree (1 major, 1 minor) Political and Social Studies (2020)  
 Bachelor's degree (2 majors) European Ethnology (2020)  
 Bachelor's degree (2 majors) Political and Social Studies (2020)  
 Bachelor's degree (2 majors) Special Education (2020)  
 Bachelor' degree (1 major) Physics (2020)  
 Bachelor' degree (1 major) Nanostructure Technology (2020)  
 Bachelor' degree (1 major) Mathematical Physics (2020)  
 Bachelor' degree (1 major) Aerospace Computer Science (2020)  
 Bachelor's degree (1 major, 1 minor) Museology and material culture (2020)  
 Bachelor's degree (1 major, 1 minor) Pedagogy (2020)  
 Bachelor's degree (2 majors) Pedagogy (2020)  
 Bachelor' degree (1 major) Psychology (2020)  
 Bachelor' degree (1 major) Biology (2021)  
 Magister Theologiae Catholic Theology (2021)  
 Bachelor's degree (2 majors) History (2021)  
 Bachelor's degree (1 major, 1 minor) History (2021)  
 Bachelor' degree (1 major) Media Communication (2021)  
 Bachelor's degree (2 majors) Theological Studies (2021)  
 Bachelor's degree (1 major, 1 minor) Theological Studies (2021)  
 Bachelor's degree (1 major, 1 minor) English and American Studies (2021)  
 Bachelor's degree (2 majors) English and American Studies (2021)  
 Bachelor' degree (1 major) Functional Materials (2021)  
 Bachelor' degree (1 major) Computer Science und Sustainability (2021)  
 Bachelor's degree (2 majors) Comparative Indo-European Linguistics (2021)  
 Bachelor' degree (1 major) Quantum Technology (2021)  
 Bachelor's degree (2 majors) Special Education (2021)  
 Bachelor' degree (1 major) Business Information Systems (2021)  
 Bachelor' degree (1 major) Economathematics (2021)  
 Bachelor' degree (1 major) Business Management and Economics (2021)  
 Bachelor' degree (1 major) Human-Computer Systems (2022)  
 Bachelor's degree (1 major, 1 minor) Museology and material culture (2022)  
 Bachelor' degree (1 major) Biology (2022)  
 Bachelor' degree (1 major) Economathematics (2022)  
 Bachelor' degree (1 major) Mathematical Data Science (2022)  
 Bachelor' degree (1 major) Artificial Intelligence and Data Science (2022)  
 Bachelor's degree (2 majors) Ancient Near Eastern Archaeology (2022)  
 Bachelor's degree (1 major, 1 minor) Ancient World (2022)  
 Bachelor's degree (2 majors) Ancient Near Eastern Studies (2022)  
 Bachelor' degree (1 major) Franco-German studies: language, culture, digital competence (2022)  
 Bachelor' degree (1 major) Midwifery (2022)  
 Bachelor' degree (1 major) European Law (2023)  
 Bachelor's degree (1 major, 1 minor) English and American Studies (2023)  
 Bachelor's degree (2 majors) English and American Studies (2023)  
 Bachelor' degree (1 major) Artificial Intelligence and Data Science (2023)  
 Bachelor' degree (1 major) Mathematics (2023)  
 Bachelor' degree (1 major) Business Information Systems (2023)



Bachelor' degree (1 major) Economathematics (2023)  
 Bachelor's degree (1 major, 1 minor) History of Medieval and Modern Art (2023)  
 Bachelor's degree (2 majors) History of Medieval and Modern Art (2023)  
 Bachelor's degree (2 majors) Special Education (2023)  
 Bachelor' degree (1 major) Business Management and Economics (2023)  
 Bachelor' degree (1 major) Geography (2023)  
 Bachelor's degree (2 majors) Geography (2023)  
 Bachelor's degree (1 major, 1 minor) Geography (2023)  
 Bachelor's degree (2 majors) European Ethnology/Empiric Cultural Studies (2023)  
 Bachelor' degree (1 major) Mathematical Physics (2024)  
 Bachelor's degree (2 majors) German Language and Literature (2024)  
 Bachelor's degree (1 major, 1 minor) German Language and Literature (2024)  
 Bachelor' degree (1 major) Music Education (2024)  
 Bachelor's degree (2 majors) Music Education (2024)  
 Bachelor's degree (1 major, 1 minor) Music Education (2024)  
 Bachelor' degree (1 major) Indology/South Asian Studies (2024)  
 Bachelor's degree (2 majors) Indology/South Asian Studies (2024)  
 Bachelor's degree (1 major, 1 minor) Indology/South Asian Studies (2024)  
 Bachelor's degree (1 major, 1 minor) Ancient World (2024)  
 Bachelor's degree (2 majors) Digital Humanities (2024)  
 Bachelor's degree (1 major, 1 minor) Digital Humanities (2024)  
 Bachelor' degree (1 major) Midwifery (2024)  
 Bachelor's degree (2 majors) Greek Philology (2024)  
 Bachelor's degree (2 majors) Latin Philology (2024)  
 Bachelor' degree (1 major) Business Information Systems (2024)  
 Bachelor' degree (1 major) Economathematics (2024)  
 Bachelor' degree (1 major) Business Management and Economics (2024)  
 Bachelor' degree (1 major) Artificial Intelligence and Data Science (2024)  
 Bachelor' degree (1 major) Human-Computer-Interaction (2024)

Module title		Abbreviation
General and Analytical Chemistry for students of natural sciences (lab)		o8-ACP-NF-152-mo1
Module coordinator		Module offered by
holder of the Chair of Anorganic Chemistry		Institute of Inorganic Chemistry
ECTS	Method of grading	Only after succ. compl. of module(s)
2	(not) successfully completed	o8-AC-ExChem
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
This module gives students the opportunity to apply in practice the knowledge they have gained through the related lecture(s). After a safety briefing, the students autonomously conduct experiments in the laboratory. The course focuses on laboratory safety, simple lab techniques, the synthesis of simple substances and analyses of unknown substances.		
<b>Intended learning outcomes</b>		
Students are able to identify fundamental problems in chemistry and perform experiments to solve them. They have developed the ability to perform the necessary stoichiometric calculations and describe the chemical processes in an appropriate manner, both in written and oral form.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
P (4)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
Vortestate/Nachtestate (pre and post-experiment examination talks approx. 15 minutes each, log approx. 5 to 10 pages each) and assessment of practical performance (2 to 4 random examinations) Assessment offered: Once a year, summer semester Language of assessment: German and/or English		
<b>Allocation of places</b>		
--		
<b>Additional information</b>		
--		
<b>Workload</b>		
60 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
--		
<b>Module appears in</b>		
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Quantum Technology (2021)		

Module title		Abbreviation
<b>Organic Chemistry for students of medicine, biomedicine, dental medicine and natural sciences</b>		o8-OC-NF-152-mo1
Module coordinator		Module offered by
lecturer of lecture "Organische Chemie für Studierende der Medizin, Biomedizin, Zahnmedizin, Ingenieur- und Naturwissenschaften"		Institute of Organic Chemistry
ECTS	Method of grading	Only after succ. compl. of module(s)
3	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
This module provides students with an overview of the theoretical principles of organic chemistry.		
<b>Intended learning outcomes</b>		
Students have become familiar with the fundamental principles of organic chemistry.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 60 minutes) Language of assessment: German and/or English		
<b>Allocation of places</b>		
--		
<b>Additional information</b>		
--		
<b>Workload</b>		
90 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
--		
<b>Module appears in</b>		
Bachelor' degree (1 major) Physics (2012) Bachelor' degree (1 major) Psychology (2010) Bachelor' degree (1 major) Economathematics (2012) Bachelor' degree (1 major) Romanic Languages (French/Spanish) (2013) Bachelor's degree (1 major, 1 minor) Pedagogy (2011) Bachelor's degree (1 major, 1 minor) Pedagogy (2013) Bachelor's degree (1 major, 1 minor) French Studies (2013) Bachelor's degree (1 major, 1 minor) History (2010) Bachelor's degree (1 major, 1 minor) Pre- and Protohistoric Archaeology (2012) Bachelor's degree (1 major, 1 minor) Spanish Studies (2010) Bachelor's degree (1 major, 1 minor) Political and Social Studies (2013) Bachelor's degree (1 major, 1 minor) English and American Studies (2010) Bachelor's degree (1 major, 1 minor) Russian Language and Culture (2008) Bachelor's degree (1 major, 1 minor) Gallo-Roman philology (2010)		
Bachelor's with 1 major Quantum Technology (2021)		page 19 / 179
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Bachelor's degree (1 major, 1 minor) German Language and Literature (2013)  
 Bachelor's degree (1 major, 1 minor) German Language and Literature (2010)  
 Bachelor's degree (1 major, 1 minor) Italian Studies (2010)  
 Bachelor's degree (2 majors) Classical Archaeology (2013)  
 Bachelor's degree (2 majors) Pedagogy (2013)  
 Bachelor's degree (2 majors) Philosophy (2013)  
 Bachelor's degree (2 majors) Special Education (2009)  
 Bachelor's degree (2 majors) Digital Humanities (2012)  
 Bachelor's degree (2 majors) Political and Social Studies (2011)  
 Bachelor's degree (2 majors) Russian Language and Culture (2012)  
 Bachelor's degree (2 majors) European Ethnology (2013)  
 Magister Theologiae Catholic Theology (2013)  
 First state examination for the teaching degree Grundschule English (2009)  
 First state examination for the teaching degree Grundschule Biology (2009)  
 First state examination for the teaching degree Grundschule Chemistry (2009)  
 First state examination for the teaching degree Grundschule Geography (2009)  
 First state examination for the teaching degree Grundschule Protestant Theology (2009)  
 First state examination for the teaching degree Grundschule German (2009)  
 First state examination for the teaching degree Grundschule History (2009)  
 First state examination for the teaching degree Grundschule History (2015)  
 First state examination for the teaching degree Grundschule Catholic Theology (2009)  
 First state examination for the teaching degree Grundschule Mathematics (2009)  
 First state examination for the teaching degree Grundschule Music (2009)  
 First state examination for the teaching degree Grundschule Physics (2009)  
 First state examination for the teaching degree Grundschule Social Science (2009)  
 First state examination for the teaching degree Grundschule Science of Sport (2009)  
 First state examination for the teaching degree Hauptschule English (2009)  
 First state examination for the teaching degree Hauptschule Biology (2009)  
 First state examination for the teaching degree Hauptschule Chemistry (2009)  
 First state examination for the teaching degree Hauptschule Geography (2009)  
 First state examination for the teaching degree Hauptschule Protestant Theology (2009)  
 First state examination for the teaching degree Hauptschule German (2009)  
 First state examination for the teaching degree Hauptschule History (2009)  
 First state examination for the teaching degree Hauptschule Catholic Theology (2009)  
 First state examination for the teaching degree Hauptschule Mathematics (2009)  
 First state examination for the teaching degree Hauptschule Music (2009)  
 First state examination for the teaching degree Hauptschule Physics (2009)  
 First state examination for the teaching degree Hauptschule Social Science (2009)  
 First state examination for the teaching degree Hauptschule Science of Sport (2009)  
 First state examination for the teaching degree Realschule English (2009)  
 First state examination for the teaching degree Realschule Biology (2009)  
 First state examination for the teaching degree Realschule Chemistry (2009)  
 First state examination for the teaching degree Realschule Geography (2009)  
 First state examination for the teaching degree Realschule Protestant Theology (2009)  
 First state examination for the teaching degree Realschule French Studies (2009)  
 First state examination for the teaching degree Realschule German (2009)  
 First state examination for the teaching degree Realschule History (2009)  
 First state examination for the teaching degree Realschule Computer Science (2012)  
 First state examination for the teaching degree Realschule Catholic Theology (2009)  
 First state examination for the teaching degree Realschule Mathematics (2009)  
 First state examination for the teaching degree Realschule Music (2009)  
 First state examination for the teaching degree Realschule Physics (2009)  
 First state examination for the teaching degree Realschule Science of Sport (2009)

First state examination for the teaching degree Gymnasium English (2009)  
 First state examination for the teaching degree Gymnasium Biology (2009)  
 First state examination for the teaching degree Gymnasium Chemistry (2009)  
 First state examination for the teaching degree Gymnasium Geography (2009)  
 First state examination for the teaching degree Gymnasium French Studies (2009)  
 First state examination for the teaching degree Gymnasium German (2009)  
 First state examination for the teaching degree Gymnasium History (2009)  
 First state examination for the teaching degree Gymnasium Greek Philology (2009)  
 First state examination for the teaching degree Gymnasium Computer Science (2009)  
 First state examination for the teaching degree Gymnasium Italian Studies (2009)  
 First state examination for the teaching degree Gymnasium Catholic Theology (2009)  
 First state examination for the teaching degree Gymnasium Latin Philology (2009)  
 First state examination for the teaching degree Gymnasium Mathematics (2012)  
 First state examination for the teaching degree Gymnasium Mathematics (2009)  
 First state examination for the teaching degree Gymnasium Music (2009)  
 First state examination for the teaching degree Gymnasium Physics (2009)  
 First state examination for the teaching degree Gymnasium Russian (2009)  
 First state examination for the teaching degree Gymnasium Social Science (2009)  
 First state examination for the teaching degree Gymnasium Spanish Studies (2009)  
 First state examination for the teaching degree Gymnasium Science of Sport (2009)  
 First state examination for the teaching degree Gymnasium Music Education, Advanced Studies (2009)  
 First state examination for the teaching degree Sonderpädagogik Pedagogy of Secondary Education (2009)  
 First state examination for the teaching degree Sonderpädagogik Pedagogy of Primary Education (2009)  
 First state examination for the teaching degree Sonderpädagogik Teaching at the German Mittelschule (2013)  
 First state examination for the teaching degree Mittelschule English (2013)  
 First state examination for the teaching degree Mittelschule Biology (2013)  
 First state examination for the teaching degree Mittelschule Chemistry (2013)  
 First state examination for the teaching degree Mittelschule Geography (2013)  
 First state examination for the teaching degree Mittelschule Protestant Theology (2013)  
 First state examination for the teaching degree Mittelschule German (2013)  
 First state examination for the teaching degree Mittelschule History (2013)  
 First state examination for the teaching degree Mittelschule Catholic Theology (2013)  
 First state examination for the teaching degree Mittelschule Mathematics (2013)  
 First state examination for the teaching degree Mittelschule Physics (2013)  
 First state examination for the teaching degree Mittelschule Social Science (2013)  
 First state examination for the teaching degree Mittelschule Science of Sport (2013)  
 Bachelor's degree (2 majors) English and American Studies (2009)  
 Bachelor's degree (2 majors) German Language and Literature (2013)  
 Bachelor' degree (1 major) Geography (2015)  
 Bachelor' degree (1 major) Mathematics (2015)  
 Bachelor' degree (1 major) Musicology (2015)  
 Bachelor' degree (1 major) Physics (2015)  
 Bachelor' degree (1 major) Psychology (2015)  
 Bachelor' degree (1 major) Business Management and Economics (2015)  
 Bachelor' degree (1 major) Nanostructure Technology (2015)  
 Bachelor' degree (1 major) Biomedicine (2015)  
 Bachelor' degree (1 major) Music Education (2015)  
 Bachelor' degree (1 major) Computational Mathematics (2015)  
 Bachelor' degree (1 major) Political and Social Studies (2015)  
 Bachelor' degree (1 major) Academic Speech Therapy (2015)  
 Bachelor' degree (1 major) Indology/South Asian Studies (2015)  
 Bachelor's degree (1 major, 1 minor) Egyptology (2015)  
 Bachelor's degree (1 major, 1 minor) Pedagogy (2015)



Bachelor's degree (1 major, 1 minor) History (2015)  
 Bachelor's degree (1 major, 1 minor) Musicology (2015)  
 Bachelor's degree (1 major, 1 minor) Philosophy (2015)  
 Bachelor's degree (1 major, 1 minor) Pre- and Protohistoric Archaeology (2015)  
 Bachelor's degree (1 major, 1 minor) Ancient World (2015)  
 Bachelor's degree (1 major, 1 minor) Music Education (2015)  
 Bachelor's degree (1 major, 1 minor) Philosophy and Religion (2015)  
 Bachelor's degree (1 major, 1 minor) Theological Studies (2015)  
 Bachelor's degree (1 major, 1 minor) Political and Social Studies (2015)  
 Bachelor's degree (1 major, 1 minor) Russian Language and Culture (2015)  
 Bachelor's degree (1 major, 1 minor) German Language and Literature (2015)  
 Bachelor's degree (2 majors) Egyptology (2015)  
 Bachelor's degree (2 majors) Pedagogy (2015)  
 Bachelor's degree (2 majors) Protestant Theology (2015)  
 Bachelor's degree (2 majors) Musicology (2015)  
 Bachelor's degree (2 majors) Philosophy (2015)  
 Bachelor's degree (2 majors) Special Education (2015)  
 Bachelor's degree (2 majors) Pre- and Protohistoric Archaeology (2015)  
 Bachelor's degree (2 majors) Latin Philology (2015)  
 Bachelor's degree (2 majors) Music Education (2015)  
 Bachelor's degree (2 majors) Philosophy and Religion (2015)  
 Bachelor's degree (2 majors) Theological Studies (2015)  
 Bachelor's degree (2 majors) Digital Humanities (2015)  
 Bachelor's degree (2 majors) Political and Social Studies (2015)  
 Bachelor's degree (2 majors) Russian Language and Culture (2015)  
 Bachelor's degree (2 majors) Greek Philology (2015)  
 Bachelor's degree (2 majors) European Ethnology (2015)  
 Bachelor's degree (2 majors) Indology/South Asian Studies (2015)  
 Bachelor's degree (2 majors) Ancient Near Eastern Studies (2015)  
 First state examination for the teaching degree Grundschule English (2015)  
 First state examination for the teaching degree Grundschule Biology (2015)  
 First state examination for the teaching degree Grundschule Chemistry (2015)  
 First state examination for the teaching degree Grundschule Geography (2015)  
 First state examination for the teaching degree Grundschule German (2015)  
 First state examination for the teaching degree Grundschule Catholic Theology (2015)  
 First state examination for the teaching degree Grundschule Mathematics (2015)  
 First state examination for the teaching degree Grundschule Pedagogy of Primary Education (2015)  
 First state examination for the teaching degree Grundschule Physics (2015)  
 First state examination for the teaching degree Grundschule Social Science (2015)  
 First state examination for the teaching degree Grundschule Didactics in English (Primary School) (2015)  
 First state examination for the teaching degree Grundschule Didactics in Biology (Primary School) (2015)  
 First state examination for the teaching degree Grundschule Didactics in Chemistry (Primary School) (2015)  
 First state examination for the teaching degree Grundschule Didactics in Geography (Primary School) (2015)  
 First state examination for the teaching degree Grundschule Didactics in German (Primary School) (2015)  
 First state examination for the teaching degree Grundschule Didactics in History (Primary School) (2015)  
 First state examination for the teaching degree Grundschule Didactics in Catholic Theology (Primary School) (2015)  
 First state examination for the teaching degree Grundschule Art Education in Primary School (2015)  
 First state examination for the teaching degree Grundschule Didactics in Science of Sport (Primary School) (2015)  
 First state examination for the teaching degree Grundschule Didactics in Mathematics (Primary School) (2015)  
 First state examination for the teaching degree Grundschule Music Education in Primary School (2015)  
 First state examination for the teaching degree Grundschule Didactics in Physics (Primary School) (2015)  
 First state examination for the teaching degree Grundschule Didactics in Social Science (Primary School) (2015)

First state examination for the teaching degree Grundschule Science of Sport (2015)  
 First state examination for the teaching degree Realschule English (2015)  
 First state examination for the teaching degree Realschule Biology (2015)  
 First state examination for the teaching degree Realschule Chemistry (2015)  
 First state examination for the teaching degree Realschule Geography (2015)  
 First state examination for the teaching degree Realschule Protestant Theology (2015)  
 First state examination for the teaching degree Realschule French Studies (2015)  
 First state examination for the teaching degree Realschule German (2015)  
 First state examination for the teaching degree Realschule History (2015)  
 First state examination for the teaching degree Realschule Computer Science (2015)  
 First state examination for the teaching degree Realschule Catholic Theology (2015)  
 First state examination for the teaching degree Realschule Mathematics (2015)  
 First state examination for the teaching degree Realschule Physics (2015)  
 First state examination for the teaching degree Realschule Science of Sport (2015)  
 First state examination for the teaching degree Gymnasium English (2015)  
 First state examination for the teaching degree Gymnasium Biology (2015)  
 First state examination for the teaching degree Gymnasium Chemistry (2015)  
 First state examination for the teaching degree Gymnasium Geography (2015)  
 First state examination for the teaching degree Gymnasium French Studies (2015)  
 First state examination for the teaching degree Gymnasium German (2015)  
 First state examination for the teaching degree Gymnasium History (2015)  
 First state examination for the teaching degree Gymnasium Greek Philology (2015)  
 First state examination for the teaching degree Gymnasium Computer Science (2015)  
 First state examination for the teaching degree Gymnasium Italian Studies (2015)  
 First state examination for the teaching degree Gymnasium Catholic Theology (2015)  
 First state examination for the teaching degree Gymnasium Latin Philology (2015)  
 First state examination for the teaching degree Gymnasium Mathematics (2015)  
 First state examination for the teaching degree Gymnasium Physics (2015)  
 First state examination for the teaching degree Gymnasium Russian (2015)  
 First state examination for the teaching degree Gymnasium Social Science (2015)  
 First state examination for the teaching degree Gymnasium Spanish Studies (2015)  
 First state examination for the teaching degree Gymnasium Science of Sport (2015)  
 First state examination for the teaching degree Sonderpädagogik Pedagogy of Primary Education (2015)  
 First state examination for the teaching degree Sonderpädagogik Didactics in German (Primary School) (2015)  
 First state examination for the teaching degree Sonderpädagogik Didactics in Catholic Theology (Primary School) (2015)  
 First state examination for the teaching degree Sonderpädagogik Art Education in Primary School (2015)  
 First state examination for the teaching degree Sonderpädagogik Didactics in Science of Sport (Primary School) (2015)  
 First state examination for the teaching degree Sonderpädagogik Didactics in Mathematics (Primary School) (2015)  
 First state examination for the teaching degree Sonderpädagogik Music Education in Primary School (2015)  
 First state examination for the teaching degree Sonderpädagogik Didactics in English (Middle School) (2015)  
 First state examination for the teaching degree Sonderpädagogik Ergonomics (Teaching at the German Mittelschule) (2015)  
 First state examination for the teaching degree Sonderpädagogik Didactics in Biology (Middle School) (2015)  
 First state examination for the teaching degree Sonderpädagogik Didactics in Chemistry (Middle School) (2015)  
 First state examination for the teaching degree Sonderpädagogik Didactics in Geography (Middle School) (2015)  
 First state examination for the teaching degree Sonderpädagogik Didactics in Protestant Theology (Middle School) (2015)  
 First state examination for the teaching degree Sonderpädagogik Didactics in German (Middle School) (2015)  
 First state examination for the teaching degree Sonderpädagogik Didactics in History (Middle School) (2015)

First state examination for the teaching degree Sonderpädagogik Didactics in Catholic Theology (Middle School) (2015)

First state examination for the teaching degree Sonderpädagogik Art Education in Middle School (2015)

First state examination for the teaching degree Sonderpädagogik Didactics in Science of Sport (Middle School) (2015)

First state examination for the teaching degree Sonderpädagogik Didactics in Mathematics (Middle School) (2015)

First state examination for the teaching degree Sonderpädagogik Music Education in Middle School (2015)

First state examination for the teaching degree Sonderpädagogik Didactics in Physics (Middle School) (2015)

First state examination for the teaching degree Sonderpädagogik Didactics in Social Science (Middle School) (2015)

First state examination for the teaching degree Sonderpädagogik Teaching at the German Mittelschule (2015)

First state examination for the teaching degree Mittelschule English (2015)

First state examination for the teaching degree Mittelschule Biology (2015)

First state examination for the teaching degree Mittelschule Chemistry (2015)

First state examination for the teaching degree Mittelschule Geography (2015)

First state examination for the teaching degree Mittelschule Protestant Theology (2015)

First state examination for the teaching degree Mittelschule German (2015)

First state examination for the teaching degree Mittelschule History (2015)

First state examination for the teaching degree Mittelschule Catholic Theology (2015)

First state examination for the teaching degree Mittelschule Mathematics (2015)

First state examination for the teaching degree Mittelschule Physics (2015)

First state examination for the teaching degree Mittelschule Social Science (2015)

First state examination for the teaching degree Mittelschule Didactics in English (Middle School) (2015)

First state examination for the teaching degree Mittelschule Ergonomics (Teaching at the German Mittelschule) (2015)

First state examination for the teaching degree Mittelschule Didactics in Biology (Middle School) (2015)

First state examination for the teaching degree Mittelschule Didactics in Chemistry (Middle School) (2015)

First state examination for the teaching degree Mittelschule Didactics in Geography (Middle School) (2015)

First state examination for the teaching degree Mittelschule Didactics in Protestant Theology (Middle School) (2015)

First state examination for the teaching degree Mittelschule Didactics in German (Middle School) (2015)

First state examination for the teaching degree Mittelschule Didactics in History (Middle School) (2015)

First state examination for the teaching degree Mittelschule Didactics in Catholic Theology (Middle School) (2015)

First state examination for the teaching degree Mittelschule Art Education in Middle School (2015)

First state examination for the teaching degree Mittelschule Didactics in Science of Sport (Middle School) (2015)

First state examination for the teaching degree Mittelschule Didactics in Mathematics (Middle School) (2015)

First state examination for the teaching degree Mittelschule Music Education in Middle School (2015)

First state examination for the teaching degree Mittelschule Didactics in Physics (Middle School) (2015)

First state examination for the teaching degree Mittelschule Didactics in Social Science (Middle School) (2015)

First state examination for the teaching degree Mittelschule Science of Sport (2015)

First state examination for the teaching degree Mittelschule Teaching at the German Mittelschule (2015)

Bachelor's degree (2 majors) Geography (2015)

Bachelor's degree (2 majors) French Studies (2015)

Bachelor's degree (2 majors) History (2015)

Bachelor's degree (2 majors) Sport Science (Focus on health and Pedagogics in Movement) (2015)

Bachelor's degree (2 majors) German Language and Literature (2015)

Bachelor' degree (1 major) Mathematical Physics (2016)

Bachelor's degree (2 majors) Theological Studies (2011)

First state examination for the teaching degree Grundschule Protestant Theology (2015)

First state examination for the teaching degree Grundschule Music (2015)



First state examination for the teaching degree Grundschule Didactics in Protestant Theology (Primary School) (2015)

First state examination for the teaching degree Realschule Music (2015)

First state examination for the teaching degree Gymnasium Music (2015)

First state examination for the teaching degree Gymnasium Music Education, Advanced Studies (2015)

First state examination for the teaching degree Sonderpädagogik Didactics in Protestant Theology (Primary School) (2015)

First state examination for the teaching degree Mittelschule Music (2015)

Bachelor's degree (1 major, 1 minor) French Studies (2016)

Bachelor's degree (2 majors) French Studies (2016)

Bachelor's degree (1 major, 1 minor) Italian Studies (2016)

Bachelor's degree (2 majors) Italian Studies (2016)

Bachelor's degree (1 major, 1 minor) Spanish Studies (2016)

Bachelor's degree (2 majors) Spanish Studies (2016)

Bachelor' degree (1 major) Romanic Languages (French/Italian) (2016)

Bachelor' degree (1 major) Romanic Languages (French/Spanish) (2016)

Bachelor' degree (1 major) Romanic Languages (Italian/Spanish) (2016)

Bachelor' degree (1 major) Business Information Systems (2016)

First state examination for the teaching degree Gymnasium French Studies (2016)

First state examination for the teaching degree Gymnasium Italian Studies (2016)

First state examination for the teaching degree Gymnasium Spanish Studies (2016)

First state examination for the teaching degree Realschule French Studies (2016)

Bachelor' degree (1 major) Games Engineering (2016)

Bachelor's degree (1 major, 1 minor) English and American Studies (2016)

Bachelor's degree (2 majors) English and American Studies (2016)

First state examination for the teaching degree Grundschule English (2016)

First state examination for the teaching degree Grundschule Didactics in English (Primary School) (2016)

First state examination for the teaching degree Realschule English (2016)

First state examination for the teaching degree Gymnasium English (2016)

First state examination for the teaching degree Mittelschule English (2016)

First state examination for the teaching degree Mittelschule Didactics in English (Middle School) (2016)

First state examination for the teaching degree Sonderpädagogik Didactics in English (Middle School) (2016)

Bachelor' degree (1 major) Media Communication (2016)

Bachelor's degree (1 major, 1 minor) Digital Humanities (2016)

Bachelor's degree (1 major, 1 minor) Geography (2017)

Bachelor's degree (1 major, 1 minor) History of Medieval and Modern Art (2017)

Bachelor's degree (2 majors) History of Medieval and Modern Art (2017)

Bachelor's degree (2 majors) Comparative Indo-European Linguistics (2017)

Bachelor' degree (1 major) Aerospace Computer Science (2017)

Bachelor' degree (1 major) Modern China (2017)

Bachelor's degree (1 major, 1 minor) Museology and material culture (2017)

Bachelor' degree (1 major) Economathematics (2017)

Bachelor' degree (1 major) Games Engineering (2017)

Bachelor' degree (1 major) Computer Science (2017)

First state examination for the teaching degree Gymnasium Greek Philology (2018)

Bachelor' degree (1 major) Media Communication (2018)

Bachelor' degree (1 major) Biomedicine (2018)

Bachelor' degree (1 major) Human-Computer Systems (2018)

Bachelor's degree (2 majors) Classical Archaeology (2018)

Bachelor's degree (1 major, 1 minor) Classical Archaeology (2018)

Bachelor's degree (1 major, 1 minor) Digital Humanities (2018)

Bachelor's degree (2 majors) Digital Humanities (2018)

First state examination for the teaching degree Grundschule Physics (2018)

First state examination for the teaching degree Grundschule Didactics in Physics (Primary School) (2018)  
 First state examination for the teaching degree Realschule Physics (2018)  
 First state examination for the teaching degree Gymnasium Physics (2018)  
 First state examination for the teaching degree Mittelschule Physics (2018)  
 First state examination for the teaching degree Sonderpädagogik Didactics in Physics (Middle School) (2018)  
 First state examination for the teaching degree Mittelschule Didactics in Physics (Middle School) (2018)  
 Bachelor' degree (1 major) Computer Science (2019)  
 First state examination for the teaching degree Gymnasium Mathematics (2019)  
 Bachelor's degree (1 major, 1 minor) English and American Studies (2019)  
 Module studies (Bachelor) Chemistry (2019)  
 Bachelor's degree (1 major, 1 minor) Indology/South Asian Studies (2019)  
 Bachelor' degree (1 major) Indology/South Asian Studies (2019)  
 Bachelor' degree (1 major) Business Information Systems (2019)  
 Bachelor's degree (2 majors) Indology/South Asian Studies (2019)  
 Bachelor' degree (1 major) Business Management and Economics (2019)  
 Bachelor' degree (1 major) Modern China (2019)  
 Module studies (Bachelor) Orientierungsstudien (2020)  
 Bachelor' degree (1 major) Biomedicine (2020)  
 Bachelor' degree (1 major) Pedagogy (2020)  
 Bachelor' degree (1 major) Political and Social Studies (2020)  
 Bachelor' degree (1 major) Business Information Systems (2020)  
 Bachelor's degree (1 major, 1 minor) Political and Social Studies (2020)  
 Bachelor's degree (2 majors) European Ethnology (2020)  
 Bachelor's degree (2 majors) Political and Social Studies (2020)  
 Bachelor's degree (2 majors) Special Education (2020)  
 First state examination for the teaching degree Mittelschule Biology (2020 (Prüfungsordnungsversion 2015))  
 First state examination for the teaching degree Sonderpädagogik Didactics in Biology (Middle School) (2020 (Prüfungsordnungsversion 2015))  
 First state examination for the teaching degree Mittelschule Didactics in Biology (Middle School) (2020 (Prüfungsordnungsversion 2015))  
 First state examination for the teaching degree Mittelschule Chemistry (2020 (Prüfungsordnungsversion 2015))  
 First state examination for the teaching degree Mittelschule Didactics in Chemistry (Middle School) (2020 (Prüfungsordnungsversion 2015))  
 First state examination for the teaching degree Mittelschule German (2020 (Prüfungsordnungsversion 2015))  
 First state examination for the teaching degree Mittelschule Didactics in German (Middle School) (2020 (Prüfungsordnungsversion 2015))  
 First state examination for the teaching degree Mittelschule English (2020 (Prüfungsordnungsversion 2016))  
 First state examination for the teaching degree Mittelschule Didactics in English (Middle School) (2020 (Prüfungsordnungsversion 2016))  
 First state examination for the teaching degree Mittelschule Protestant Theology (2020 (Prüfungsordnungsversion 2015))  
 First state examination for the teaching degree Mittelschule Didactics in Protestant Theology (Middle School) (2020 (Prüfungsordnungsversion 2015))  
 First state examination for the teaching degree Mittelschule Geography (2020 (Prüfungsordnungsversion 2015))  
 First state examination for the teaching degree Mittelschule Didactics in Geography (Middle School) (2020 (Prüfungsordnungsversion 2015))  
 First state examination for the teaching degree Mittelschule History (2020 (Prüfungsordnungsversion 2015))  
 First state examination for the teaching degree Mittelschule Didactics in History (Middle School) (2020 (Prüfungsordnungsversion 2015))  
 First state examination for the teaching degree Mittelschule Catholic Theology (2020 (Prüfungsordnungsversion 2015))  
 First state examination for the teaching degree Mittelschule Didactics in Catholic Theology (Middle School) (2020 (Prüfungsordnungsversion 2015))

First state examination for the teaching degree Mittelschule Mathematics (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Mittelschule Didactics in Mathematics (Middle School) (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Mittelschule Art Education in Middle School (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Mittelschule Science of Sport (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Mittelschule Didactics in Science of Sport (Middle School) (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Mittelschule Music (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Mittelschule Music Education in Middle School (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Mittelschule Teaching at the German Mittelschule (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Didactics in English (Middle School) (2020 (Prüfungsordnungsversion 2016))
First state examination for the teaching degree Sonderpädagogik Didactics in Chemistry (Middle School) (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Didactics in Geography (Middle School) (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Didactics in Protestant Theology (Middle School) (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Didactics in German (Middle School) (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Didactics in History (Middle School) (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Didactics in Catholic Theology (Middle School) (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Art Education in Middle School (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Didactics in Science of Sport (Middle School) (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Didactics in Mathematics (Middle School) (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Music Education in Middle School (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Teaching at the German Mittelschule (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Art Education in Primary School (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Music Education in Primary School (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Didactics in Science of Sport (Primary School) (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Didactics in German (Primary School) (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Didactics in Mathematics (Primary School) (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Pedagogy of Primary Education (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Didactics in Protestant Theology (Primary School) (2020 (Prüfungsordnungsversion 2015))
First state examination for the teaching degree Sonderpädagogik Didactics in Catholic Theology (Primary School) (2020 (Prüfungsordnungsversion 2015))

Bachelor' degree (1 major) Physics (2020)  
 Bachelor' degree (1 major) Nanostructure Technology (2020)  
 Bachelor' degree (1 major) Mathematical Physics (2020)  
 Bachelor' degree (1 major) Aerospace Computer Science (2020)  
 Bachelor's degree (1 major, 1 minor) Museology and material culture (2020)  
 First state examination for the teaching degree Grundschule Didactics in Physics (Primary School) (2020)  
 First state examination for the teaching degree Grundschule Physics (2020)  
 First state examination for the teaching degree Gymnasium Physics (2020)  
 First state examination for the teaching degree Realschule Physics (2020)  
 First state examination for the teaching degree Sonderpädagogik Didactics in Physics (Middle School) (2020)  
 First state examination for the teaching degree Mittelschule Didactics in Physics (Middle School) (2020)  
 First state examination for the teaching degree Mittelschule Physics (2020)  
 Bachelor's degree (1 major, 1 minor) Pedagogy (2020)  
 Bachelor's degree (2 majors) Pedagogy (2020)  
 First state examination for the teaching degree Grundschule Political and Social Studies (2020)  
 First state examination for the teaching degree Grundschule Didactics in Political and Social Studies (Primary School) (2020)  
 First state examination for the teaching degree Sonderpädagogik MS-Didaktik Career and Economics (2020)  
 First state examination for the teaching degree Sonderpädagogik Didactics in Political and Social Studies (Secondary School) (2020)  
 First state examination for the teaching degree Mittelschule MS-Didaktik Career and Economics (2020)  
 First state examination for the teaching degree Mittelschule Didactics in Political and Social Studies (Secondary School) (2020)  
 First state examination for the teaching degree Mittelschule Political and Social Studies (2020)  
 First state examination for the teaching degree Gymnasium Political and Social Studies (2020)  
 Bachelor' degree (1 major) Psychology (2020)  
 Magister Theologiae Catholic Theology (2021)  
 Bachelor's degree (2 majors) History (2021)  
 Bachelor's degree (1 major, 1 minor) History (2021)  
 First state examination for the teaching degree Grundschule History (2021)  
 First state examination for the teaching degree Gymnasium History (2021)  
 First state examination for the teaching degree Realschule History (2021)  
 First state examination for the teaching degree Mittelschule History (2021)  
 Bachelor' degree (1 major) Media Communication (2021)  
 Bachelor's degree (2 majors) Theological Studies (2021)  
 Bachelor's degree (1 major, 1 minor) Theological Studies (2021)  
 Bachelor's degree (1 major, 1 minor) English and American Studies (2021)  
 Bachelor's degree (2 majors) English and American Studies (2021)  
 First state examination for the teaching degree Grundschule Pedagogy of Primary Education (2021)  
 First state examination for the teaching degree Gymnasium English (2021)  
 First state examination for the teaching degree Gymnasium Philosophy and Ethics (2021)  
 Bachelor' degree (1 major) Computer Science und Sustainability (2021)  
 Bachelor's degree (2 majors) Comparative Indo-European Linguistics (2021)  
 Bachelor' degree (1 major) Quantum Technology (2021)  
 Bachelor's degree (2 majors) Special Education (2021)  
 Bachelor' degree (1 major) Business Information Systems (2021)  
 Bachelor' degree (1 major) Econometrics (2021)  
 Bachelor' degree (1 major) Business Management and Economics (2021)  
 First state examination for the teaching degree Sonderpädagogik Pedagogy of Primary Education (2021)  
 Bachelor' degree (1 major) Human-Computer Systems (2022)  
 Bachelor's degree (1 major, 1 minor) Museology and material culture (2022)  
 Bachelor' degree (1 major) Econometrics (2022)  
 Bachelor' degree (1 major) Mathematical Data Science (2022)



Bachelor' degree (1 major) Artificial Intelligence and Data Science (2022)  
 First state examination for the teaching degree Gymnasium Philosophy and Ethics (2022)  
 Bachelor's degree (2 majors) Ancient Near Eastern Archaeology (2022)  
 Bachelor's degree (1 major, 1 minor) Ancient World (2022)  
 Bachelor's degree (2 majors) Ancient Near Eastern Studies (2022)  
 Bachelor' degree (1 major) Franco-German studies: language, culture, digital competence (2022)  
 Bachelor' degree (1 major) Midwifery (2022)  
 First state examination for the teaching degree Gymnasium Russian (2023)  
 First state examination for the teaching degree Gymnasium Mathematics (2023)  
 First state examination for the teaching degree Gymnasium English (2023)  
 First state examination for the teaching degree Realschule English (2023)  
 First state examination for the teaching degree Grundschule English (2023)  
 First state examination for the teaching degree Grundschule Didactics in English (Primary School) (2023)  
 First state examination for the teaching degree Mittelschule English (2023)  
 First state examination for the teaching degree Mittelschule Didactics in English (Middle School) (2023)  
 First state examination for the teaching degree Sonderpädagogik Didactics in English (Middle School) (2023)  
 First state examination for the teaching degree Gymnasium Geography (2023)  
 First state examination for the teaching degree Realschule Geography (2023)  
 First state examination for the teaching degree Grundschule Geography (2023)  
 First state examination for the teaching degree Mittelschule Geography (2023)  
 Bachelor' degree (1 major) European Law (2023)  
 Bachelor's degree (1 major, 1 minor) English and American Studies (2023)  
 Bachelor's degree (2 majors) English and American Studies (2023)  
 Bachelor' degree (1 major) Artificial Intelligence and Data Science (2023)  
 Bachelor' degree (1 major) Mathematics (2023)  
 Bachelor' degree (1 major) Business Information Systems (2023)  
 Bachelor' degree (1 major) Econometrics (2023)  
 Bachelor's degree (1 major, 1 minor) History of Medieval and Modern Art (2023)  
 Bachelor's degree (2 majors) History of Medieval and Modern Art (2023)  
 Bachelor's degree (2 majors) Special Education (2023)  
 Bachelor' degree (1 major) Business Management and Economics (2023)  
 Bachelor' degree (1 major) Geography (2023)  
 Bachelor's degree (2 majors) Geography (2023)  
 Bachelor's degree (1 major, 1 minor) Geography (2023)  
 Bachelor's degree (2 majors) European Ethnology/Empiric Cultural Studies (2023)  
 First state examination for the teaching degree Grundschule German (2024)  
 First state examination for the teaching degree Gymnasium German (2024)  
 First state examination for the teaching degree Realschule German (2024)  
 First state examination for the teaching degree Sonderpädagogik Didactics in German (Middle School) (2024)  
 First state examination for the teaching degree Mittelschule Didactics in German (Middle School) (2024)  
 First state examination for the teaching degree Grundschule Didactics in German (Primary School) (2024)  
 First state examination for the teaching degree Sonderpädagogik Didactics in German (Primary School) (2024)  
 First state examination for the teaching degree Mittelschule German (2024)  
 Bachelor' degree (1 major) Mathematical Physics (2024)  
 Bachelor's degree (2 majors) German Language and Literature (2024)  
 Bachelor's degree (1 major, 1 minor) German Language and Literature (2024)  
 Bachelor' degree (1 major) Music Education (2024)  
 Bachelor's degree (2 majors) Music Education (2024)  
 Bachelor's degree (1 major, 1 minor) Music Education (2024)  
 First state examination for the teaching degree Grundschule Music Education in Primary School (2024)  
 First state examination for the teaching degree Sonderpädagogik Music Education in Primary School (2024)  
 First state examination for the teaching degree Mittelschule Music Education in Middle School (2024)  
 First state examination for the teaching degree Sonderpädagogik Music Education in Middle School (2024)

Bachelor' degree (1 major) Indology/South Asian Studies (2024)  
 Bachelor's degree (2 majors) Indology/South Asian Studies (2024)  
 Bachelor's degree (1 major, 1 minor) Indology/South Asian Studies (2024)  
 Bachelor's degree (1 major, 1 minor) Ancient World (2024)  
 Bachelor's degree (2 majors) Digital Humanities (2024)  
 Bachelor's degree (1 major, 1 minor) Digital Humanities (2024)  
 Bachelor' degree (1 major) Midwifery (2024)  
 Bachelor's degree (2 majors) Greek Philology (2024)  
 Bachelor's degree (2 majors) Latin Philology (2024)  
 First state examination for the teaching degree Gymnasium Latin Philology (2024)  
 Bachelor' degree (1 major) Business Information Systems (2024)  
 Bachelor' degree (1 major) Economathematics (2024)  
 Bachelor' degree (1 major) Business Management and Economics (2024)  
 Bachelor' degree (1 major) Artificial Intelligence and Data Science (2024)  
 First state examination for the teaching degree Gymnasium English (2024)  
 First state examination for the teaching degree Mittelschule MS-Didaktik Career and Economics (2024)  
 First state examination for the teaching degree Sonderpädagogik MS-Didaktik Career and Economics (2024)  
 First state examination for the teaching degree Grundschule History (2024)  
 First state examination for the teaching degree Gymnasium History (2024)  
 First state examination for the teaching degree Realschule History (2024)  
 First state examination for the teaching degree Mittelschule History (2024)  
 First state examination for the teaching degree Mittelschule Didactics in History (Middle School) (2024)  
 First state examination for the teaching degree Sonderpädagogik Didactics in History (Middle School) (2024)  
 First state examination for the teaching degree Grundschule Didactics in History (Primary School) (2024)  
 First state examination for the teaching degree Gymnasium Greek Philology (2024)  
 Bachelor' degree (1 major) Human-Computer-Interaction (2024)

# Classical Physics

(16 ECTS credits)

Module title		Abbreviation
<b>Classical Physics 1 (Mechanics)</b>		11-E-M-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
8	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	Admission prerequisite to assessment: completion of exercises (approx. 13 exercise sheets per semester). Students who successfully completed approx. 50% of exercises will qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the semester.
Contents		
<p>1. Principles: Physical quantities, prefactors, derived quantities, dimensional analysis, time / length / mass (definition, measurement procedures, SI), importance of metrology;</p> <p>2. Point Mechanics: Kinematics, motion in 2D and 3D / vectors, special cases: Uniform and constant accelerated motion, free fall, slat litter; circular motion in polar coordinates;</p> <p>3. Newton's laws: Forces and momentum definition, weight vs. mass forces on the pendulum, forces on an atomic scale, isotropic and anisotropic friction. Preparation of the equations of motion and solutions;</p> <p>4. Work and energy: (Kinetic) performance, examples;</p> <p>5. Elastic, inelastic and super-elastic collision: Energy and momentum conservation, surges in centre of mass and balance system, rocket equation;</p> <p>6. Conservative and non-conservative force fields: Potential, potential energy; law, weight scale, field strength and potential of gravity (general relations);</p> <p>7. Rotational motion: Angular momentum, angular velocity, torque, rotational energy, moment of inertia, analogies to linear translation, applications, satellites (geostationary and interstellar), escape velocities, trajectories in the central potential;</p> <p>8. Tidal forces: Inertial system, reference systems, apparent forces, Foucault pendulum, Coriolis force, centrifugal force;</p> <p>9. Galilean transformation: Brief digression to Maxwell's equations, ether, Michelson interferometer, Einstein's postulates, problem of simultaneity, Lorentz transformation, time dilation and length contraction, relativistic impulse;</p> <p>10. Rigid body and gyroscope: Determining the centre of mass, inertia tensor and -ellipsoid, principal axes and their stability, tensor on the example of the elasticity tensor, physics of the bike; gyroscope: Precession and nutation, the Earth as a spinning top;</p> <p>11. Friction: Static and dynamic friction, stick-slip motion, rolling friction, viscous friction, laminar flow, eddy formation;</p> <p>12. Vibration: Representation by means of complex e-function, equation of motion (DGL) on forces, torque and power approach, Taylor expansion, harmonic approximation; spring and pendulum, physical pendulum, damped vibration (resonant case, Kriechfall, aperiodic limit), forced vibration, Fourier analysis;</p> <p>13. Coupled vibrations: Eigenvalues and eigenfunctions, double pendulum, deterministic vs. chaotic motion, non-linear dynamics and chaos;</p> <p>14. Waves: Wave equation, transverse and longitudinal waves, polarisation, principle of superposition, reflection at the open and closed end, speed of sound; interference, Doppler effect; phase and group velocity, dispersion relation;</p> <p>15. Elastic deformation of solid bodies: Elastic modulus, general Hooke's law, elastic waves;</p> <p>16. Fluids: Hydrostatic pressure and buoyancy, surface tension and contact angle, capillary forces, steady flows, Bernoulli equation; Boyle-Mariotte, gas laws, barometric height formula, air pressure, compressibility and compressive modulus;</p> <p>17. Kinetic theory of gases: ideal and real gas, averages, distribution functions, equipartition theorem, Brownian motion, collision cross section, mean free path, diffusion and osmosis, degrees of freedom, specific heat</p>		



### Intended learning outcomes

The students understand the basic contexts and principles of mechanics, vibration, waves and kinetic theory of gases. They are able to apply mathematical methods to the formulation of physical contexts and autonomously apply their knowledge to the solution of mathematical-physical tasks.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: Ü: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 120 minutes)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

Registration: If a student registers for the exercises and obtains the qualification for admission to assessment, this will be considered a declaration of will to seek admission to assessment pursuant to Section 20 Subsection 3 Sentence 4 ASPO (general academic and examination regulations). If the module coordinators subsequently find that the student has obtained the qualification for admission to assessment, they will put the student's registration for assessment into effect. Only those students that meet the respective prerequisites can successfully register for an assessment. Students who did not register for an assessment or whose registration for an assessment was not put into effect will not be admitted to the respective assessment. If a student takes an assessment to which he/she has not been admitted, the grade achieved in this assessment will not be considered.

### Workload

240 h

### Teaching cycle

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 53 I Nr. 1 a)

§ 77 I Nr. 1 a)

### Module appears in

Bachelor' degree (1 major) Physics (2015)  
Bachelor' degree (1 major) Nanostructure Technology (2015)  
Bachelor' degree (1 major) Mathematical Physics (2015)  
Bachelor's degree (1 major, 1 minor) Physics (Minor, 2015)  
First state examination for the teaching degree Grundschule Physics (2015)  
First state examination for the teaching degree Realschule Physics (2015)  
First state examination for the teaching degree Gymnasium Physics (2015)  
First state examination for the teaching degree Mittelschule Physics (2015)  
Bachelor' degree (1 major) Mathematical Physics (2016)  
First state examination for the teaching degree Grundschule Physics (2018)  
First state examination for the teaching degree Realschule Physics (2018)  
First state examination for the teaching degree Gymnasium Physics (2018)  
First state examination for the teaching degree Mittelschule Physics (2018)  
Bachelor' degree (1 major) Physics (2020)  
Bachelor' degree (1 major) Nanostructure Technology (2020)  
Bachelor' degree (1 major) Mathematical Physics (2020)  
Bachelor's degree (1 major, 1 minor) Physics (Minor, 2020)  
First state examination for the teaching degree Grundschule Physics (2020)  
First state examination for the teaching degree Gymnasium Physics (2020)  
First state examination for the teaching degree Realschule Physics (2020)

First state examination for the teaching degree Mittelschule Physics (2020)  
Bachelor' degree (1 major) Functional Materials (2021)  
Bachelor' degree (1 major) Quantum Technology (2021)  
exchange program Physics (2023)  
Bachelor' degree (1 major) Mathematical Physics (2024)

Module title		Abbreviation
Classical Physics 2 (Heat and Electromagnetism)		11-E-E-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
8	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	Admission prerequisite to assessment: completion of exercises (approx. 13 exercise sheets per semester). Students who successfully completed approx. 50% of exercises will qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the semester.
Contents		
<ol style="list-style-type: none"> <li>1. Thermodynamics (linked to 11-E-M); temperature and quantity of heat, thermometer, Kelvin scale;</li> <li>2. Heat conduction, heat transfer, diffusion, convection, radiant heat;</li> <li>3. Fundamental theorems of thermodynamics, entropy, irreversibility, Maxwell's demon;</li> <li>4. Heat engines, working diagrams, efficiency, example: Stirling engine;</li> <li>5. Real gases and liquids, states of matter (also solids), van der Waals, critical point, phase transitions, critical phenomena (opalescence), coexistence region, Joule-Thomson;</li> <li>6. Electrostatics, basic concepts: Electrical charge, forces; electric field, reps. field concept, field lines, field of a point charge;</li> <li>7. Gaussian sentence, related to Coulomb's law, definition of "river"; Gaussian surface, divergence theorem; special symmetries; divergence and GS in differential form;</li> <li>8. Electrical potential, working in the E-box, electric. potential, potential difference, voltage; potential equation, equipotential surfaces; several important examples: Sphere, hollow sphere, capacitor plates, electric dipole; lace effects, Segner wheel;</li> <li>9. Matter in the E-field, charge in a homogeneous field, Millikan experiment, Braun tube; electron: Field emission, thermionic emission, dipole in homogeneous and inhomogeneous field; induction, Faraday cage;</li> <li>10. Capacitor, mirror charge, definition, capacity; plate and spherical capacitor; combination of capacitors; media in the capacitor; electrical polarisation, displacement and orientation polarisation, microscopic image; dielectric displacement; electrolytic capacitor; Piezoelectric effect;</li> <li>11. Electricity, introduction, current density, drift velocity, conduction mechanisms;</li> <li>12. Resistance and conductivity, resistivity, temperature dependence; Ohm's law; realisations (resistive and non-ohmic, NTC, PTC);</li> <li>13. Circuits, electrical networks, Kirchhoff's rules (meshes, nodes); internal resistance of a voltage source, measuring instruments; Wheatstone bridge;</li> <li>14. Power and energy in the circuit; Capacitor charge; galvanic element; thermovoltage;</li> <li>15. Transfer mechanisms, conduction in solids: Band model, semiconductor; line in liquids and gases;</li> <li>16. Magnetostatics, fundamental laws; permanent magnet, field properties, definitions and units; Earth's magnetic field; Amper's Law, analogous to e-box, magn. river, swirl;</li> <li>17. Vector potential, formal derivation, analogous to electric scalar potential; calculation of fields, examples, Helmholtz coils;</li> <li>18. Moving charge in the static magnetic field, current balance, Lorentz force, right-hand rule, electric motor; dipole field; movement paths, mass spectrometer, Wien filters, Hall effect; electron: <math>e / m</math> determination;</li> <li>19. matter in the magnetic field, effects of the field on matter, relative permeability, susceptibility; para-, dia-, ferromagnetism; magn. moment of the electron, behaviour at interfaces;</li> <li>20. induction, Faraday's law of induction, Lenz's rule, flux change, eddy electric field, Waltenhofen's pendulum; inductance, self-induction; applications: Transformer, generator;</li> <li>21. Maxwell's displacement current, choice of integration area, displacement current; Maxwell's extension, wave equation; Maxwell equations;</li> <li>22. AC: Fundamentals, sinusoidal vibrations, amplitude, period and phase; power and RMS value, ohmic resistance; Capacitive &amp; inductive resistor, capacitor and coil, phase shift and frequency dependence; impedance: Complex resistance; performance of the AC;</li> </ol>		
Bachelor's with 1 major Quantum Technology (2021)		page 35 / 179

23. Resonant circuits, combinations of RLC; series and parallel resonant circuit; forced vibration, damped harmonic oscillator (related to 11-E-M);  
24: Hertz dipole, characteristics of irradiation, near field, far field; Rayleigh scattering; accelerated charge, synchrotron radiation, X-rays; 25. Electromagnetic waves: Principles, Maxwell's determination to electromagnetism, radiation pressure (Poynting vector, radiation pressure).

### Intended learning outcomes

The students understand the basic principles and contexts of thermodynamics, science of electricity and magnetism. They know relevant experiments to observe and measure these principles and contexts. They are able to apply mathematical methods to the formulation of physical contexts and autonomously apply their knowledge to the solution of mathematical-physical tasks.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: Ü: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 120 minutes)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

Registration: If a student registers for the exercises and obtains the qualification for admission to assessment, this will be considered a declaration of will to seek admission to assessment pursuant to Section 20 Subsection 3 Sentence 4 ASPO (general academic and examination regulations). If the module coordinators subsequently find that the student has obtained the qualification for admission to assessment, they will put the student's registration for assessment into effect. Only those students that meet the respective prerequisites can successfully register for an assessment. Students who did not register for an assessment or whose registration for an assessment was not put into effect will not be admitted to the respective assessment. If a student takes an assessment to which he/she has not been admitted, the grade achieved in this assessment will not be considered.

### Workload

240 h

### Teaching cycle

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 53 I Nr. 1 a)

§ 77 I Nr. 1 a)

### Module appears in

Bachelor' degree (1 major) Physics (2015)  
Bachelor' degree (1 major) Nanostructure Technology (2015)  
Bachelor' degree (1 major) Mathematical Physics (2015)  
Bachelor's degree (1 major, 1 minor) Physics (Minor, 2015)  
First state examination for the teaching degree Grundschule Physics (2015)  
First state examination for the teaching degree Realschule Physics (2015)  
First state examination for the teaching degree Gymnasium Physics (2015)  
First state examination for the teaching degree Mittelschule Physics (2015)  
Bachelor' degree (1 major) Mathematical Physics (2016)  
First state examination for the teaching degree Grundschule Physics (2018)  
First state examination for the teaching degree Realschule Physics (2018)  
First state examination for the teaching degree Gymnasium Physics (2018)  
First state examination for the teaching degree Mittelschule Physics (2018)  
Bachelor' degree (1 major) Physics (2020)

Bachelor' degree (1 major) Nanostructure Technology (2020)  
 Bachelor' degree (1 major) Mathematical Physics (2020)  
 Bachelor's degree (1 major, 1 minor) Physics (Minor, 2020)  
 First state examination for the teaching degree Grundschule Physics (2020)  
 First state examination for the teaching degree Gymnasium Physics (2020)  
 First state examination for the teaching degree Realschule Physics (2020)  
 First state examination for the teaching degree Mittelschule Physics (2020)  
 Bachelor' degree (1 major) Functional Materials (2021)  
 Bachelor' degree (1 major) Quantum Technology (2021)  
 exchange program Physics (2023)  
 Bachelor' degree (1 major) Mathematical Physics (2024)

# Optics and Quantum Physics I

(6 ECTS credits)

Module title			Abbreviation
Optics and Quantum Physics			11-E-OAV-152-m01
Module coordinator		Module offered by	
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy	
ECTS	Method of grading	Only after succ. compl. of module(s)	
6	numerical grade	--	
Duration	Module level	Other prerequisites	
2 semester	undergraduate	--	
Contents			
A. optics and quanta			
1. Light (linked to 11-E-E): basic concepts, the speed of light, Huygens-Fresnel principle: reflection, refraction.			
2. Light in matter: propagation velocity in the medium; dispersion, complex and frequency-dependent dielectric constant; absorption, Kramers-Kronig relation, interfaces, Fresnel equations, polarization, generation by absorption, birefringence, optical activity (dipole)			
3. Geometrical optics: basic concepts, Fermat's principle, optical path, planar interfaces, Snell's law, total reflection, optical tunneling, evanescent waves, prism; normal and anomalous dispersion, curved interfaces, thin and thick lenses, lens systems, lens grinder formula, aberrations, imaging errors (spherical & chromatic aberration, astigmatism, coma, distortion, correction approaches).			
4. Optical instruments: characteristics; camera, eye, magnifying glass, microscope, telescope types, bundle beam vs. image construction (electron lenses, electron microscope), confocal microscopy.			
5. Wave optics: spatial and temporal coherence, Young's double slit experiment, interference pattern (intensity profile), thin films, parallel layers, wedge-shaped layers, phase shift, Newton rings, interferometer (Michelson, Mach-Zender, Fabry-Perot).			
6. Diffraction in the far field: Fraunhofer diffraction, , single slit, intensity distribution, apertures, resolving power, Rayleigh & Abbé criterion, Fourier optics, optical grating, n-fold slit, intensity distribution, grating spectrometer and resolution, diffraction off atomic lattices, convolution theorem.			
7. Diffraction in the near field: Fresnel, near-field diffraction at circular apertures/disks, Fresnel zone plate, near-field microscopy, holography, Huygens-Fresnel concept; white light hologram.			
8. Failure of classical physics I - from light wave to photon: black body radiation and Planck's quantum hypothesis; photoelectric effect and Einstein's explanation, Compton effect, light as a particle, wave-particle duality, , quantum structure of nature			
9. Failure of classical physics II - particles as waves: de Broglie's matter wave concept; diffraction of particle waves (Davisson-Germer-experiment, double slit interference).			
10. Wave mechanics: wave packets, phase and group velocity (recap of 11-EM), uncertainty principle, Nyquist-Shannon theorem, wave function as probability amplitude, probability of residence, measurement process in quantum mechanics (double-slit experiment & which-way information, collapse of the wave function, Schrödinger's cat).			
11. Mathematical concepts of quantum mechanics: Schrödinger equation as wave equation, conceptual comparison to wave optics, free particle and particles in a potential, time-independent Schrödinger equation as eigenvalue equation, simple examples in 1D (potential step, potential barrier and tunnel effect, box potential and energy quantization, harmonic oscillator), box potential in higher dimensions and degeneracy, formal theory of QM (states, operators, observables).			
B. atomic and molecular physics			
1. Structure of atoms: experimental evidence for the existence of atoms, size of the atom, charges and masses in the atom, isotopes, internal structure, Rutherford experiment, instability of the "classical" Rutherford atom			
2. Quantum mechanical foundations of atomic physics (short recap of part A.): light as particle beam, particles as waves, wave functions and probability interpretation, uncertainty relation and stability of the atom, energy quantization in the atom, Franck-Hertz experiment, atomic spectra, Bohr's model and its limitations, non-relativistic Schrödinger equation.			
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3. The non-relativistic hydrogen atom: hydrogen and hydrogen-like atoms, central-symmetric potential and angular momentum in QM, Schrödinger equation of the H-atom, atomic orbitals, radial and angular wave functions, quantum numbers, energy eigenvalues.
4. Atoms in external fields: orbital magnetic dipole moment, gyromagnetic ratio, magnetic fields: normal Zeeman effect, electrical fields: Stark effect.
5. Fine and hyperfine structure: electronic spin and magnetic spin moment, Stern-Gerlach experiment, Einstein-de Haas effect, glimpse of the Dirac equation (spin as relativistic phenomenon and existence of antimatter), electron spin resonance (ESR), spin-orbit coupling, relativistic fine structure, Lamb shift (quantum electrodynamics), nuclear spin and hyperfine structure.
6. Multielectron atoms: helium atom as simplest example, indistinguishability of identical particles, (anti)symmetry with respect to particle exchange, fermions and bosons, relationship to spin, Pauli principle, orbital and spin wave function of two-particle systems (spin singlets and triplets), LS- and jj-coupling, periodic table of the elements, Aufbau principles and Hund's rules.
7. Light-matter interaction: time-dependent perturbation theory (Fermi's Golden Rule) and optical transitions, matrix elements and dipole approximation, selection rules and symmetry, line broadening (lifetime, Doppler effect, collision broadening), atomic spectroscopy.
8. LASER: elementary optical processes (absorption, spontaneous and stimulated emission), stimulated emission as light amplification, Einstein's rate equations, thermal equilibrium, non-equilibrium character of a laser: rate equations, population inversion, and laser condition, principle structure of a laser, optical pumping, 2-, 3- and 4-level lasers, examples (ruby laser, He-Ne laser, semiconductor laser).
9. Inner-shell excitations and x-ray physics: generation of x-ray radiation, Bremsstrahlung and characteristic spectrum, x-ray emission for elemental analysis (EDX), x-ray absorption and contrast formation in x-ray images, x-ray photoemission, non-radiative Auger processes, synchrotron radiation, application examples.
10. Molecules and chemical bonding: molecular hydrogen ion ( $H_2^+$ ) as simplest example: rigid molecule approximation and LCAO approach, bonding and antibonding molecular orbitals, hydrogen molecule ( $H_2$ ): molecular orbital vs. Heitler-London approximation, diatomic heteronuclear molecules: covalent vs. ionic bonding, van der Waals bonds and Lennard-Jones potential, (time allowing: conjugated molecules).
11. Molecule rotations and vibrations: Born-Oppenheimer approximation, rigid rotator (symmetric and unsymmetrical molecules), centrifugal splitting/expansion, molecule as (an)harmonic oscillator, Morse potential, normal vibrational modes, vibrational-rotational interaction.
12. Molecular spectroscopy: transition matrix elements, vibrational spectroscopy: infrared spectroscopy and Raman effect, vibrational-rotational transitions: Fortrat diagram, electronic transitions: Franck-Condon principle.

### Intended learning outcomes

The students understand the basic principles and contexts of radiation, wave and quantum optics and quantum phenomena as well as Atomic and Molecular Physics. They understand the theoretical concepts and know the structure and application of important optical instruments and measuring methods. They understand the ideas and concepts of quantum theory and Astrophysics and the relevant experiments to observe and measure quantum phenomena. They are able to discuss their knowledge and to integrate it into a bigger picture.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + V (4)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

oral examination of one candidate each (approx. 30 minutes)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Workload

180 h

### Teaching cycle

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Module appears in**

Bachelor' degree (1 major) Physics (2015)  
Bachelor' degree (1 major) Nanostructure Technology (2015)  
Bachelor' degree (1 major) Physics (2020)  
Bachelor' degree (1 major) Nanostructure Technology (2020)  
Bachelor' degree (1 major) Quantum Technology (2021)  
exchange program Physics (2023)

## Optics and Quantum Physics II

(10 ECTS credits)

Module title		Abbreviation
Optics and Waves - Exercises		11-E-OA-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
5	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
Contents		
Exercises in Optics according to the content of 11-E-OAV. Among others Basic concepts, Fermat's principle, optical path, light in matter, polarization, Geometrical Optics, Optical instruments, wave optics, interference, thin films, interferometers, Fraunhofer diffraction optical grating, Fresnel diffraction, holography, wave packets, wave equation and Schrödinger equation, quantum structure of nature, etc.		
Intended learning outcomes		
The students understand the basic principles and contexts of radiation, wave and quantum optics. They are able to apply mathematical methods to the formulation of physical contexts and autonomously apply their knowledge to the solution of mathematical-physical tasks.		
Courses (type, number of weekly contact hours, language — if other than German)		
Ü (2) Module taught in: Ü: German or English		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 120 minutes) Language of assessment: German and/or English		
Allocation of places		
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Additional information		
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Workload		
150 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
§ 53 I Nr. 1 a) § 77 I Nr. 1 a)		
Module appears in		
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) First state examination for the teaching degree Grundschule Physics (2015) First state examination for the teaching degree Realschule Physics (2015) First state examination for the teaching degree Gymnasium Physics (2015) First state examination for the teaching degree Mittelschule Physics (2015) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Quantum Technology (2021) exchange program Physics (2023)		
Bachelor's with 1 major Quantum Technology (2021)	JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	page 43 / 179

Module title		Abbreviation
Atoms and Molecules - Exercises		11-E-AA-202-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
5	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
Contents		
Exercises in atomic and quantum physics according to the knowledge provided by 11-E-OAV. Among others Structure of atoms, Experimental fundamental laws of quantum physics, the Schrödinger equation, quantum mechanics of the hydrogen atom, atoms in external fields, multi-electron atoms, optical transitions and spectroscopy, laser, molecules and chemical bonding, molecular rotations and vibrations, etc.		
Intended learning outcomes		
Students have an understanding of the fundamental interrelationships and the fundamental laws of quantum phenomena, atomic and molecular physics. they will be able to formulate physical interrelationships of atomic and quantum physics mathematically and apply their knowledge in solving mathematical-physical tasks autonomously.		
Courses (type, number of weekly contact hours, language — if other than German)		
Ü (2) Module taught in: German or English		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 120 minutes) Language of assessment: German and/or English		
Allocation of places		
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Additional information		
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Workload		
150 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
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Module appears in		
Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Quantum Technology (2021) exchange program Physics (2023)		

## **Solid State Physics**

(8 ECTS credits)

Module title		Abbreviation
Introduction to Solid State Physics		11-E-F-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
8	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
Contents		
<p>1. The free-electron gas (FEG), free electrons; density of states; Pauli principle; Fermi-Dirac statistics; spec. heat, Sommerfeld coefficient; electrons in fields: Drude-Lorentz-Sommerfeld; electrical and thermal conductivity, Wiedemann-Franz law; Hall effect; limitations of the model</p> <p>2. Crystal structure, periodic lattice; types of lattices; Bravais lattice; Miller indices; simple crystal structures; lattice defects; polycrystals; amorphous solids; group theoretical approaches, the importance of symmetry for electronic properties</p> <p>3. The reciprocal lattice (RG), motivation: Diffraction; Bragg condition; definition; Brillouin zones; diffraction theory: Scattering; Ewald construction; Bragg equation; Laue's equation; structure and form factor</p> <p>4. Structure determination, probes: X-ray, electron, neutron; methods: Laue, Debye-Scherrer, rotating crystal; electron diffraction, LEED</p> <p>5. lattice vibrations (phonons), equations of motion; dispersion; group velocity; diatomic base: optical, acoustic branch; quantisation: Phonon momentum; optical properties in the infrared; dielectric function (Lorentz model); examples of dispersion curves (occ. Kramers-Kronig), measurement methods</p> <p>6. Thermal properties of insulators, Einstein and Debye model; phonon density of states; anharmonicity and thermal expansion; thermal conductivity; Umklapp processes; crystal defects</p> <p>7. Electrons in a periodic potential, Bloch theorem; band structure; approximation of nearly free electrons (NFE); strongly bound electrons (tight binding, LCAO); examples of band structures, Fermi surfaces, spin-orbit interaction</p> <p>8. Superconductivity, BCS theory, pairing, coupling of bosonic and fermionic modes, band structure, many-particle aspects (quasiparticle concept)</p>		
Intended learning outcomes		
<p>The students understand the basic contexts and principles of Solid-State Physics (bonding and structure, lattice dynamics, thermal properties, principles of electronic properties (free electron gas)). They understand the structure of solids and know the experimental methods and theoretical models for the description of phenomena of Solid-State Physics. They are able to apply mathematical methods to the formulation of physical contexts and autonomously apply their knowledge to the solution of mathematical-physical tasks.</p>		
Courses (type, number of weekly contact hours, language — if other than German)		
<p>V (4) + Ü (2)</p> <p>Module taught in: Ü: German or English</p>		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
<p>written examination (approx. 120 minutes)</p> <p>Language of assessment: German and/or English</p>		
Allocation of places		
--		
Additional information		
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Workload		
240 h		



<b>Teaching cycle</b>
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)
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<b>Module appears in</b>
<p>Bachelor' degree (1 major) Mathematics (2015)</p> <p>Bachelor' degree (1 major) Physics (2015)</p> <p>Bachelor' degree (1 major) Nanostructure Technology (2015)</p> <p>Bachelor' degree (1 major) Mathematical Physics (2015)</p> <p>Bachelor' degree (1 major) Computational Mathematics (2015)</p> <p>Bachelor's degree (1 major, 1 minor) Physics (Minor, 2015)</p> <p>Bachelor' degree (1 major) Mathematical Physics (2016)</p> <p>Bachelor' degree (1 major) Physics (2020)</p> <p>Bachelor' degree (1 major) Nanostructure Technology (2020)</p> <p>Bachelor' degree (1 major) Mathematical Physics (2020)</p> <p>Bachelor's degree (1 major, 1 minor) Physics (Minor, 2020)</p> <p>Bachelor' degree (1 major) Quantum Technology (2021)</p> <p>Bachelor' degree (1 major) Mathematics (2023)</p> <p>exchange program Physics (2023)</p> <p>Bachelor' degree (1 major) Mathematical Physics (2024)</p>

# Theoretical Physics I

(6 ECTS credits)

Module title		Abbreviation
Quantum Mechanics and Statistical Physics		11-T-QS-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
2 semester	undergraduate	--
Contents		
<p>A. Quantum mechanics:</p> <ol style="list-style-type: none"> <li>History and principles; limits of classical physics; fundamental historical experiments; from classical physics to quantum mechanics (QM);</li> <li>Wave function and Schrödinger equation (SG): SG for free particles; superposition; probability distribution for pulse measurement; correspondence principles: postulates of QM; Ehrenfest theorem; continuity equation; stationary solutions of SG</li> <li>Formalisation of QM: Eigenvalue equations; Physical significance of the eigenvalues of an operator; state space and Dirac notation; representations in state space; tensor products of state spaces;</li> <li>Postulates of QM (and their interpretation): state; measurement; chronological development; energy-time uncertainty;</li> <li>One-Dimensional problems: The harmonic oscillator; potential level; potential barrier; potential well; symmetry properties;</li> <li>Spin-1/2 systems I: Theoretical description in Dirac notation; Spin 1/2 in the homogeneous magnetic field; two-level systems (qubits);</li> <li>Angular momentum: Commutation and rotations; eigenvalues of the angular momentum operators (abstract); solution of the eigenvalue equation in polar coordinates (concrete);</li> <li>Central potential - hydrogen atom: Bonding states in 3D; Coulomb potential;</li> <li>Motion in an electromagnetic field; Hamiltonian operator; Normal Zeeman effect; canonical and kinetic momentum; Gauge transformation; Aharonov-Bohm effect; Schrödinger, Heisenberg and interaction representation; motion of a free electron in a magnetic field;</li> <li>Spin-1/2 systems II: Formulation using angular momentum algebra;</li> <li>Addition of angular momenta;</li> <li>Approximation methods: Stationary perturbation theory (with examples); variational method; WKB method; time-dependent perturbation theory;</li> <li>Atoms with several electrons: Identical particles; helium atom; Hartree and Hartree-Fock approximation; atomic structure and Hund's rules;</li> </ol> <p>B. Statistical Physics and thermodynamics:</p> <ol style="list-style-type: none"> <li>Principles of statistics: Elements of statistics (central limit theorem and statistics of extremes); micro- and macro-states; probability space (conditional probability, statistical independence);</li> <li>Statistical Physics: Entropy and probability theory; entropy in classical physics; thermodynamic equilibrium in closed and open systems (with energy and / or particle exchange);</li> <li>Ideal systems: Spin systems; linear oscillators; ideal gas;</li> <li>Statistical Physics and thermodynamics: The 1st law; quasi-static processes; entropy and temperature; generalised forces; the second and third law; reversibility; transition from Statistical Physics to thermodynamics;</li> <li>Thermodynamics: Thermodynamic fundamentals relationship; thermodynamic potentials; changes of state; thermodynamic machines (Carnot engine and efficiency); chemical potential;</li> <li>Ideal Systems II, quantum statistics: Systems of identical particles; ideal Fermi gas; ideal Bose gas and Bose-Einstein condensation; grids and normal modes: Phonons;</li> <li>Systems of interacting particles: Approximation methods (mean-field theory, Sommerfeld expansion); computer simulation (Monte Carlo method); interacting phonons (Debye approximation); Ising models (particularities in 1 and 2 dimensions); Yang-Lee-theorems; Van der Waals equation for real interacting gases;</li> </ol>		

7. Critical phenomena: Scaling laws, critical slowing down, fast variable as Bad (electron-phonon interaction and BCS superconductivity); magnetism (quantum criticality at low temperatures, quantum phase transitions at  $T = 0$ ); problems of the thermodynamic limit

#### Intended learning outcomes

The students have knowledge of the methods of Theoretical Physics. They know the principles of mechanics, Statistical Physics and thermodynamics. They are able to discuss the acquired theoretical concepts and to attribute them to bigger physical contexts.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + V (4)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

oral examination of one candidate each (approx. 30 minutes)

Language of assessment: German and/or English

#### Allocation of places

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#### Additional information

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#### Workload

180 h

#### Teaching cycle

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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#### Module appears in

Bachelor' degree (1 major) Nanostructure Technology (2015)

Bachelor' degree (1 major) Nanostructure Technology (2020)

Bachelor' degree (1 major) Quantum Technology (2021)

exchange program Physics (2023)

## Theoretical Physics II

(10 ECTS credits)

Module title		Abbreviation
Quantum Mechanics - Exercises		11-T-QA-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
5	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	Admission prerequisite to assessment: completion of exercises (approx. 13 exercise sheets per semester). Students who successfully completed approx. 50% of exercises will qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the semester.
Contents		
Exercises in quantum mechanics according to the content of 11 T-SEV. Among others Wave function and Schrödinger equation (SG), formalisation of QM, eigenvalue equations, postulates of QM, one-dimensional problems, spin-1/2 systems, angular momentum, central potential, hydrogen atom, movement in the electromagnetic field, addition of angular momenta, approximation methods, atoms with several electrons, etc.		
Intended learning outcomes		
The students are familiar with the mathematical methods of quantum mechanics and are able to independently apply them to the description and solution of problems of quantum theory and to interpret the results in a physical manner.		
Courses (type, number of weekly contact hours, language — if other than German)		
Ü (2) Module taught in: Ü: German or English		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 120 minutes) Language of assessment: German and/or English		
Allocation of places		
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Additional information		
Registration: If a student registers for the exercises and obtains the qualification for admission to assessment, this will be considered a declaration of will to seek admission to assessment pursuant to Section 20 Subsection 3 Sentence 4 ASPO (general academic and examination regulations). If the module coordinators subsequently find that the student has obtained the qualification for admission to assessment, they will put the student's registration for assessment into effect. Only those students that meet the respective prerequisites can successfully register for an assessment. Students who did not register for an assessment or whose registration for an assessment was not put into effect will not be admitted to the respective assessment. If a student takes an assessment to which he/she has not been admitted, the grade achieved in this assessment will not be considered.		
Workload		
150 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
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Module appears in		

Bachelor' degree (1 major) Nanostructure Technology (2015)  
Bachelor' degree (1 major) Nanostructure Technology (2020)  
Bachelor' degree (1 major) Quantum Technology (2021)  
exchange program Physics (2023)



Module title			Abbreviation
Statistical Physics - Exercises			11-T-SA-152-m01
Module coordinator		Module offered by	
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy	
ECTS	Method of grading	Only after succ. compl. of module(s)	
5	numerical grade	--	
Duration	Module level	Other prerequisites	
1 semester	undergraduate	--	
Contents			
Exercises in Statistical Physics and theoretical thermodynamics according to the content of 11 T-SEV content. Among others Principles of statistics, Statistical Physics, ideal systems, fundamental theorems, thermodynamic potentials, quantum statistics, Fermi and Bose gas, systems of interacting particles, approximation methods, Ising models, critical phenomena, etc.			
Intended learning outcomes			
The students are familiar with the mathematical methods of theoretical thermodynamics and Statistical Physics and are able to independently apply them to the description and solution of problems of Statistical Physics and to interpret the results in a physical manner.			
Courses (type, number of weekly contact hours, language — if other than German)			
Ü (2) Module taught in: Ü: German or English			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
written examination (approx. 120 minutes) Language of assessment: German and/or English			
Allocation of places			
--			
Additional information			
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Workload			
150 h			
Teaching cycle			
--			
Referred to in LPO I (examination regulations for teaching-degree programmes)			
--			
Module appears in			
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Mathematical Physics (2015) Bachelor' degree (1 major) Mathematical Physics (2016) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Mathematical Physics (2020) Bachelor' degree (1 major) Quantum Technology (2021) exchange program Physics (2023) Bachelor' degree (1 major) Mathematical Physics (2024)			
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# Mathematics

(24 ECTS credits)

Module title			Abbreviation
Mathematics 1 for Students of Physics and Quantum Technology			10-M-PHY1-212-m01
Module coordinator		Module offered by	
Dean of Studies Mathematik (Mathematics)		Institute of Mathematics	
ECTS	Method of grading	Only after succ. compl. of module(s)	
8	numerical grade	--	
Duration	Module level	Other prerequisites	
1 semester	undergraduate	--	
Contents			
Fundamentals on numbers and functions, sequences and series, differential and integral calculus in one variable, vector spaces, simple differential equations.			
Intended learning outcomes			
The student gets acquainted with basic concepts of mathematics. He/She learns to apply these methods to simple problems in natural and engineering sciences, in particular in the fields of physics and quantum technology, and is able to interpret the results.			
Courses (type, number of weekly contact hours, language — if other than German)			
V (5) + Ü (2) Exercrcises in: German or English			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
a) written examination (Usually chosen, approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, 15 minutes per candidate) Language of assessment: German and/or English creditable for bonus			
Allocation of places			
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Additional information			
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Workload			
240 h			
Teaching cycle			
--			
Referred to in LPO I (examination regulations for teaching-degree programmes)			
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Module appears in			
Bachelor' degree (1 major) Quantum Technology (2021) exchange program Mathematics (2023)			

Module title			Abbreviation
Mathematics 2 for Students of Physics and Quantum Technology			10-M-PHY2-212-m01
Module coordinator		Module offered by	
Dean of Studies Mathematik (Mathematics)		Institute of Mathematics	
ECTS	Method of grading	Only after succ. compl. of module(s)	
8	numerical grade	--	
Duration	Module level	Other prerequisites	
1 semester	undergraduate	--	
Contents			
Linear maps and systems of linear equations, matrix calculus, eigenvalue theory, differential and integral calculus in several variables, differential equations, Fourier analysis.			
Intended learning outcomes			
The student gets acquainted with fundamental concepts of advanced mathematics. He/She learns to apply these methods to simple problems in natural and engineering sciences, in particular in the field of physics and quantum technology, and is able to interpret the results.			
Courses (type, number of weekly contact hours, language — if other than German)			
V (5) + Ü (2) Exercises in: German or English			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
a) written examination (Usually chosen, approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, 15 minutes per candidate) Language of assessment: German and/or English creditable for bonus			
Allocation of places			
--			
Additional information			
--			
Workload			
240 h			
Teaching cycle			
--			
Referred to in LPO I (examination regulations for teaching-degree programmes)			
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Module appears in			
Bachelor' degree (1 major) Quantum Technology (2021) exchange program Mathematics (2023)			

Module title			Abbreviation
Mathematics 3 for Students of Physics and related Disciplines (Differential Equations)			11-M-D-152-m01
Module coordinator		Module offered by	
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy	
ECTS	Method of grading	Only after succ. compl. of module(s)	
8	numerical grade	--	
Duration	Module level	Other prerequisites	
1 semester	undergraduate	--	
Contents			
Basics of ordinary differential equations in physics. Ordinary differential equations and systems of differential equations. Fundamentals of function theory.  1. Ordinary differential equations 1.1 Solution methods 1.2 Existence and uniqueness theorem 1.3 Systems of differential equations 1.4 Greens function for inhomogeneous problems 1.5 Hermitsche DGL, Legendre DGL  2. Function theory 2.1 Complex functions 2.2 Differentiation, holomorphic functions 2.3 Singularities in the complex 2.4 Complex integration and the Cauchy integral theorem 2.5 Laurent series, residual theorem, Fourier transformation 2.6 Analytical continuation, meromorphic functions, whole functions 2.7 gamma, beta, hypergeometric functions, sets of Weierstrasse and Mittag-Leffler 2.8 Differential equations in the complex, Bessel differential equation 2.9 Saddle point method  3. (quasi) linear differential equations of 1st order			
Intended learning outcomes			
The student has basic knowledge of mathematics to understand the dynamic equations and knowledge of solution methods for ordinary differential equations as well as the theory of the functions of a complex variable and is proficient in the required computing techniques.			
Courses (type, number of weekly contact hours, language — if other than German)			
V (4) + Ü (2) Module taught in: Ü: German or English			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
written examination (approx. 120 minutes) Language of assessment: German and/or English			
Allocation of places			
--			
Additional information			
--			

<b>Workload</b>
240 h
<b>Teaching cycle</b>
--
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)
--
<b>Module appears in</b>
<p>Bachelor' degree (1 major) Physics (2015)</p> <p>Bachelor' degree (1 major) Nanostructure Technology (2015)</p> <p>Bachelor' degree (1 major) Functional Materials (2015)</p> <p>Bachelor' degree (1 major) Physics (2020)</p> <p>Bachelor' degree (1 major) Nanostructure Technology (2020)</p> <p>Bachelor' degree (1 major) Functional Materials (2021)</p> <p>Bachelor' degree (1 major) Quantum Technology (2021)</p> <p>exchange program Physics (2023)</p>

## Laboratory Course Physics

(11 ECTS credits)



Module title		Abbreviation
Laboratory Course Physics A (Mechanics, Heat, Electromagnetism)		11-P-PA-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
3	(not) successfully completed	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
Measurement tasks in mechanics, thermodynamics and electricity theory, e.g. measurement of voltages and currents, heat capacity, calorimetry, density of bodies, dynamic viscosity, elasticity, surface tension, spring constant, drafting of graphics and drafting of measurement protocols.		
<b>Intended learning outcomes</b>		
The students know and have mastered physical measuring methods and experimenting techniques. They are able to independently plan and conduct experiments, to cooperate with others, and to document the results in a measuring protocol.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
P (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
practical assignment with talk (approx. 30 minutes) Preparing, performing and evaluating (record of readings or lab report) the experiments will be considered successfully completed if a Testat (exam) is passed. Exactly one experiment that was not successfully completed can be repeated once. After completion of all experiments, talk (with discussion; approx. 30 minutes) to test the candidate's understanding of the physics-related contents of the module. Talks that were not successfully completed can be repeated once. Both components of the assessment have to be successfully completed.		
<b>Allocation of places</b>		
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<b>Additional information</b>		
--		
<b>Workload</b>		
90 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module appears in</b>		
Bachelor' degree (1 major) Mathematics (2015) Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Mathematical Physics (2015) Bachelor' degree (1 major) Computational Mathematics (2015) Bachelor' degree (1 major) Aerospace Computer Science (2015) Bachelor' degree (1 major) Mathematical Physics (2016) Bachelor' degree (1 major) Aerospace Computer Science (2017) Bachelor' degree (1 major) Physics (2020)		
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Bachelor' degree (1 major) Nanostructure Technology (2020)  
 Bachelor' degree (1 major) Mathematical Physics (2020)  
 Bachelor' degree (1 major) Aerospace Computer Science (2020)  
 Bachelor' degree (1 major) Quantum Technology (2021)  
 Bachelor' degree (1 major) Mathematics (2023)  
 exchange program Physics (2023)  
 Bachelor' degree (1 major) Mathematical Physics (2024)

Module title		Abbreviation
<b>Laboratory Course Quantum Technology B (Classical Physics, Electricity, Circuits)</b>		11-P-NB-212-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
4	(not) successfully completed	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	Students are highly recommended to complete modules 11-P-PA and 11-P-FR1 prior to completing module 11-P-NB.
<b>Contents</b>		
Physical laws of optics, vibrations and waves, science of electricity and circuits with electric components.		
<b>Intended learning outcomes</b>		
The student has knowledge and mastery of physical measuring instruments and experimental techniques. He/She is able to plan experiments independently and to perform well in cooperation with others, and to document the measurement results in a measurement protocol. He/She is able to evaluate the measurement result using error propagation and basics of statistics, to draw conclusions and to present and to discuss theses conclusions.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
P (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
Practical assignment with talk (approx. 30 minutes) Preparing, performing and evaluating (record of readings or lab report) the experiments will be considered successfully completed if a Testat (exam) is passed. Exactly one experiment that was not successfully completed can be repeated once. After completion of all experiments, talk (with discussion; approx. 30 minutes) to test the candidate's understanding of the physics-related contents of the module. Talks that were not successfully completed can be repeated once. Both components of the assessment have to be successfully completed.		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
120 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module appears in</b>		
Bachelor' degree (1 major) Quantum Technology (2021) exchange program Physics (2023)		

Module title		Abbreviation
<b>Advanced Laboratory Course Quantum Technology C (Modern Physics, Computer Aided Experiments)</b>		11-P-NC-212-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
4	(not) successfully completed	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	Students are highly recommended to complete module 11-P-NB prior to completing module 11-P-NC.
<b>Contents</b>		
Physical laws of wave optics, Molecular, Atomic and Nuclear Physics and modern measuring methods using special computerised devices with examples from optics and Solid-State Physics.		
<b>Intended learning outcomes</b>		
The students are able to build and almost independently operate advanced experimental setups. They are able to record measuring results in a structured manner, even in case of huge data traffic, and to analyse the results by using error propagation and statistics. They are able to evaluate results, to draw conclusions and to present and discuss them in a scientific paper and a presentation.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
P (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
practical assignment with talk (approx. 30 minutes) Preparing, performing and evaluating (record of readings or lab report) the experiments will be considered successfully completed if a Testat (exam) is passed. Exactly one experiment that was not successfully completed can be repeated once. After completion of all experiments, talk (with discussion; approx. 30 minutes) to test the candidate's understanding of the physics-related contents of the module. Talks that were not successfully completed can be repeated once. Both components of the assessment have to be successfully completed.		
<b>Allocation of places</b>		
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<b>Additional information</b>		
--		
<b>Workload</b>		
120 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module appears in</b>		
Bachelor' degree (1 major) Quantum Technology (2021) exchange program Physics (2023)		

## Compulsory Electives

(32 ECTS credits)

## **Semiconductor Electronics**

(min. 6 ECTS credits)

Module title		Abbreviation
Electronic Circuits		11-EL-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
Principles of electronic components and circuits. Analogous circuit technology: Passive (resistors, capacitors, coils and diodes) and active components (bipolar and field-effect transistors, operational amplifiers). Digital circuits: different types of gates and CMOS circuits. Microcontroller		
<b>Intended learning outcomes</b>		
The students have knowledge of the practical setup of electronic circuits from the field of analogous and digital circuit technology.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Assessment offered: Once a year, summer semester Language of assessment: German and/or English		
<b>Allocation of places</b>		
--		
<b>Additional information</b>		
--		
<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
--		
<b>Module appears in</b>		
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor's degree (1 major, 1 minor) Physics (Minor, 2015) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor's degree (1 major, 1 minor) Physics (Minor, 2020) Bachelor' degree (1 major) Quantum Technology (2021)		
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exchange program Physics (2023)

Module title		Abbreviation
Physics of Semiconductor Devices		11-SPD-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
<p>Based on the fundamentals of Semiconductor Physics, the lecture provides an insight into semiconductor key technologies and discusses the main components in the fields of electronics and photonics on the basis of examples. The basic part introduces the crystal structures and band and phonon dispersions of technologically relevant semiconductors. The following part discusses the principles of charge transport involving non-equilibrium effects based on the charge carrier density of the thermal equilibrium. The part on technology gives an insight into the methods of production of semiconductor materials and presents the most important methods of planar technology. It discusses the way of functioning of the following components, sorted according to volume components, interface components and application fields: Rectifier diodes, Zener diodes, varistor, varactor, tunnel diodes, IMPATT, Baritt- and Gunn diodes, photodiode, solar cell, LED, semiconductor injection laser, transistor, JFET, Thyristor, Diac, Triac, Schottky diode, MOSFET, MESFET, HFET. It highlights the importance of low-dimensional charge carrier systems for technology and basic research and shows recent developments in the components sector.</p>		
<b>Intended learning outcomes</b>		
<p>The students know the characteristics of semiconductors, they have gained an overview of the electronic and phonon band structures of important semiconductors and the resulting electronic, optical and thermal properties. They know the principles of charge transport as well as the Poisson, Boltzmann and continuity equation for the solution of questions. They have gained insights into the methods of semiconductor production and are familiar with the theories of planar technology and recent developments in this field, they have a basic understanding of component production. They understand the structure and way of functioning of the main components of electronics (diode, transistor, field-effect transistor, thyristor, diac, triac), of microwave applications (tunnel, Impatt, Baritt or Gunn diode) and of optoelectronics (photo diode, solar cell, light-emitting diode, semiconductor injection laser), they know the realisation possibilities of low-dimensional charge carrier systems on the basis of semiconductors and their technological relevance, they are familiar with current developments in the field of components.</p>		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
<p>written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Assessment offered: Once a year, summer semester</p> <p>Language of assessment: German and/or English</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>
--
<b>Workload</b>
180 h
<b>Teaching cycle</b>
--
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)
--
<b>Module appears in</b>
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Master's degree (1 major) Functional Materials (2016) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Quantum Technology (2021) Master's degree (1 major) Functional Materials (2022) exchange program Physics (2023)

Module title		Abbreviation
Semiconductor Lasers and Photonics		11-HLF-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	graduate	--
Contents		
<p>This lecture discusses the principles of laser physics, based on the example of semiconductor lasers, and current developments regarding components. The principles of lasers are described on the basis of a general laser model, which will then be extended to special aspects of semiconductor lasers. Basic concepts such as threshold condition, characteristic curve and laser efficiency are derived from coupled rate equations for charge carriers and photons. Other topics of the lecture are optical processes in semiconductors, layer and ridge waveguides, laser resonators, mode selection, dynamic properties as well as technology for the generation of semiconductor lasers. The lecture closes with current topics of laser research such as quantum dot lasers, quantum cascade lasers, terahertz lasers or high-performance lasers.</p>		
Intended learning outcomes		
<p>The students have advanced knowledge of the principles of semiconductor-laser physics. They can apply their knowledge to modern questions and know the applications in the current development of components.</p>		
Courses (type, number of weekly contact hours, language — if other than German)		
<p>V (3) + R (1) Module taught in: German or English</p>		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
<p>written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Assessment offered: Once a year, summer semester Language of assessment: German and/or English</p>		
Allocation of places		
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Additional information		
--		
Workload		
180 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
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Module appears in		
<p>Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015)</p>		
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Master's degree (1 major) Functional Materials (2016)  
Bachelor' degree (1 major) Physics (2020)  
Bachelor' degree (1 major) Nanostructure Technology (2020)  
Bachelor' degree (1 major) Quantum Technology (2021)  
Master's degree (1 major) Functional Materials (2022)  
exchange program Physics (2023)

Module title		Abbreviation
Fundamentals of Semiconductor Physics		11-HLP-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
1. Symmetry properties 2. Crystal formation and electronic band structure 3. Optical excitations and their coupling effects 4. Electron-phonon coupling 5. Temperature-dependent transport properties 6. (Semi-)magnetic semiconductors		
<b>Intended learning outcomes</b>		
The students are familiar with the principles of Semiconductor Physics. They understand the structure of semiconductors and know their physical properties and effects. They know important applications.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Assessment offered: Once a year, summer semester Language of assessment: German and/or English		
<b>Allocation of places</b>		
--		
<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
--		
<b>Module appears in</b>		
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020)		
Bachelor's with 1 major Quantum Technology (2021)	JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	page 73 / 179

Bachelor' degree (1 major) Quantum Technology (2021)  
exchange program Physics (2023)

Module title		Abbreviation
Crystal Growth, thin Layers and Lithography		11-KDS-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
Contents		
Crystal growth, thin films, lithography.		
Intended learning outcomes		
The students have knowledge of crystal growth and the techniques and methods to control crystal growth in the laboratory. They have methodological knowledge of the production and examination of thin layers and know techniques and applications of lithography.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Assessment offered: Once a year, winter semester Language of assessment: German and/or English		
Allocation of places		
--		
Additional information		
--		
Workload		
180 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
--		
Module appears in		
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Quantum Technology (2021) exchange program Physics (2023)		



Module title		Abbreviation
Current Topics in Semiconductor Electronics		11-BXN6A-152-m01
Module coordinator		Module offered by
chairperson of examination committee		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	unknown	Approval by examination committee required.
Contents		
No information on contents available.		
Intended learning outcomes		
No information on intended learning outcomes available.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
<p>written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German or English</p>		
Allocation of places		
--		
Additional information		
--		
Workload		
180 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
--		
Module appears in		
<p>Bachelor' degree (1 major) Nanostructure Technology (2015)</p> <p>Bachelor' degree (1 major) Nanostructure Technology (2020)</p> <p>Bachelor' degree (1 major) Quantum Technology (2021)</p>		

# Materials Science

( ECTS credits)

Module title		Abbreviation
Nanoanalytics		11-NAN-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	graduate	--
<b>Contents</b>		
Principles of analytic procedures in the field of nanostructure physics, imaging techniques from a microscopic level up to an atomic level, examination of chemical composition, spectroscopy of electronic properties, usage of X-ray methods. - Physics and material systems on the nanoscale. - Scanning probes: Atomic force microscopy. Scanning tunneling microscopy. - Electron probes: Scanning electron microscope. Transmission electron microscope. - Secondary ions - mass spectrometry - X-ray methods: Synchrotron spectroscopy. Photoemission. X-ray absorption		
<b>Intended learning outcomes</b>		
The students have basic knowledge of modern research methods for different nanostructures up to an atomic level. They know microscoping procedures that are used in practice in labs and the industry as well as spectroscopic methods for the determination of electronic properties. They are able to evaluate the efficiency of different research methods.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Assessment offered: Once a year, winter semester Language of assessment: German and/or English		
<b>Allocation of places</b>		
--		
<b>Additional information</b>		
--		
<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module appears in</b>		
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015)		
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Master's degree (1 major) Functional Materials (2016)  
Bachelor' degree (1 major) Physics (2020)  
Bachelor' degree (1 major) Nanostructure Technology (2020)  
Bachelor' degree (1 major) Quantum Technology (2021)  
exchange program Physics (2023)

Module title		Abbreviation
<b>Solid State Physics 2</b>		11-FK2B-202-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
8	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
Contents		
<p>1. Electrons in a periodic potential – the band structure</p> <p>a. Electrical and thermal transport</p> <p>b. Bloch theorem</p> <p>c. Electrons</p> <p>2. Semi-classical models of dynamic processes</p> <p>a. Electrical transport in partially and completely filled bands</p> <p>b. Fermi surfaces; measurement techniques</p> <p>c. Electrical transport in external magnetic fields</p> <p>d. Boltzmann-equations of transport</p> <p>3. The dielectric function and ferroelectrics</p> <p>a. Macroscopic electrodynamics and microscopic theory</p> <p>b. Polarizability of solids, of lattices, of valence electrons and quasi-free electrons; optical phonons, polaritons, plasmons, inter-band transitions, Wannier-Mott excitons</p> <p>c. Ferromagnetism</p> <p>4. Semiconductors</p> <p>a. Characteristics</p> <p>b. Intrinsic semiconductors</p> <p>c. Doped semiconductors</p> <p>d. Physics and applications of p-n junctions</p> <p>e. Heterostructures</p> <p>5. Magnetism</p> <p>a. Atomic dia- and paramagnetism</p> <p>b. Dia- and paramagnetism in metals</p> <p>c. Ferromagnetism</p> <p>6. Superconductivity</p> <p>a. Phenomena</p> <p>b. Models of superconductivity</p> <p>c. Tunnel experiments und applications</p>		
Intended learning outcomes		
Knowledge of effects, concepts and models in advanced solid state physics. Familiarity with the theoretical principles and with applications of experimental methods.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (4) + R (2)		
Module taught in: German or English		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method</p>		

of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Language of assessment: German and/or English

Assessment offered: in semester of module and following semester

#### Allocation of places

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#### Additional information

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#### Workload

240 h

#### Teaching cycle

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#### Referred to in LPO I (examination regulations for teaching-degree programmes)

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#### Module appears in

Bachelor' degree (1 major) Physics (2020)

Bachelor' degree (1 major) Nanostructure Technology (2020)

Bachelor' degree (1 major) Quantum Technology (2021)

exchange program Physics (2023)

Module title		Abbreviation
Principles of Energy Technologies		11-ENT-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	graduate	--
<b>Contents</b>		
Physical principles of energy conservation and energy conversion, energy transport and energy storage as well as renewable resources of energy. We also discuss aspects of optimising materials (e.g. nanostructured insulating materials, selective layers, highly activated carbons). The course is especially suitable for teaching degree students. Energy conservation via thermal insulation. Thermodynamic energy efficiency. Fossil fired energy converters. Nuclear power plants. Hydroelectricity. Wind turbines. Photovoltaics. Solar thermal: Heat. Solar thermal: Electricity. Biomass. Geothermal energy. Energy storage. Energy transport		
<b>Intended learning outcomes</b>		
The students know the principles of different methods of energy technology, especially energy conversion, transport and storage. They understand the structures of corresponding installations and are able to compare them.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Assessment offered: Once a year, winter semester Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
§ 22 II Nr. 1 h) § 22 II Nr. 2 f) § 22 II Nr. 3 f)		
<b>Module appears in</b>		
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015)		
Bachelor's with 1 major Quantum Technology (2021)	JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	page 82 / 179

First state examination for the teaching degree Grundschule Physics (2015)  
 First state examination for the teaching degree Grundschule Didactics in Physics (Primary School) (2015)  
 First state examination for the teaching degree Realschule Physics (2015)  
 First state examination for the teaching degree Gymnasium Physics (2015)  
 First state examination for the teaching degree Sonderpädagogik Didactics in Physics (Middle School) (2015)  
 First state examination for the teaching degree Mittelschule Physics (2015)  
 First state examination for the teaching degree Mittelschule Didactics in Physics (Middle School) (2015)  
 Master's degree (1 major) Functional Materials (2016)  
 First state examination for the teaching degree Grundschule Physics (2018)  
 First state examination for the teaching degree Grundschule Didactics in Physics (Primary School) (2018)  
 First state examination for the teaching degree Realschule Physics (2018)  
 First state examination for the teaching degree Gymnasium Physics (2018)  
 First state examination for the teaching degree Mittelschule Physics (2018)  
 First state examination for the teaching degree Sonderpädagogik Didactics in Physics (Middle School) (2018)  
 First state examination for the teaching degree Mittelschule Didactics in Physics (Middle School) (2018)  
 Bachelor' degree (1 major) Physics (2020)  
 Bachelor' degree (1 major) Nanostructure Technology (2020)  
 First state examination for the teaching degree Grundschule Didactics in Physics (Primary School) (2020)  
 First state examination for the teaching degree Grundschule Physics (2020)  
 First state examination for the teaching degree Gymnasium Physics (2020)  
 First state examination for the teaching degree Realschule Physics (2020)  
 First state examination for the teaching degree Sonderpädagogik Didactics in Physics (Middle School) (2020)  
 First state examination for the teaching degree Mittelschule Didactics in Physics (Middle School) (2020)  
 First state examination for the teaching degree Mittelschule Physics (2020)  
 Bachelor' degree (1 major) Quantum Technology (2021)  
 Master's degree (1 major) Functional Materials (2022)  
 exchange program Physics (2023)



Module title		Abbreviation
Nanotechnology in Energy Research		11-NTE-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	graduate	--
<b>Contents</b>		
Nanotechnology is of great significance for energy research. Energy efficiency can be heightened in numerous processes or applications by using special functional materials. This module covers special materials, surfaces and structures that have optimised properties due to effects of nanotechnology. It explains the underlying physical contexts. It uses specific materials and components as examples, such as thermal insulation materials, heat accumulators, functional nanoscale layer and particle systems with spectral selective properties, nanoporous vacuum insulations and electrode materials.		
<b>Intended learning outcomes</b>		
The students have specific and advanced knowledge of the application of nanotechnology in the field of energy research. They know methods of nanotechnology to influence the properties of materials and their applications. They are able to apply their knowledge to specific questions.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Assessment offered: Once a year, summer semester Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module appears in</b>		
Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Quantum Technology (2021)		
Bachelor's with 1 major Quantum Technology (2021)	JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	page 84 / 179

Master's degree (1 major) Functional Materials (2022)  
exchange program Physics (2023)

Module title		Abbreviation
Laboratory Course Physical Technology of Material Synthesis		11-PPT-212-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
5	(not) successfully completed	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	Students of Funktionswerkstoffe (Functional Materials, Bachelor's) are recommended to take module 11-P-FR1.
Contents		
Physical material properties, growth and coating procedures, methods of characterisation and structuring technologies.		
Intended learning outcomes		
The students have knowledge of the practical basics of material characterisation and physical technology for material synthesis.		
Courses (type, number of weekly contact hours, language — if other than German)		
P (5) Module taught in: German or English		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
Preparation of the experiment will be considered successfully completed if a pre-experiment oral test (approx. 15 minutes) is passed. Performing and evaluating the experiments will be considered successfully completed if a Testat (exam) is passed. An experiment log (approx. 8 pages) must be prepared. Each component of the assessment can be repeated once in the respective semester. Only if both components of the assessment have been successfully completed in the same semester will the module component be considered successfully completed. Assessment offered: Once a year, winter semester Language of assessment: German and/or English		
Allocation of places		
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Additional information		
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Workload		
150 h		
Teaching cycle		
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Referred to in LPO I (examination regulations for teaching-degree programmes)		
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Module appears in		
Bachelor' degree (1 major) Functional Materials (2021) Bachelor' degree (1 major) Quantum Technology (2021) exchange program Physics (2023)		

Module title		Abbreviation
Coating Technologies based on Vapour Deposition		11-BVG-202-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
5	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
Physical and technical basics of PVD and CVD systems and processes. Layer deposition and layer characterization. Application of coating materials on an industrial scale.		
<b>Intended learning outcomes</b>		
The student has in-depth knowledge in the field of gas-phase deposition processes and gains insights into their industrial significance and diversity.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. creditable for bonus Language of assessment: German and/or English		
<b>Allocation of places</b>		
--		
<b>Additional information</b>		
--		
<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
--		
<b>Module appears in</b>		
Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Quantum Technology (2021) Master's degree (1 major) Functional Materials (2022) exchange program Physics (2023)		

Module title		Abbreviation
<b>Molecular Materials (Lecture)</b>		o8-FU-MoMaV-152-mo1
Module coordinator		Module offered by
degree programme coordinator Funktionswerkstoffe (Functional Materials)		Chair of Chemical Technology of Material Synthesis
ECTS	Method of grading	Only after succ. compl. of module(s)
5	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
Chemical bonds and molecular interactions, supramolecular chemistry, molecular materials, colloids, nanoparticles, thin films.		
<b>Intended learning outcomes</b>		
Students have developed an understanding of the relationship between the physical, chemical and technological properties of materials and their structure. They know the significance of various inter and intramolecular interactions and how they determine the properties of molecular materials. They have learned how to familiarise themselves with a topic in the field, deliver a presentation on that topic, discuss it as well as to give and receive feedback.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + S (1)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
[a] written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)] as well as talk (approx. 30 minutes), weighted 3:1 Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
--		
<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module appears in</b>		
Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Functional Materials (2015) Master's degree (1 major) Chemistry (2016) Master's teaching degree Gymnasium MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2016) Supplementary course MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2016) Master's degree (1 major) Chemistry (2018) Master's teaching degree Gymnasium MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2020) Supplementary course MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2020) Bachelor' degree (1 major) Nanostructure Technology (2020)		
Bachelor's with 1 major Quantum Technology (2021)	JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	page 88 / 179

Bachelor' degree (1 major) Quantum Technology (2021)  
Master's degree (1 major) Chemistry (2024)

Module title		Abbreviation
Chemically and bio-inspired Nanotechnology for Material Synthesis		o8-FU-NT-152-mo1
Module coordinator		Module offered by
degree programme coordinator Funktionswerkstoffe (Functional Materials)		Chair of Chemical Technology of Material Synthesis
ECTS	Method of grading	Only after succ. compl. of module(s)
5	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
Synthesis methods and parameters in sol-gel chemistry as well as characterisation and applications of the created materials. Fundamental principles of biomineralisation, the structure of biomaterials, introduction to bio-inspired material synthesis.		
<b>Intended learning outcomes</b>		
Students have developed a sound knowledge of sol-gel chemistry and biomineralisation.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (4)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes) Language of assessment: German and/or English		
<b>Allocation of places</b>		
--		
<b>Additional information</b>		
--		
<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module appears in</b>		
Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Functional Materials (2015) Master's degree (1 major) Chemistry (2016) Master's teaching degree Gymnasium MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2016) Supplementary course MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2016) Master's degree (1 major) Chemistry (2018) Master's teaching degree Gymnasium MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2020) Supplementary course MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Quantum Technology (2021) Master's degree (1 major) Chemistry (2024)		

Module title			Abbreviation
Nanoscale Materials			o8-PCM3-161-mo1
Module coordinator		Module offered by	
lecturer of the seminar "Nanoskalige Materialien"		Institute of Physical and Theoretical Chemistry	
ECTS	Method of grading	Only after succ. compl. of module(s)	
5	numerical grade	--	
Duration	Module level	Other prerequisites	
1 semester	graduate	--	
Contents			
This module discusses advanced topics in nanoscale materials. It focuses on the structure, properties, fabrication, modern characterisation methods and application areas of nanoscale materials.			
Intended learning outcomes			
Students are able to characterise nanoscale materials. They are able to name analytical methods and application areas of nanoscale materials.			
Courses (type, number of weekly contact hours, language — if other than German)			
S (2) + Ü (1) Module taught in: German or English			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) talk (approx. 30 minutes) Language of assessment: German and/or English creditable for bonus			
Allocation of places			
--			
Additional information			
--			
Workload			
150 h			
Teaching cycle			
--			
Referred to in LPO I (examination regulations for teaching-degree programmes)			
--			
Module appears in			
Master's degree (1 major) Chemistry (2016) Master's degree (1 major) Mathematics (2016) Master's degree (1 major) Computational Mathematics (2016) Master's degree (1 major) Functional Materials (2016) Master's teaching degree Gymnasium MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2016) Supplementary course MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2016) Master's degree (1 major) Chemistry (2018) Master's degree (1 major) Computational Mathematics (2019) Master's degree (1 major) Mathematics (2019) Master's teaching degree Gymnasium MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2020) Supplementary course MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2020) Bachelor' degree (1 major) Quantum Technology (2021)			
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Master's degree (1 major) Computational Mathematics (2022)  
Master's degree (1 major) Functional Materials (2022)  
Master's degree (1 major) Mathematics (2022)  
Master's degree (1 major) Chemistry (2024)  
Master's degree (1 major) Computational Mathematics (2024)  
Master's degree (1 major) Mathematics (2024)

Module title			Abbreviation
Material Sciences 1 (Basic introduction)			o8-FU-MaWi1-212-mo1
Module coordinator		Module offered by	
holder of the Chair of Chemical Technology of Material Synthesis		Chair of Chemical Technology of Material Synthesis	
ECTS	Method of grading	Only after succ. compl. of module(s)	
5	numerical grade	--	
Duration	Module level	Other prerequisites	
2 semester	undergraduate	--	
Contents			
<p>Part A Structure of materials</p> <p>The students learn about the atomic structure of solid materials.</p> <p>Part B Metallic Materials</p> <p>The students learn about the structure of metallic materials as well as their mechanical properties including deformation and failure mechanism as well as the analysis of mechanical properties. In addition, the corrosion and corrosion protection of metallic materials is introduced.</p> <p>Part C Numerical Methods</p> <p>The students are introduced to numerical methods like finite element methods (FEM) and Monte-Carlo-Simulation.</p>			
Intended learning outcomes			
The students know the structure of solids, thermodynamic properties like enthalpy and entropy, the laws of diffusion and lattice defects. They are familiar with deformation and corrosion mechanisms in metals. The students acquire knowledge about thermodynamic of solids. They understand phase transitions, alloys and phase separation of metals. The students can explain the deformation as well as hardening due to dislocations of metals. The students can apply FEM to simple problems and perform simulations based on the Monte-Carlo-method.			
Courses (type, number of weekly contact hours, language — if other than German)			
V (2) + Ü (1) + V (2)			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes) Language of assessment: German and/or English			
Allocation of places			
--			
Additional information			
--			
Workload			
150 h			
Teaching cycle			
--			
Referred to in LPO I (examination regulations for teaching-degree programmes)			
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Module appears in			
Bachelor' degree (1 major) Functional Materials (2021)			
Bachelor's with 1 major Quantum Technology (2021)		JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	page 93 / 179

Bachelor' degree (1 major) Quantum Technology (2021)  
Master's degree (1 major) Chemistry (2024)

Module title		Abbreviation
Material Science 2 (The Material Groups)		o8-FU-MaWi2-152-mo1
Module coordinator		Module offered by
holder of the Chair of Chemical Technology of Material Synthesis		Chair of Chemical Technology of Material Synthesis
ECTS	Method of grading	Only after succ. compl. of module(s)
5	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
Contents		
Fabrication and properties of the main material groups. Metals: structure and microstructure, phase transitions and properties; thermo-mechanical treatment; Martensitic transitions; ductility and strength; form memory alloys. Ceramics: oxidic and non-oxidic structural ceramics; electric and magnetic properties of functional ceramics; glass. Polymer materials: thermoplasts, duromers, elastomers. Composite materials.		
Intended learning outcomes		
Students have developed a knowledge of the fabrication and properties of the main material groups and are able to apply that knowledge to research problems.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (3) + Ü (1)		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes) Language of assessment: German and/or English		
Allocation of places		
--		
Additional information		
--		
Workload		
150 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
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Module appears in		
Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Functional Materials (2015) Master's degree (1 major) Chemistry (2016) Master's teaching degree Gymnasium MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2016) Supplementary course MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2016) Master's degree (1 major) Chemistry (2018) Master's teaching degree Gymnasium MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2020) Supplementary course MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Functional Materials (2021)		
Bachelor's with 1 major Quantum Technology (2021)	JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	page 95 / 179

Bachelor' degree (1 major) Quantum Technology (2021)  
Master's degree (1 major) Chemistry (2024)

Module title		Abbreviation
Chemical Nanotechnology: Analytics and Applications		o8-FU-NT-AA-152-m01
Module coordinator		Module offered by
degree programme coordinator Funktionswerkstoffe (Functional Materials)		Chair of Chemical Technology of Material Synthesis
ECTS	Method of grading	Only after succ. compl. of module(s)
5	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	graduate	--
<b>Contents</b>		
Introduction to the theory and application of characterisation methods in nanotechnology. Thermoanalysis, rheological methods, dynamic light scattering. Application of nanomaterials in industry and technology.		
<b>Intended learning outcomes</b>		
Students have developed an advanced knowledge of the characterisation and application of nanomaterials.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (4)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes) Language of assessment: German and/or English		
<b>Allocation of places</b>		
--		
<b>Additional information</b>		
--		
<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module appears in</b>		
Bachelor' degree (1 major) Nanostructure Technology (2015) Master's degree (1 major) Functional Materials (2016) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Quantum Technology (2021) Master's degree (1 major) Functional Materials (2022)		

Module title		Abbreviation
Methods of Non-Destructive Material Testing		11-ZMB-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
4	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
Contents		
Principles of non-destructive material and component testing. Thermography. Neutron radiography. X-ray testing. Ultrasound. Optical testing, laser. Image processing.		
Intended learning outcomes		
The students have basic knowledge of the generation and interaction processes of different types of radiation (heat, X-ray, terahertz), particles (neutrons) or ultrasound waves with materials. They know the applied methods for the detection of radiation types, particles and ultrasound waves and are able to apply them to basic problems of material testing and characterisation.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (2) + R (1) Module taught in: German or English		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Assessment offered: Once a year, winter semester Language of assessment: German and/or English		
Allocation of places		
--		
Additional information		
--		
Workload		
120 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
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Module appears in		
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Master's degree (1 major) Functional Materials (2016) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Quantum Technology (2021)		
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Master's degree (1 major) Functional Materials (2022)  
exchange program Physics (2023)



## Life Sciences

( ECTS credits)

Module title			Abbreviation
Membranebiology of Plants for Advanced Students			07-4BFPS2-152-m01
Module coordinator		Module offered by	
holder of the Chair of Plant Physiology and Biophysics		Faculty of Biology	
ECTS	Method of grading	Only after succ. compl. of module(s)	
5	numerical grade	--	
Duration	Module level	Other prerequisites	
1 semester	undergraduate	--	
Contents			
In this module, students will acquire the general fundamentals of plant membrane transport and the biophysical methods with which it can be characterised. For this purpose, students will be introduced to modern methods of molecular biology and imaging as well as data collection and analysis.			
Intended learning outcomes			
Students understand basic membrane transport processes and are able to use experimental methods in experiments with intact plants, isolated plant cells as well as animal expression systems.			
Courses (type, number of weekly contact hours, language — if other than German)			
V (1) + Ü (5)			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
a) written examination (approx. 45 to 60 minutes) or b) log (approx. 10 to 20 pages) or c) oral examination of one candidate each (approx. 30 minutes) or d) oral examination in groups of up to 3 candidates (approx. 20 minutes per candidate) or e) presentation (approx. 20 to 30 minutes) or f) practical examination (on average approx. 2 hours; time to complete will vary according to subject area but will not exceed a maximum of 4 hours). Students will be informed about the method and length of the assessment prior to the course. creditable for bonus			
Allocation of places			
16 places. Should the number of applications exceed the number of available places, places will be allocated as follows: Students of the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits will be given preferential consideration. Should the module be used in other subjects, there will be two quotas: 95% of places will be allocated to students of the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits and 5% of places (a minimum of one place in total) will be allocated to students of the Bachelor's degree subject Biologie (Biology) with 60 ECTS credits and to students of the Bachelor's degree subjects Computational Mathematics and Mathematik (Mathematics), each with 180 ECTS credits, as part of the application-oriented subject Biology (as well as potentially to students of other 'importing' subjects). Should the number of places available in one quota exceed the number of applications, the remaining places will be allocated to applicants from the other quota. Should there be, within one module component, several courses with a restricted number of places, there will be a uniform regulation for the courses of one module component. In this case, places on all courses of a module component that are concerned will be allocated in the same procedure. In this procedure, applicants who already have successfully completed at least one other module component of the respective module will be given preferential consideration. A waiting list will be maintained and places re-allocated as they become available. Selection process group 1 (95%): Places will primarily be allocated according to the applicants' previous academic achievements. For this purpose, applicants will be ranked according to the number of ECTS credits they have achieved and their average grade of all assessments taken during their studies or of all module components in the subject of Biologie (Biology) (excluding Chemie (Chemistry), Physik (Physics), Mathematik (Mathematics)) at the time of application. This will be done as follows: First, applicants will be ranked, firstly, according to their average grade weighted according to the number of ECTS credits (qualitative ranking) and, secondly, according to their total number of ECTS credits achieved (quantitative ranking). The applicants' position in a third ranking will be calculated as the sum of these two rankings, and places will be allocated according to this third ranking.			
Bachelor's with 1 major Quantum Technology (2021)		JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	
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Among applicants with the same ranking, places will be allocated according to the qualitative ranking or otherwise by lot.

Selection process group 2 (5%): Places will be allocated according to the following quotas: Quota 1 (50 % of places): total number of ECTS credits already achieved in modules/module components of the Faculty of Biology; among applicants with the same number of ECTS credits achieved, places will be allocated by lot. Quota 2 (25 % of places): number of subject semesters of the respective applicant; among applicants with the same number of subject semesters, places will be allocated by lot. Quota 3 (25 % of places): lottery.

Should the module be used only in the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits, places will be allocated according to the selection process of group 1.

#### Additional information

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#### Workload

150 h

#### Teaching cycle

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#### Referred to in LPO I (examination regulations for teaching-degree programmes)

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#### Module appears in

Bachelor' degree (1 major) Biology (2015)  
Bachelor' degree (1 major) Nanostructure Technology (2015)  
Bachelor' degree (1 major) Biology (2017)  
Bachelor' degree (1 major) Nanostructure Technology (2020)  
Bachelor' degree (1 major) Biology (2021)  
Bachelor' degree (1 major) Quantum Technology (2021)  
Bachelor' degree (1 major) Biology (2022)  
exchange program Biosciences (2022)

Module title			Abbreviation
Methods in Biotechnology			07-4S1AMB-152-m01
Module coordinator		Module offered by	
holder of the Chair of Biotechnology and Biophysics		Faculty of Biology	
ECTS	Method of grading	Only after succ. compl. of module(s)	
5	numerical grade	--	
Duration	Module level	Other prerequisites	
1 semester	undergraduate	--	
Contents			
This module (lecture and seminar) will provide students with an overview of instrument-based methods in biotechnology and biomedicine and the underlying physical principles. It will discuss modern methods for the analysis of biological matter on the molecular and cellular level. These methods include light microscopy, fluorescence spectroscopy, electron microscopy, atomic force microscopy, flow cytometry and microfluidics.			
Intended learning outcomes			
Students will gain an overview of key methods in biotechnology and their respective advantages and disadvantages. They will learn to decide what method is most suitable for addressing a particular issue.			
Courses (type, number of weekly contact hours, language — if other than German)			
V (2) + S (2)			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
written examination (approx. 30 to 60 minutes) creditable for bonus			
Allocation of places			
25 places. Should the number of applications exceed the number of available places, places will be allocated as follows: Students of the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits will be given preferential consideration. Should the module be used in other subjects, there will be two quotas: 95% of places will be allocated to students of the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits and 5% of places (a minimum of one place in total) will be allocated to students of the Bachelor's degree subject Biologie (Biology) with 60 ECTS credits and to students of the Bachelor's degree subjects Computational Mathematics and Mathematik (Mathematics), each with 180 ECTS credits, as part of the application-oriented subject Biology (as well as potentially to students of other 'importing' subjects). Should the number of places available in one quota exceed the number of applications, the remaining places will be allocated to applicants from the other quota. Should there be, within one module component, several courses with a restricted number of places, there will be a uniform regulation for the courses of one module component. In this case, places on all courses of a module component that are concerned will be allocated in the same procedure. In this procedure, applicants who already have successfully completed at least one other module component of the respective module will be given preferential consideration. A waiting list will be maintained and places re-allocated as they become available. Selection process group 1 (95%): Places will primarily be allocated according to the applicants' previous academic achievements. For this purpose, applicants will be ranked according to the number of ECTS credits they have achieved and their average grade of all assessments taken during their studies or of all module components in the subject of Biologie (Biology) (excluding Chemie (Chemistry), Physik (Physics), Mathematik (Mathematics)) at the time of application. This will be done as follows: First, applicants will be ranked, firstly, according to their average grade weighted according to the number of ECTS credits (qualitative ranking) and, secondly, according to their total number of ECTS credits achieved (quantitative ranking). The applicants' position in a third ranking will be calculated as the sum of these two rankings, and places will be allocated according to this third ranking. Among applicants with the same ranking, places will be allocated according to the qualitative ranking or otherwise by lot.			

Selection process group 2 (5%): Places will be allocated according to the following quotas: Quota 1 (50 % of places): total number of ECTS credits already achieved in modules/module components of the Faculty of Biology; among applicants with the same number of ECTS credits achieved, places will be allocated by lot. Quota 2 (25 % of places): number of subject semesters of the respective applicant; among applicants with the same number of subject semesters, places will be allocated by lot. Quota 3 (25 % of places): lottery.  
Should the module be used only in the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits, places will be allocated according to the selection process of group 1.

**Additional information**

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**Workload**

150 h

**Teaching cycle**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Module appears in**

Bachelor' degree (1 major) Biology (2015)  
Bachelor' degree (1 major) Mathematics (2015)  
Bachelor' degree (1 major) Nanostructure Technology (2015)  
Bachelor' degree (1 major) Computational Mathematics (2015)  
Bachelor' degree (1 major) Biology (2017)  
Bachelor' degree (1 major) Nanostructure Technology (2020)  
Bachelor' degree (1 major) Biology (2021)  
Bachelor's degree (1 major, 1 minor) Biology (Minor, 2021)  
Bachelor' degree (1 major) Quantum Technology (2021)  
Bachelor' degree (1 major) Biology (2022)  
exchange program Biosciences (2022)  
Bachelor' degree (1 major) Mathematics (2023)

Module title			Abbreviation
Aspects of Molecular Biotechnology			07-4S1MOLB-152-m01
Module coordinator		Module offered by	
holder of the Chair of Biotechnology and Biophysics		Faculty of Biology	
ECTS	Method of grading	Only after succ. compl. of module(s)	
5	numerical grade	--	
Duration	Module level	Other prerequisites	
1 semester	undergraduate	--	
Contents			
Fundamental principles of "white" biotechnology, bioreactors, biocatalysis, immobilisation of cells and enzymes, production of biomolecules, molecular biology, recombinant DNA technology, protein engineering, biosensor design, drug design, drug targeting, molecular diagnostics, recombinant antibodies, hybridoma technology, electromanipulation of cells.			
Intended learning outcomes			
Students will gain an overview of traditional and modern methods in biotechnology and their respective advantages and disadvantages. They will learn to decide what method is most suitable for addressing a particular issue. Students will acquire a knowledge of fundamental methods in biotechnology that will enable them to independently review relevant literature. In addition, they will become acquainted with - or, where necessary, will be able to independently acquaint themselves with - relevant mechanisms.			
Courses (type, number of weekly contact hours, language — if other than German)			
V (2) + S (2)			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
written examination (approx. 30 to 60 minutes) creditable for bonus			
Allocation of places			
25 places. Should the number of applications exceed the number of available places, places will be allocated as follows: Students of the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits will be given preferential consideration. Should the module be used in other subjects, there will be two quotas: 95% of places will be allocated to students of the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits and 5% of places (a minimum of one place in total) will be allocated to students of the Bachelor's degree subject Biologie (Biology) with 60 ECTS credits and to students of the Bachelor's degree subjects Computational Mathematics and Mathematik (Mathematics), each with 180 ECTS credits, as part of the application-oriented subject Biology (as well as potentially to students of other 'importing' subjects). Should the number of places available in one quota exceed the number of applications, the remaining places will be allocated to applicants from the other quota. Should there be, within one module component, several courses with a restricted number of places, there will be a uniform regulation for the courses of one module component. In this case, places on all courses of a module component that are concerned will be allocated in the same procedure. In this procedure, applicants who already have successfully completed at least one other module component of the respective module will be given preferential consideration. A waiting list will be maintained and places re-allocated as they become available. Selection process group 1 (95%): Places will primarily be allocated according to the applicants' previous academic achievements. For this purpose, applicants will be ranked according to the number of ECTS credits they have achieved and their average grade of all assessments taken during their studies or of all module components in the subject of Biologie (Biology) (excluding Chemie (Chemistry), Physik (Physics), Mathematik (Mathematics)) at the time of application. This will be done as follows: First, applicants will be ranked, firstly, according to their average grade weighted according to the number of ECTS credits (qualitative ranking) and, secondly, according to their total number of ECTS credits achieved (quantitative ranking). The applicants' position in a third ranking will be calculated as the sum of these two rankings, and places will be allocated according to this third ranking.			
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Among applicants with the same ranking, places will be allocated according to the qualitative ranking or otherwise by lot.

Selection process group 2 (5%): Places will be allocated according to the following quotas: Quota 1 (50 % of places): total number of ECTS credits already achieved in modules/module components of the Faculty of Biology; among applicants with the same number of ECTS credits achieved, places will be allocated by lot. Quota 2 (25 % of places): number of subject semesters of the respective applicant; among applicants with the same number of subject semesters, places will be allocated by lot. Quota 3 (25 % of places): lottery.

Should the module be used only in the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits, places will be allocated according to the selection process of group 1.

#### Additional information

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#### Workload

150 h

#### Teaching cycle

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#### Referred to in LPO I (examination regulations for teaching-degree programmes)

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#### Module appears in

Bachelor' degree (1 major) Biology (2015)  
Bachelor' degree (1 major) Mathematics (2015)  
Bachelor' degree (1 major) Nanostructure Technology (2015)  
Bachelor' degree (1 major) Computational Mathematics (2015)  
Master's degree (1 major) Functional Materials (2016)  
Bachelor' degree (1 major) Biology (2017)  
Bachelor' degree (1 major) Nanostructure Technology (2020)  
Bachelor' degree (1 major) Biology (2021)  
Bachelor's degree (1 major, 1 minor) Biology (Minor, 2021)  
Bachelor' degree (1 major) Quantum Technology (2021)  
Bachelor' degree (1 major) Biology (2022)  
Master's degree (1 major) Functional Materials (2022)  
exchange program Biosciences (2022)  
Bachelor' degree (1 major) Mathematics (2023)



Module title			Abbreviation
Special Bioinformatics 1			07-4S1MZ6-152-m01
Module coordinator		Module offered by	
holder of the Chair of Bioinformatics		Faculty of Biology	
ECTS	Method of grading	Only after succ. compl. of module(s)	
5	numerical grade	--	
Duration	Module level	Other prerequisites	
1 semester	undergraduate	--	
Contents			
Fundamental principles of the tree of life, fundamental principles of phylogenetics (methods and markers), fundamental principles of evolutionary biology (concepts), sequence analysis, RNA structure prediction, phylogenetic reconstruction.			
Intended learning outcomes			
Students are able to use software and databases for sequence analysis, RNA structure prediction and phylogenetic reconstruction.			
Courses (type, number of weekly contact hours, language — if other than German)			
V (1) + Ü (5)			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
Log (approx. 10 to 20 pages) Language of assessment: German or English creditable for bonus			
Allocation of places			
20 places. Should the number of applications exceed the number of available places, places will be allocated as follows: Students of the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits will be given preferential consideration. Should the module be used in other subjects, there will be two quotas: 95% of places will be allocated to students of the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits and 5% of places (a minimum of one place in total) will be allocated to students of the Bachelor's degree subject Biologie (Biology) with 60 ECTS credits and to students of the Bachelor's degree subjects Computational Mathematics and Mathematik (Mathematics), each with 180 ECTS credits, as part of the application-oriented subject Biology (as well as potentially to students of other 'importing' subjects). Should the number of places available in one quota exceed the number of applications, the remaining places will be allocated to applicants from the other quota. Should there be, within one module component, several courses with a restricted number of places, there will be a uniform regulation for the courses of one module component. In this case, places on all courses of a module component that are concerned will be allocated in the same procedure. In this procedure, applicants who already have successfully completed at least one other module component of the respective module will be given preferential consideration. A waiting list will be maintained and places re-allocated as they become available. Selection process group 1 (95%): Places will primarily be allocated according to the applicants' previous academic achievements. For this purpose, applicants will be ranked according to the number of ECTS credits they have achieved and their average grade of all assessments taken during their studies or of all module components in the subject of Biologie (Biology) (excluding Chemie (Chemistry), Physik (Physics), Mathematik (Mathematics)) at the time of application. This will be done as follows: First, applicants will be ranked, firstly, according to their average grade weighted according to the number of ECTS credits (qualitative ranking) and, secondly, according to their total number of ECTS credits achieved (quantitative ranking). The applicants' position in a third ranking will be calculated as the sum of these two rankings, and places will be allocated according to this third ranking. Among applicants with the same ranking, places will be allocated according to the qualitative ranking or otherwise by lot.			



Selection process group 2 (5%): Places will be allocated according to the following quotas: Quota 1 (50 % of places): total number of ECTS credits already achieved in modules/module components of the Faculty of Biology; among applicants with the same number of ECTS credits achieved, places will be allocated by lot. Quota 2 (25 % of places): number of subject semesters of the respective applicant; among applicants with the same number of subject semesters, places will be allocated by lot. Quota 3 (25 % of places): lottery.  
Should the module be used only in the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits, places will be allocated according to the selection process of group 1.

**Additional information**

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**Workload**

150 h

**Teaching cycle**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Module appears in**

Bachelor' degree (1 major) Biology (2015)  
Bachelor' degree (1 major) Mathematics (2015)  
Bachelor' degree (1 major) Nanostructure Technology (2015)  
Bachelor' degree (1 major) Computational Mathematics (2015)  
Bachelor's degree (1 major, 1 minor) Biology (Minor, 2015)  
Bachelor' degree (1 major) Biology (2017)  
Bachelor' degree (1 major) Nanostructure Technology (2020)  
Bachelor' degree (1 major) Biology (2021)  
Bachelor's degree (1 major, 1 minor) Biology (Minor, 2020)  
Bachelor's degree (1 major, 1 minor) Biology (Minor, 2021)  
Bachelor' degree (1 major) Quantum Technology (2021)  
Bachelor' degree (1 major) Biology (2022)  
exchange program Biosciences (2022)  
Bachelor' degree (1 major) Mathematics (2023)

Module title			Abbreviation
Basics in Light- and Electron-Microscopy			07-4S1MZ1-152-mo1
Module coordinator		Module offered by	
head of the Department of Electronmicroscopy		Faculty of Biology	
ECTS	Method of grading	Only after succ. compl. of module(s)	
5	numerical grade	--	
Duration	Module level	Other prerequisites	
1 semester	undergraduate	--	
Contents			
Fundamental principles of confocal laser scanning microscopy and electron microscopy.			
Intended learning outcomes			
Students have acquired theoretical knowledge and practical skills in the area of light and electron microscopy.			
Courses (type, number of weekly contact hours, language — if other than German)			
V (1) + Ü (5)			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
written examination (approx. 30 to 60 minutes) creditable for bonus			
Allocation of places			
18 places. Should the number of applications exceed the number of available places, places will be allocated as follows: Students of the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits will be given preferential consideration. Should the module be used in other subjects, there will be two quotas: 95% of places will be allocated to students of the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits and 5% of places (a minimum of one place in total) will be allocated to students of the Bachelor's degree subject Biologie (Biology) with 60 ECTS credits and to students of the Bachelor's degree subjects Computational Mathematics and Mathematik (Mathematics), each with 180 ECTS credits, as part of the application-oriented subject Biology (as well as potentially to students of other 'importing' subjects). Should the number of places available in one quota exceed the number of applications, the remaining places will be allocated to applicants from the other quota. Should there be, within one module component, several courses with a restricted number of places, there will be a uniform regulation for the courses of one module component. In this case, places on all courses of a module component that are concerned will be allocated in the same procedure. In this procedure, applicants who already have successfully completed at least one other module component of the respective module will be given preferential consideration. A waiting list will be maintained and places re-allocated as they become available. Selection process group 1 (95%): Places will primarily be allocated according to the applicants' previous academic achievements. For this purpose, applicants will be ranked according to the number of ECTS credits they have achieved and their average grade of all assessments taken during their studies or of all module components in the subject of Biologie (Biology) (excluding Chemie (Chemistry), Physik (Physics), Mathematik (Mathematics)) at the time of application. This will be done as follows: First, applicants will be ranked, firstly, according to their average grade weighted according to the number of ECTS credits (qualitative ranking) and, secondly, according to their total number of ECTS credits achieved (quantitative ranking). The applicants' position in a third ranking will be calculated as the sum of these two rankings, and places will be allocated according to this third ranking. Among applicants with the same ranking, places will be allocated according to the qualitative ranking or otherwise by lot. Selection process group 2 (5%): Places will be allocated according to the following quotas: Quota 1 (50 % of places): total number of ECTS credits already achieved in modules/module components of the Faculty of Biology; among applicants with the same number of ECTS credits achieved, places will be allocated by lot. Quota 2 (25 % of places): number of subject semesters of the respective applicant; among applicants with the same number of subject semesters, places will be allocated by lot. Quota 3 (25 % of places): lottery.			
Bachelor's with 1 major Quantum Technology (2021)		JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	
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Should the module be used only in the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits, places will be allocated according to the selection process of group 1.

**Additional information**

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**Workload**

150 h

**Teaching cycle**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Module appears in**

Bachelor' degree (1 major) Biology (2015)  
Bachelor' degree (1 major) Mathematics (2015)  
Bachelor' degree (1 major) Nanostructure Technology (2015)  
Bachelor' degree (1 major) Computational Mathematics (2015)  
Bachelor's degree (1 major, 1 minor) Biology (Minor, 2015)  
Bachelor' degree (1 major) Biology (2017)  
Bachelor' degree (1 major) Nanostructure Technology (2020)  
Bachelor' degree (1 major) Biology (2021)  
Bachelor's degree (1 major, 1 minor) Biology (Minor, 2020)  
Bachelor' degree (1 major) Quantum Technology (2021)  
Bachelor' degree (1 major) Biology (2022)  
exchange program Biosciences (2022)

Module title			Abbreviation
Specific Biotechnology 2			07-5S2MZ4-152-m01
Module coordinator		Module offered by	
holder of the Chair of Biotechnology and Biophysics		Faculty of Biology	
ECTS	Method of grading	Only after succ. compl. of module(s)	
10	numerical grade	--	
Duration	Module level	Other prerequisites	
1 semester	undergraduate	--	
Contents			
This practical course provides students with an insight into different biotechnological and biophysical topics. Under expert guidance, students will perform selected experiments on the following topics: cellular and molecular biotechnology, nano and microsystems biotechnology, biomaterials and biosensors, high-resolution fluorescence microscopy, fluorescence spectroscopy, analysis and electromanipulation of cells.			
Intended learning outcomes			
Students will have acquired a knowledge of fundamental biotechnological and biophysical methods and their applications that will enable them to independently review relevant literature. In addition, they will have become acquainted with - or, where necessary, will be able to independently acquaint themselves with - biophysical mechanisms. Students will have acquired practical experience performing experiments, using a variety of scientific tools. In the seminar, students will have acquired detailed theoretical knowledge on these experiments and will have delivered a short presentation (15 minutes) on one of the experiments they performed.			
Courses (type, number of weekly contact hours, language — if other than German)			
Ü (7) + S (1) Module taught in: German and/or English			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
a) written examination (approx. 45 to 60 minutes) or b) log (approx. 10 to 20 pages) or c) oral examination of one candidate each (approx. 30 minutes) or d) oral examination in groups of up to 3 candidates (approx. 20 minutes per candidate) or e) presentation (approx. 20 to 30 minutes) or f) practical examination (on average approx. 2 hours; time to complete will vary according to subject area but will not exceed a maximum of 4 hours). Students will be informed about the method and length of the assessment prior to the course. Language of assessment: German and/or English creditable for bonus			
Allocation of places			
18 places. Should the number of applications exceed the number of available places, places will be allocated as follows: Students of the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits will be given preferential consideration. Should the module be used in other subjects, there will be two quotas: 95% of places will be allocated to students of the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits and 5% of places (a minimum of one place in total) will be allocated to students of the Bachelor's degree subject Biologie (Biology) with 60 ECTS credits and to students of the Bachelor's degree subjects Computational Mathematics and Mathematik (Mathematics), each with 180 ECTS credits, as part of the application-oriented subject Biology (as well as potentially to students of other 'importing' subjects). Should the number of places available in one quota exceed the number of applications, the remaining places will be allocated to applicants from the other quota. Should there be, within one module component, several courses with a restricted number of places, there will be a uniform regulation for the courses of one module component. In this case, places on all courses of a module component that are concerned will be allocated in the same procedure. In this procedure, applicants who already have successfully completed at least one other module component of the respective module will be given preferential consideration. A waiting list will be maintained and places re-allocated as they become available.			

Selection process group 1 (95%): Places will primarily be allocated according to the applicants' previous academic achievements. For this purpose, applicants will be ranked according to the number of ECTS credits they have achieved and their average grade of all assessments taken during their studies or of all module components in the subject of Biologie (Biology) (excluding Chemie (Chemistry), Physik (Physics), Mathematik (Mathematics)) at the time of application. This will be done as follows: First, applicants will be ranked, firstly, according to their average grade weighted according to the number of ECTS credits (qualitative ranking) and, secondly, according to their total number of ECTS credits achieved (quantitative ranking). The applicants' position in a third ranking will be calculated as the sum of these two rankings, and places will be allocated according to this third ranking. Among applicants with the same ranking, places will be allocated according to the qualitative ranking or otherwise by lot.

Selection process group 2 (5%): Places will be allocated according to the following quotas: Quota 1 (50 % of places): total number of ECTS credits already achieved in modules/module components of the Faculty of Biology; among applicants with the same number of ECTS credits achieved, places will be allocated by lot. Quota 2 (25 % of places): number of subject semesters of the respective applicant; among applicants with the same number of subject semesters, places will be allocated by lot. Quota 3 (25 % of places): lottery.

Should the module be used only in the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits, places will be allocated according to the selection process of group 1.

#### Additional information

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#### Workload

300 h

#### Teaching cycle

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#### Referred to in LPO I (examination regulations for teaching-degree programmes)

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#### Module appears in

Bachelor' degree (1 major) Biology (2015)  
Bachelor' degree (1 major) Nanostructure Technology (2015)  
Bachelor' degree (1 major) Biology (2017)  
Bachelor' degree (1 major) Nanostructure Technology (2020)  
Bachelor' degree (1 major) Biology (2021)  
Bachelor' degree (1 major) Quantum Technology (2021)  
Bachelor' degree (1 major) Biology (2022)  
exchange program Biosciences (2022)

Module title		Abbreviation
Laboratory and Measurement Technology in Biophysics		11-LMB-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	graduate	--
<b>Contents</b>		
The lecture covers relevant principles of molecular and cellular biology as well as the physical principles of biophysical procedures for the examination and manipulation of biological systems. The main topics are optical measuring techniques and sensors, methods of single-particle detection, special microscoping techniques and methods of structure elucidation of biomolecules.		
<b>Intended learning outcomes</b>		
The students know the principles of molecular and cellular biology as well as the physical principles of biophysical procedures for the examination and manipulation of biological systems. They have knowledge of optical measuring techniques and their applications and are able to apply techniques of structure elucidation to simple biomolecules.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Assessment offered: Once a year, summer semester Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module appears in</b>		
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Master's degree (1 major) Functional Materials (2016) Bachelor' degree (1 major) Physics (2020)		
Bachelor's with 1 major Quantum Technology (2021)	JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	page 113 / 179

Bachelor' degree (1 major) Nanostructure Technology (2020)  
Bachelor' degree (1 major) Quantum Technology (2021)  
Master's degree (1 major) Functional Materials (2022)  
exchange program Physics (2023)

# Mathematics, Theory and Computer Aided Methods

( ECTS credits)



Module title			Abbreviation
Introduction to Quantum Computing and Quantum Information			11-QUI-202-m01
Module coordinator		Module offered by	
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy	
ECTS	Method of grading	Only after succ. compl. of module(s)	
6	numerical grade	--	
Duration	Module level	Other prerequisites	
1 semester	undergraduate	--	
Contents			
Basic concepts of quantum theory and statistics. Qubits and the representation of quantum-mechanical states by density operators. Theory of the measurement process. Von Neumann entropy, bipartite systems, entanglement, and entanglement measures. Quantum channels, Kraus operators and Stinespring theorem. Decoherence of quantum states. Introduction to quantum teleportation and quantum cryptography. First steps in the theory of quantum computation and error correction.			
Intended learning outcomes			
Knowledge of the basic principles of quantum information theory and its application. Deepened understanding of specific properties of quantum systems such as entanglement. Overview of the most important theorems and possible applications of quantum information theory. The aim is to prepare the students for further elective courses on this subject in the Master's study program.			
Courses (type, number of weekly contact hours, language — if other than German)			
V (3) + R (1) Module taught in: German or English			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English Assessment offered: In the semester in which the course is offered and in the subsequent semester			
Allocation of places			
--			
Additional information			
--			
Workload			
180 h			
Teaching cycle			
--			
Referred to in LPO I (examination regulations for teaching-degree programmes)			
--			
Module appears in			
Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020)			
Bachelor's with 1 major Quantum Technology (2021)		JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	page 116 / 179

Bachelor' degree (1 major) Mathematical Physics (2020)  
Bachelor' degree (1 major) Quantum Technology (2021)  
exchange program Physics (2023)  
Bachelor' degree (1 major) Mathematical Physics (2024)

Module title			Abbreviation
Introduction to Relativistic Physics and Classical Field Theory			11-RRF-202-m01
Module coordinator		Module offered by	
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy	
ECTS	Method of grading	Only after succ. compl. of module(s)	
6	numerical grade	--	
Duration	Module level	Other prerequisites	
1 semester	undergraduate	--	
Contents			
Principles of the special theory of relativity, relativistic mechanics, covariant formulation in the Minkowski space, basic concepts of classical field theory using the example of the scalar field. Electrodynamics as Relativistic Field Theory, Conservation Quantities, Currents and Noether Theorem. Elements of relativistic hydrodynamics as well as elementary foundations of the general relativity theory for special metrics, e.g. black holes.			
Intended learning outcomes			
Knowledge of the principles of special relativity and standard methods for solving classical relativistic problems in covariant representation. Safe handling of classical relativistic field theories as well as a rough overview of the basics of general relativity. The students should be prepared for further elective courses in theoretical physics in the Master's program.			
Courses (type, number of weekly contact hours, language — if other than German)			
V (3) + R (1) Module taught in: German or English			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English Assessment offered: Once a year, summer semester			
Allocation of places			
--			
Additional information			
--			
Workload			
180 h			
Teaching cycle			
--			
Referred to in LPO I (examination regulations for teaching-degree programmes)			
--			
Module appears in			
Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Mathematical Physics (2020)			
Bachelor's with 1 major Quantum Technology (2021)		JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	
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Bachelor' degree (1 major) Quantum Technology (2021)  
exchange program Physics (2023)  
Bachelor' degree (1 major) Mathematical Physics (2024)

Module title			Abbreviation
Statistics, Data Analysis and Computer Physics			11-SDC-152-m01
Module coordinator		Module offered by	
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy	
ECTS	Method of grading	Only after succ. compl. of module(s)	
4	numerical grade	--	
Duration	Module level	Other prerequisites	
1 semester	graduate	--	
Contents			
Statistics, data analysis and computer physics.			
Intended learning outcomes			
The students have specific and advanced knowledge in the field of statistics, data analysis and Computational Physics.			
Courses (type, number of weekly contact hours, language — if other than German)			
V (2) + R (1) Module taught in: German or English			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Assessment offered: Once a year, winter semester Language of assessment: German and/or English			
Allocation of places			
--			
Additional information			
--			
Workload			
120 h			
Teaching cycle			
--			
Referred to in LPO I (examination regulations for teaching-degree programmes)			
--			
Module appears in			
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Mathematical Physics (2015) Bachelor' degree (1 major) Mathematical Physics (2016) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Mathematical Physics (2020) Bachelor' degree (1 major) Quantum Technology (2021) exchange program Physics (2023)			
Bachelor's with 1 major Quantum Technology (2021)		JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	page 120 / 179

Bachelor' degree (1 major) Mathematical Physics (2024)

Module title		Abbreviation
Numerical Mathematics 1 for students of other subjects		10-M-NUM1af-152-m01
Module coordinator		Module offered by
Dean of Studies Mathematik (Mathematics)		Institute of Mathematics
ECTS	Method of grading	Only after succ. compl. of module(s)
10	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
Solution of systems of linear equations and curve fitting problems, nonlinear equations and systems of equations, interpolation with polynomials, splines and trigonometric functions, numerical integration.		
<b>Intended learning outcomes</b>		
The student is acquainted with the fundamental concepts and methods in numerical mathematics, applies them to practical problems and knows about their typical fields of application.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (4) + Ü (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
a) written examination (approx. 90 to 180 minutes, usually chosen) or b) oral examination of one candidate each (15 to 30 minutes) or c) oral examination in groups (groups of 2, 10 to 15 minutes per candidate) Language of assessment: German and/or English creditable for bonus		
<b>Allocation of places</b>		
--		
<b>Additional information</b>		
--		
<b>Workload</b>		
300 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
--		
<b>Module appears in</b>		
Bachelor' degree (1 major) Computer Science (2015) Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Aerospace Computer Science (2015) Bachelor' degree (1 major) Functional Materials (2015) Bachelor' degree (1 major) Aerospace Computer Science (2017) Bachelor' degree (1 major) Computer Science (2017) Bachelor' degree (1 major) Computer Science (2019) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Aerospace Computer Science (2020) Bachelor' degree (1 major) Functional Materials (2021) Bachelor' degree (1 major) Computer Science und Sustainability (2021)		
Bachelor's with 1 major Quantum Technology (2021)	JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	page 122 / 179

Bachelor' degree (1 major) Quantum Technology (2021)  
 Bachelor' degree (1 major) Artificial Intelligence and Data Science (2022)  
 Bachelor' degree (1 major) Artificial Intelligence and Data Science (2023)  
 Bachelor' degree (1 major) Artificial Intelligence and Data Science (2024)



Module title			Abbreviation
Numerical Mathematics 2 for students of other subjects			10-M-NUM2af-152-mo1
Module coordinator		Module offered by	
Dean of Studies Mathematik (Mathematics)		Institute of Mathematics	
ECTS	Method of grading	Only after succ. compl. of module(s)	
10	numerical grade	--	
Duration	Module level	Other prerequisites	
1 semester	undergraduate	--	
Contents			
Eigenvalue problems, linear programming, methods for initial value problems for ordinary differential equations, boundary value problems.			
Intended learning outcomes			
The student is able to draw a distinction between the different concepts of numerical mathematics and knows about their advantages and limitations concerning the possibilities of application in different fields of natural and engineering sciences and economics.			
Courses (type, number of weekly contact hours, language — if other than German)			
V (4) + Ü (2)			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
a) written examination (approx. 90 to 180 minutes, usually chosen) or b) oral examination of one candidate each (15 to 30 minutes) or c) oral examination in groups (groups of 2, 10 to 15 minutes per candidate) Language of assessment: German and/or English creditable for bonus			
Allocation of places			
--			
Additional information			
--			
Workload			
300 h			
Teaching cycle			
--			
Referred to in LPO I (examination regulations for teaching-degree programmes)			
--			
Module appears in			
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Aerospace Computer Science (2015) Bachelor' degree (1 major) Functional Materials (2015) Bachelor' degree (1 major) Aerospace Computer Science (2017) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Aerospace Computer Science (2020) Bachelor' degree (1 major) Functional Materials (2021) Bachelor' degree (1 major) Quantum Technology (2021)			

Module title		Abbreviation
Programming course for students of Mathematics and other subjects		10-M-PRG-152-m01
Module coordinator		Module offered by
Dean of Studies Mathematik (Mathematics)		Institute of Mathematics
ECTS	Method of grading	Only after succ. compl. of module(s)
3	(not) successfully completed	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
Basics of a modern programming language (e. g. C).		
<b>Intended learning outcomes</b>		
The student is able to work independently on small programming exercises and standard programming problems in mathematics.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
P (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
project in the form of programming exercises (approx. 20 to 25 hours) Assessment offered: Once a year, summer semester Language of assessment: German and/or English		
<b>Allocation of places</b>		
--		
<b>Additional information</b>		
--		
<b>Workload</b>		
90 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
§ 22 II Nr. 3 f)		
<b>Module appears in</b>		
Bachelor' degree (1 major) Mathematics (2015) Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Economathematics (2015) Bachelor' degree (1 major) Mathematical Physics (2015) Bachelor' degree (1 major) Computational Mathematics (2015) Bachelor' degree (1 major) Functional Materials (2015) First state examination for the teaching degree Gymnasium Mathematics (2015) Bachelor' degree (1 major) Mathematical Physics (2016) Bachelor' degree (1 major) Economathematics (2017) First state examination for the teaching degree Gymnasium Mathematics (2019) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Mathematical Physics (2020) Bachelor' degree (1 major) Functional Materials (2021)		
Bachelor's with 1 major Quantum Technology (2021)	JMU Würzburg • generated 30-Mär-2024 • exam. reg. da- ta record Bachelor (180 ECTS) Quantentechnologie - 2021	page 125 / 179

Bachelor' degree (1 major) Quantum Technology (2021)  
 Bachelor' degree (1 major) Economathematics (2021)  
 Bachelor' degree (1 major) Economathematics (2022)  
 Bachelor' degree (1 major) Mathematical Data Science (2022)  
 exchange program Mathematics (2023)  
 First state examination for the teaching degree Gymnasium Mathematics (2023)  
 Bachelor' degree (1 major) Mathematics (2023)  
 Bachelor' degree (1 major) Economathematics (2023)  
 Bachelor' degree (1 major) Mathematical Physics (2024)  
 Bachelor' degree (1 major) Economathematics (2024)

Module title		Abbreviation
Computational Mathematics		10-M-COM-152-m01
Module coordinator		Module offered by
Dean of Studies Mathematik (Mathematics)		Institute of Mathematics
ECTS	Method of grading	Only after succ. compl. of module(s)
4	(not) successfully completed	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
Contents		
Introduction to modern mathematical software for symbolic computation (e. g. Mathematica or Maple) and numerical computation (e. g. Matlab) to supplement the basic modules in analysis and linear algebra (10-M-ANA-G and 10-M-LNA-G). Computer-based solution of problems in linear algebra, geometry, analysis, in particular differential and integral calculus; visualisation of functions.		
Intended learning outcomes		
The student learns the use of advanced modern mathematical software packages, and is able to assess their fields of application to solve mathematical problems.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (1) + Ü (2)		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
project in the form of programming exercises (approx. 20 to 25 hours) Assessment offered: Once a year, winter semester Language of assessment: German and/or English		
Allocation of places		
--		
Additional information		
--		
Workload		
120 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
§ 22 II Nr. 3 f)		
Module appears in		
Bachelor' degree (1 major) Mathematics (2015) Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Economathematics (2015) Bachelor' degree (1 major) Mathematical Physics (2015) Bachelor' degree (1 major) Computational Mathematics (2015) Bachelor' degree (1 major) Functional Materials (2015) First state examination for the teaching degree Gymnasium Mathematics (2015) Bachelor' degree (1 major) Mathematical Physics (2016) Bachelor' degree (1 major) Economathematics (2017) First state examination for the teaching degree Gymnasium Mathematics (2019) Bachelor' degree (1 major) Physics (2020)		
Bachelor's with 1 major Quantum Technology (2021)	JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	page 127 / 179

Bachelor' degree (1 major) Nanostructure Technology (2020)  
 Bachelor' degree (1 major) Mathematical Physics (2020)  
 Bachelor' degree (1 major) Functional Materials (2021)  
 Bachelor' degree (1 major) Quantum Technology (2021)  
 Bachelor' degree (1 major) Economathematics (2021)  
 Bachelor' degree (1 major) Economathematics (2022)  
 Bachelor' degree (1 major) Mathematical Data Science (2022)  
 exchange program Mathematics (2023)  
 First state examination for the teaching degree Gymnasium Mathematics (2023)  
 Bachelor' degree (1 major) Mathematics (2023)  
 Bachelor' degree (1 major) Economathematics (2023)  
 Bachelor' degree (1 major) Mathematical Physics (2024)  
 Bachelor' degree (1 major) Economathematics (2024)

Module title			Abbreviation
Mathematics 4 for Students of Physics and related Disciplines (Complex Analysis)			11-M-F-152-m01
Module coordinator		Module offered by	
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy	
ECTS	Method of grading	Only after succ. compl. of module(s)	
8	numerical grade	--	
Duration	Module level	Other prerequisites	
1 semester	undergraduate	--	
Contents			
<p>Basic knowledge of functional analysis that is required in the course Quantum Mechanics I. The definition of Hilbert space opens up understanding of quantum mechanical states as vectors. The representation-free form of quantum mechanics and the representation as a wave function generated by basic states form an important element of the formal framework of quantum mechanics with the so-called bracket formalism by Dirac.</p> <p>Fundamentals of partial differential equations in physics and systems of differential equations.</p> <p>Part I: functional analysis</p> <p>1.1 Linear vector spaces</p> <p>1.2 Metric, standardized spaces</p> <p>1.3 Linear operators</p> <p>1.4 Function space, completion, Lebesgue integral, Hilbert space</p> <p>1.5 Linear operators on the Hilbert space</p> <p>1.6 Matrix representation of operators</p> <p>1.8 The Dirac delta function and its different representations</p> <p>Part II: differential equations</p> <p>2. Partial differential equations</p> <p>2.1 Linear partial differential equations of 2nd order</p> <p>2.2 1D and 3D wave equation</p> <p>2.3 Helmholtz equation and potential theory</p> <p>2.4 Parabolic differential equations</p>			
Intended learning outcomes			
The student has basic knowledge of mathematics and basic knowledge of Hilbert space mathematics, as well as knowledge of solution methods for partial differential equations and is proficient in the necessary computing techniques.			
Courses (type, number of weekly contact hours, language — if other than German)			
V (4) + Ü (2)			
Module taught in: Ü: German or English			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
written examination (approx. 120 minutes)			
Language of assessment: German and/or English			
Allocation of places			
--			
Additional information			
--			
Workload			
240 h			

<b>Teaching cycle</b>
--
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)
--
<b>Module appears in</b>
<p>Bachelor' degree (1 major) Physics (2015)</p> <p>Bachelor' degree (1 major) Nanostructure Technology (2015)</p> <p>Bachelor' degree (1 major) Physics (2020)</p> <p>Bachelor' degree (1 major) Nanostructure Technology (2020)</p> <p>Bachelor' degree (1 major) Functional Materials (2021)</p> <p>Bachelor' degree (1 major) Quantum Technology (2021)</p> <p>exchange program Physics (2023)</p>

Module title		Abbreviation
Theoretical Mechanics		11-T-M-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
8	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	Admission prerequisite to assessment: completion of exercises (approx. 13 exercise sheets per semester). Students who successfully completed approx. 50% of exercises will qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the semester.
Contents		
<p>1. Newton's formulation: Inertial systems, Newton's laws of motion, equations of motion; one-dimensional motion, energy conservation; Harmonic oscillator; Movement in space of intuition, conservative forces;</p> <p>2. Lagrangian formulation: Variational principles, Euler-Lagrange equation; constraints; coordinate transformations, mechanical gauge transformation; symmetries, Noether theorem, cyclic coordinates; accelerated reference systems and apparent forces;</p> <p>3. Hamiltonian formulation: Legendre transformation, phase space; Hamilton function, canonical equations; Poisson brackets, canonical transformations; generator of symmetries, conservation laws; minimal coupling; Liouville theorem; Hamilton-Jacobi formulation [optional];</p> <p>4. Applications: Central-force problems; mechanical similarity, Virial theorem; minor vibrations; particles in an electromagnetic field; rigid bodies, torque and inertia tensor, centrifugal and Euler equations [optional]; scattering, cross section [optional];</p> <p>5. Relativistic dynamics: Lorentz Transformation; Minkowski space; equations of motion; 6. Non-linear dynamics: Stability theory; KAM theory [optional]; deterministic chaos [optional]</p>		
Intended learning outcomes		
The students have gained first experiences concerning the working methods of Theoretical Physics. They are familiar with the principles of theoretical mechanics and their different formulations. They are able to independently apply the acquired mathematical methods and techniques to simple problems of Theoretical Physics and to interpret the results. They have especially acquired knowledge of basic mathematical concepts.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (4) + Ü (2) Module taught in: Ü: German or English		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 120 minutes) Language of assessment: German and/or English		
Allocation of places		
--		
Additional information		
Registration: If a student registers for the exercises and obtains the qualification for admission to assessment, this will be considered a declaration of will to seek admission to assessment pursuant to Section 20 Subsection 3 Sentence 4 ASPO (general academic and examination regulations). If the module coordinators subsequently find that the student has obtained the qualification for admission to assessment, they will put the student's registration for assessment into effect. Only those students that meet the respective prerequisites can successfully register for an assessment. Students who did not register for an assessment or whose registration for an assessment was not put into effect will not be admitted to the respective assessment. If a student takes an assessment to which he/she has not been admitted, the grade achieved in this assessment will not be considered.		
Bachelor's with 1 major Quantum Technology (2021)	JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	page 131 / 179



<b>Workload</b>
240 h
<b>Teaching cycle</b>
--
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)
--
<b>Module appears in</b>
<p>Bachelor' degree (1 major) Mathematics (2015)</p> <p>Bachelor' degree (1 major) Physics (2015)</p> <p>Bachelor' degree (1 major) Nanostructure Technology (2015)</p> <p>Bachelor' degree (1 major) Mathematical Physics (2015)</p> <p>Bachelor' degree (1 major) Computational Mathematics (2015)</p> <p>Bachelor's degree (1 major, 1 minor) Physics (Minor, 2015)</p> <p>Bachelor' degree (1 major) Physics (2020)</p> <p>Bachelor' degree (1 major) Nanostructure Technology (2020)</p> <p>Bachelor' degree (1 major) Mathematical Physics (2020)</p> <p>Bachelor's degree (1 major, 1 minor) Physics (Minor, 2020)</p> <p>Bachelor' degree (1 major) Quantum Technology (2021)</p> <p>Bachelor' degree (1 major) Mathematics (2023)</p> <p>exchange program Physics (2023)</p> <p>Bachelor' degree (1 major) Mathematical Physics (2024)</p>

Module title		Abbreviation
Electrodynamics		11-T-E-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
8	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
Contents		
<p>0. Mathematical tools: Gradient, divergence, curl; curve, surface, volume integrals; Stokes and Gaussian sentence; Delta function; Fourier transform; full functional systems; solving PDEs;</p> <p>1. Maxwell equations;</p> <p>2. Electrostatics: Coulomb's law; electrostatic potential; charged interface; electrostatic field energy (capacitor); multipole expansion; Boundary value problems; numerical solution; Image charges; Green's functions; development according to orthogonal functions;</p> <p>3. Magnetostatics: Current density; continuity equation; vector potential; Biot-Savart law; magnetic moment; analogies to electrostatics;</p> <p>4. Maxwell equations in matter: Electrical and magnetic susceptibility; interfaces;</p> <p>5. Dynamics of electromagnetic fields: Faraday induction; RCL-circuits; field energy and pulse; potentials; plane waves; wave packets; plane waves in matter; cavity resonators and wave guides; inhomogeneous wave equation; temporally oscillating sources and dipole radiation; accelerated point charges;</p> <p>6. Special Theory of Relativity: Lorentz transform; simultaneity; length contraction and time dilation; light cone; effect, energy and momentum; co- and contra-variant tensors; covariant classical mechanics;</p> <p>7. Covariant electrodynamics: Field strength tensor and Maxwell's equations; transformation of the fields; Doppler effect; Lorentz force</p>		
Intended learning outcomes		
The students have advanced knowledge of the methods of Theoretical Physics. They know the principles of theoretical electrodynamics. They are familiar with the corresponding mathematical methods and are able to independently apply them to the description and solution of problems in this area.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (4) + Ü (2) Module taught in: Ü: German or English		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 120 minutes) Language of assessment: German and/or English		
Allocation of places		
--		
Additional information		
--		
Workload		
240 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
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#### Module appears in

Bachelor' degree (1 major) Mathematics (2015)  
 Bachelor' degree (1 major) Nanostructure Technology (2015)  
 Bachelor' degree (1 major) Computational Mathematics (2015)  
 Bachelor's degree (1 major, 1 minor) Physics (Minor, 2015)  
 Bachelor' degree (1 major) Nanostructure Technology (2020)  
 Bachelor's degree (1 major, 1 minor) Physics (Minor, 2020)  
 Bachelor' degree (1 major) Quantum Technology (2021)  
 Bachelor' degree (1 major) Mathematics (2023)  
 exchange program Physics (2023)

# Applied Physics

( ECTS credits)

Module title		Abbreviation
Principles of Two- and Three-Dimensional Röntgen Imaging		11-ZDR-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	graduate	--
Contents		
Physics of X-ray generation (X-ray tubes, synchrotron). Physics of the interaction between X-rays and matter (photon absorption, scattering), physics of X-ray detection. Mathematics of reconstruction algorithms (filtered rear projection, Fourier reconstruction, iterative methods). Image processing (image data pre-processing, feature extraction, visualisation,...). Applications of X-ray imaging in the industrial sector (component testing, material characterisation, metrology, biology, ...). Radiation protection and biological radiation effect (dose, ...).		
Intended learning outcomes		
The students know the principles of generating X-rays and of their interactions with matter. They know imaging techniques using X-rays and methods of image processing as well as application areas of these methods.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Assessment offered: Once a year, summer semester Language of assessment: German and/or English		
Allocation of places		
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Additional information		
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Workload		
180 h		
Teaching cycle		
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Referred to in LPO I (examination regulations for teaching-degree programmes)		
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Module appears in		
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Master's degree (1 major) Functional Materials (2016) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020)		
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Bachelor' degree (1 major) Quantum Technology (2021)  
Master's degree (1 major) Functional Materials (2022)  
exchange program Physics (2023)

Module title		Abbreviation
Imaging Methods at the Synchrotron		11-BMS-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
Contents		
Periodic and aperiodic signals. Fundamentals of discrete and exact Fourier transform. Basics of digital signal and image processing. Discretisation of signals / sampling theorem (Shannon). Homogeneous and linear filter, the convolution product. Tapering functions and interpolation of images. The Parsival theorem, correlation and energetic aspects. Statistical signals, image noise, moments, stationary signals. Tomography: Hankel and Radon transform.		
Intended learning outcomes		
The students know the principles of digital image and signal processing. They know the ways of functioning and applications of different image processing methods and are able to apply them in practice.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Assessment offered: Once a year, summer semester Language of assessment: German and/or English		
Allocation of places		
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Additional information		
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Workload		
180 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
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Module appears in		
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Master's degree (1 major) Functional Materials (2016) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020)		
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Bachelor' degree (1 major) Quantum Technology (2021)  
Master's degree (1 major) Functional Materials (2022)  
exchange program Physics (2023)



Module title		Abbreviation
Imaging Sensors in Infrared		11-ASI-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
3	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
Infrared cameras are important experimental and technical tools, e.g. for measuring temperatures. The spectral range of infrared ranges from the visible spectrum, where the Sun is dominating as the natural source of light, up to microwaves and radiowaves with artificial emitters. There is distinct and sometimes dominating emission from bodies with ambient temperature in the infrared spectrum. The lecture provides an introduction to the physical optics of this spectral range and discusses: Peculiarities of infrared cameras and thermal images, different types of sensors (bolometer, quantum well, superlattice) as well as the evaluation of such sensors on the basis of neurophysiological aspects.		
<b>Intended learning outcomes</b>		
The students have specific and advanced knowledge in the field of infrared spectral imaging. They know various technologies and detector structures as well as their application areas.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (2) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Assessment offered: Once a year, summer semester Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
90 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module appears in</b>		
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Physics (2020)		
Bachelor's with 1 major Quantum Technology (2021)	JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	page 140 / 179

Bachelor' degree (1 major) Nanostructure Technology (2020)  
Bachelor' degree (1 major) Quantum Technology (2021)  
exchange program Physics (2023)

Module title		Abbreviation
Principles of Image Processing		11-EBV-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
3	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
Contents		
Introduction to image processing. Pictures as two-dimensional signals; digitalisation. Two-dimensional Fourier transform. Histogram equalisation (e.g. image brightening) and pixel connectivity (e.g. noise reduction). Automatic image recognition: Segmentation, classification. Technological image generation. Applications (e.g. motion tracking). Three-dimensional images.		
Intended learning outcomes		
The students have specific and advanced knowledge in the field of image processing. They know the principles and theory of signal processing for images and have corresponding knowledge of image generation. They are able to independently work with literature, they understand the characteristics of image processing with commercial software and are able to process images for the analysis of experiments with imaging measuring methods.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (2) Module taught in: German or English		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Assessment offered: Once a year, winter semester Language of assessment: German and/or English		
Allocation of places		
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Additional information		
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Workload		
90 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
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Module appears in		
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020)		
Bachelor's with 1 major Quantum Technology (2021)	JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	page 142 / 179

Bachelor' degree (1 major) Quantum Technology (2021)  
exchange program Physics (2023)

Module title		Abbreviation
Laboratory and Measurement Technology		11-LMT-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
Introduction to electronic and optical measuring methods of physical metrology, vacuum technology and cryogenics, cryogenics, light sources, spectroscopic methods and measured value acquisition.		
<b>Intended learning outcomes</b>		
The students have competencies in the field of electronic and optical measuring methods of physical metrology, vacuum technology and cryogenics, cryogenics, light sources, spectroscopic methods and measured value acquisition.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Assessment offered: Once a year, winter semester Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module appears in</b>		
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor's degree (1 major, 1 minor) Physics (Minor, 2015) Master's degree (1 major) Functional Materials (2016) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor's degree (1 major, 1 minor) Physics (Minor, 2020)		
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Bachelor' degree (1 major) Quantum Technology (2021)  
Master's degree (1 major) Functional Materials (2022)  
exchange program Physics (2023)

Module title		Abbreviation
Introduction to Labview		11-LVW-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	graduate	--
Contents		
<p>The module comprises basic and advanced courses. The basic course "NI LabVIEW Basic 1" is the first level of each LabVIEW learning phase. LabVIEW Basic provides a systematic introduction to the functions and application fields of the development environment of LabVIEW. The students become acquainted with dataflow programming and with common LabVIEW architectures. They learn to develop LabVIEW applications for various application fields, from assessment and measurement applications up to data collection, device control, data recording and measurement analysis. In the advanced course "NI LabVIEW Core 2", the students learn to develop comprehensive standalone applications, including the graphical development environment LabVIEW. The course builds upon LabVIEW Basic 1 and provides an introduction to the most common development technologies, in order to enable the students to successfully implement and distribute LabVIEW applications for different application fields. Course topics include techniques and procedures for the optimisation of application performance, e.g. through an optimised reuse of existing codes, usage of file I/O functions, principles of data management, event computing and methods of error handling. After finishing the course, the students have the ability to apply LabVIEW functions according to individual requirements, which enables a fast and productive application development.</p>		
Intended learning outcomes		
<p>The students have specific and advanced knowledge in the application field of LabVIEW. They know the principles of working with LabVIEW and are able to develop applications, e.g. for recording and analysing measuring data.</p>		
Courses (type, number of weekly contact hours, language — if other than German)		
<p>V (1) + R (3) Module taught in: German or English</p>		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
<p>written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Assessment offered: Once a year, winter semester Language of assessment: German and/or English</p>		
Allocation of places		
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Additional information		
--		
Workload		
180 h		

<b>Teaching cycle</b>
--
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)
--
<b>Module appears in</b>
<p>Bachelor' degree (1 major) Physics (2015)</p> <p>Bachelor' degree (1 major) Nanostructure Technology (2015)</p> <p>Bachelor' degree (1 major) Physics (2020)</p> <p>Bachelor' degree (1 major) Nanostructure Technology (2020)</p> <p>Bachelor' degree (1 major) Quantum Technology (2021)</p> <p>exchange program Physics (2023)</p>



Module title		Abbreviation
Electrochemical Energy Storage and Conversion		o8-FU-EEW-152-m01
Module coordinator		Module offered by
holder of the Chair of Chemical Technology of Material Synthesis		Chair of Chemical Technology of Material Synthesis
ECTS	Method of grading	Only after succ. compl. of module(s)
5	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
Contents		
Chemistry and application of: battery systems (aqueous and non-aqueous systems such as lead, nickel cadmium and nickel metal hydride, sodium sulphur, sodium nickel chloride, lithium ion accumulators), electrochemical double layer capacitors, redox-flow batteries, fuel cell systems (AFC, PEMFC, DMFC, PAFC, SOFC), solar cells (Si, CIS, CIGS, GaAs, organic and dye solar cell), thermoelectric devices.		
Intended learning outcomes		
Students have developed a knowledge of electrochemical energy storage and conversion and are able to apply that knowledge to research problems.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (2) + P (1) + E (1)		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
a) assessment and b) Vortestate/Nachtestate (pre and post-experiment examination talks approx. 15 minutes each, log approx. 5 to 10 pages each) and assessment of practical assignments (2 to 4 random examinations), weighted 7:3 Assessment offered: Once a year, summer semester Language of assessment: German and/or English		
Allocation of places		
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Additional information		
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Workload		
150 h		
Teaching cycle		
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Referred to in LPO I (examination regulations for teaching-degree programmes)		
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Module appears in		
Bachelor' degree (1 major) Nanostructure Technology (2015) Master's degree (1 major) Physics (2016) Master's degree (1 major) Nanostructure Technology (2016) Master's degree (1 major) Functional Materials (2016) Master's degree (1 major) Nanostructure Technology (2020) Master's degree (1 major) Physics (2020) Master's degree (1 major) Physics International (2020) Master's degree (1 major) Quantum Engineering (2020) Bachelor' degree (1 major) Nanostructure Technology (2020)		
Bachelor's with 1 major Quantum Technology (2021)	JMU Würzburg • generated 30-Mär-2024 • exam. reg. data record Bachelor (180 ECTS) Quantentechnologie - 2021	page 148 / 179

Bachelor' degree (1 major) Quantum Technology (2021)  
Master's degree (1 major) Quantum Technology (2021)

## Current Topics in Quantum Technology

( ECTS credits)

Module title		Abbreviation
Current Topics in Quantum Technology		11-BXN5-212-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
5	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
Current topics in experimental physics. Credited academic achievements, e.g. in case of change of university or study abroad.		
<b>Intended learning outcomes</b>		
The student possesses advanced knowledge meeting the requirements of a module in Nanosciences or Quantum Technology on Bachelor's level. He/She commands knowledge in a current field in Quantum Technology or Nanosciences and insight into the measuring and evaluation methods which are necessary to acquire this knowledge. He/She is able to classify and to link the learnt. He/She knows about fields of application.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (2) + R (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
Written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, 30 minutes per candidate) or report on practical course (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
Approval from examination committee required.		
<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module appears in</b>		
Bachelor' degree (1 major) Quantum Technology (2021)		
Module studies (Bachelor) Quantum Technology (2021)		

Module title		Abbreviation
Current Topics in Quantum Technology		11-BXN6-212-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
Current topics in experimental physics. Credited academic achievements, e.g. in case of change of university or study abroad.		
<b>Intended learning outcomes</b>		
The student possesses advanced knowledge meeting the requirements of a module in Nanosciences or Quantum Technology on Bachelor's level. He/She commands knowledge in a current field in Quantum Technology or Nanosciences and insight into the measuring and evaluation methods which are necessary to acquire this knowledge. He/She is able to classify and to link the learnt. He/She knows about fields of application.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
Written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, 30 minutes per candidate) or report on practical course (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
Approval from examination committee required.		
<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module appears in</b>		
Bachelor' degree (1 major) Quantum Technology (2021)		
Module studies (Bachelor) Quantum Technology (2021)		

Module title		Abbreviation
Current Topics in Quantum Technology		11-BXN8-212-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
8	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
Contents		
Current topics in experimental physics. Credited academic achievements, e.g. in case of change of university or study abroad.		
Intended learning outcomes		
The student possesses advanced knowledge meeting the requirements of a module in Nanosciences or Quantum Technology on Bachelor's level. He/She commands knowledge in a current field in Quantum Technology or Nanosciences and insight into the measuring and evaluation methods which are necessary to acquire this knowledge. He/She is able to classify and to link the learnt. He/She knows about fields of application.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (4) + R (2)		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
Written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, 30 minutes per candidate) or report on practical course (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English		
Allocation of places		
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Additional information		
Approval from examination committee required.		
Workload		
240 h		
Teaching cycle		
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Referred to in LPO I (examination regulations for teaching-degree programmes)		
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Module appears in		
Bachelor' degree (1 major) Quantum Technology (2021) Module studies (Bachelor) Quantum Technology (2021)		

Module title		Abbreviation
Current Topics in Physics		11-BXP8-152-m01
Module coordinator		Module offered by
chairperson of examination committee		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
8	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	Approval from examination committee required.
Contents		
Current topics of Experimental and Theoretical Physics. Accredited academic achievements, e.g. in case of change of university or study abroad.		
Intended learning outcomes		
The students have advanced competencies corresponding to the requirements of a module of Experimental or Theoretical Physics of the Bachelor's programme of Nanostructure Technology. They have knowledge of a current subdiscipline of Physics and understand the measuring and/or calculation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (4) + R (2)		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English		
Allocation of places		
--		
Additional information		
--		
Workload		
240 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
--		
Module appears in		
Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor's degree (1 major, 1 minor) Physics (Minor, 2015) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor's degree (1 major, 1 minor) Physics (Minor, 2020) Bachelor' degree (1 major) Quantum Technology (2021) Module studies (Bachelor) Quantum Technology (2021)		

Module title		Abbreviation
Current Topics in Physics		11-BXP6-152-m01
Module coordinator		Module offered by
chairperson of examination committee		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	Approval from examination committee required.
Contents		
Current topics of Experimental and Theoretical Physics. Accredited academic achievements, e.g. in case of change of university or study abroad.		
Intended learning outcomes		
The students have advanced competencies corresponding to the requirements of a module of Experimental or Theoretical Physics of the Bachelor's programme of Nanostructure Technology. They have knowledge of a current subdiscipline of Physics and understand the measuring and/or calculation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English		
Allocation of places		
--		
Additional information		
--		
Workload		
180 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
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Module appears in		
Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor's degree (1 major, 1 minor) Physics (Minor, 2015) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor's degree (1 major, 1 minor) Physics (Minor, 2020) Bachelor' degree (1 major) Quantum Technology (2021) Module studies (Bachelor) Quantum Technology (2021)		



Module title		Abbreviation
Current Topics Physics		11-BXP5-152-m01
Module coordinator		Module offered by
chairperson of examination committee		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
5	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	Approval from examination committee required.
Contents		
Current topics of Experimental and Theoretical Physics. Accredited academic achievements, e.g. in case of change of university or study abroad.		
Intended learning outcomes		
The students have advanced competencies corresponding to the requirements of a module of Experimental or Theoretical Physics of the Bachelor's programme of Nanostructure Technology. They have knowledge of a current subdiscipline of Physics and understand the measuring and/or calculation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (2) + R (2)		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English		
Allocation of places		
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Additional information		
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Workload		
150 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
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Module appears in		
Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Quantum Technology (2021) Module studies (Bachelor) Quantum Technology (2021)		

Module title		Abbreviation
Selected Topics in Quantum Technology		11-CSN6-212-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
Current topics in experimental physics. Credited academic achievements, e.g. in case of change of university or study abroad.		
<b>Intended learning outcomes</b>		
The student possesses advanced knowledge meeting the requirements of a module in Nanosciences or Quantum Technology on Bachelor's level. He/She commands knowledge in a current field in Quantum Technology or Nanosciences and insight into the measuring and evaluation methods which are necessary to acquire this knowledge. He/She is able to classify and to link the learnt. He/She knows about fields of application.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
Written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, 30 minutes per candidate) or report on practical course (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
Approval from examination committee required.		
<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module appears in</b>		
Bachelor' degree (1 major) Quantum Technology (2021) Module studies (Bachelor) Quantum Technology (2021)		

Module title		Abbreviation
Selected Topics in Solid State Physics		11-CSF6-152-m01
Module coordinator		Module offered by
chairperson of examination committee		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	Approval from examination committee required.
Contents		
Selected topics of Solid-State Physics.		
Intended learning outcomes		
The students have basic knowledge of a specialist field of Solid-State Physics and understand the measuring and evaluation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English		
Allocation of places		
--		
Additional information		
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Workload		
180 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
--		
Module appears in		
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Module studies (Master) Physics (2019) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Quantum Technology (2021) Module studies (Master) Quantum Technology (2021)		

Module title		Abbreviation
Selected Topics in Energy and Material Science		11-CSEM6-152-m01
Module coordinator		Module offered by
chairperson of examination committee		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	Approval from examination committee required.
Contents		
Selected topics of energy and materials research.		
Intended learning outcomes		
The students have basic knowledge of energy and material research and understand the measuring and evaluation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English		
Allocation of places		
--		
Additional information		
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Workload		
180 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
--		
Module appears in		
Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Quantum Technology (2021) Module studies (Master) Quantum Technology (2021)		

Module title		Abbreviation
Novel Transport Phenomena		11-NTP-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
6	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
Contents		
Current research topics and applications of novel transport phenomena.		
Intended learning outcomes		
The students have knowledge of a current subdiscipline of nanostructure technology or nano sciences, especially in the field of novel transport phenomena, and understand the measuring and evaluation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English		
Allocation of places		
--		
Additional information		
--		
Workload		
180 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
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Module appears in		
Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Quantum Technology (2021)		

## Key Skills Area

(20 ECTS credits)

## General Key Skills

(5 ECTS credits)

In addition to the modules listed below, students may also take modules offered by JMU as part of the pool of general transferable skills (ASQ).

## General Key Skills (subject-specific)

( ECTS credits)



Module title		Abbreviation
<b>MINT Preparatory Course Mathematical Methods of Physics</b>		11-P-VKM-202-m01
Module coordinator		Module offered by
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
3	(not) successfully completed	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
Contents		
Mathematical basics and elementary calculus refreshing and extending knowledge from school, especially as an introduction and preparation for the modules of experimental and theoretical physics. 1. Basic geometry and algebra, 2. differential calculus and series, 3. integral calculus, 4. vectors – directional quantities, 5. coordinate systems, 6. complex numbers		
Intended learning outcomes		
Students are in command of knowledge of basic mathematics and possess skills in elementary calculus as required for the successful start into the studies of experimental and theoretical physics.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (1) + Ü (2) Module taught in: German or English		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
a) exercises (successful completion of approx. 50% of approx. 6 exercise sheets) or b) talk (approx. 15 minutes) Assessment offered: Once a year, winter semester		
Allocation of places		
--		
Additional information		
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Workload		
90 h		
Teaching cycle		
Teaching cycle: every year, winter semester		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
§ 22 II Nr. 1 h) § 22 II Nr. 2 f) § 22 II Nr. 3 f)		
Module appears in		
Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Mathematical Physics (2020) Bachelor's degree (1 major, 1 minor) Physics (Minor, 2020) First state examination for the teaching degree Grundschule Didactics in Physics (Primary School) (2020) First state examination for the teaching degree Grundschule Physics (2020) First state examination for the teaching degree Gymnasium Physics (2020) First state examination for the teaching degree Realschule Physics (2020) First state examination for the teaching degree Sonderpädagogik Didactics in Physics (Middle School) (2020)		
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First state examination for the teaching degree Mittelschule Didactics in Physics (Middle School) (2020)  
First state examination for the teaching degree Mittelschule Physics (2020)  
Bachelor' degree (1 major) Quantum Technology (2021)  
Bachelor' degree (1 major) Mathematical Physics (2024)

<b>Module title</b>		<b>Abbreviation</b>
<b>Fit for Industry</b>		11-FFI-202-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
3	(not) successfully completed	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	undergraduate	--
<b>Contents</b>		
Physicist at work. Activities in the industry and at the university. Orientation in the industrial environment. Product development. Possible salary. Project management. Marketing, corporate strategy and management. Leadership and Soft Skills		
<b>Intended learning outcomes</b>		
The students are aware of the requirements for a job in the industry and can make a decision based on their knowledge about their own professional future.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (1) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English Assessment offered: Once a year, summer semester		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
90 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module appears in</b>		
Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Quantum Technology (2021) exchange program Physics (2023)		

Module title		Abbreviation
Project Management in Practice		11-PMP-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
3	(not) successfully completed	--
Duration	Module level	Other prerequisites
1 semester	graduate	--
Contents		
Technical project management in practice, contents: Definitions, terms, cardinal errors in project management, project schedule, kick-off and stakeholder, teams and resources, milestones and planning, visualisation and reporting, conflicts, success factors, technical and economic controlling, target agreement, balanced score cards, solving exemplary cases		
Intended learning outcomes		
The students have knowledge of technical project management. They are familiar with different methods and success factors and are able to define, plan and successfully conduct a project.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (1) + R (1) Module taught in: German or English		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Assessment offered: In the semester in which the course is offered and in the subsequent semester Language of assessment: German and/or English		
Allocation of places		
--		
Additional information		
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Workload		
90 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
--		
Module appears in		
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Quantum Technology (2021)		

Module title		Abbreviation
<b>Biotechnology and Social Acceptance</b>		07-SQF-BGA-152-m01
Module coordinator		Module offered by
holder of the Chair of Plant Physiology and Biophysics		Faculty of Biology
ECTS	Method of grading	Only after succ. compl. of module(s)
3	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
Applications of green biotechnology; biological background, economic interests, ecological risks, social acceptability.		
<b>Intended learning outcomes</b>		
Students are able to discuss/evaluate society's views of biotechnology. They know how to conduct a literature search and are able to critically review scientific publications as well as issues raised by society. Students have enhanced their oral and written presentation skills and are able to use these to present the data they have collected.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (1) + S (2) Module taught in: German and/or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
term paper or preparing educational materials (approx. 5 to 10 pages) Language of assessment: German and/or English creditable for bonus		
<b>Allocation of places</b>		
<p>20 places.</p> <p>Should the number of applications exceed the number of available places, places will be allocated as follows: Students of the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits will be given preferential consideration. Should the module be used in other subjects, there will be two quotas: 95% of places will be allocated to students of the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits and 5% of places (a minimum of one place in total) will be allocated to students of the Bachelor's degree subject Biologie (Biology) with 60 ECTS credits and to students of the Bachelor's degree subjects Computational Mathematics and Mathematik (Mathematics), each with 180 ECTS credits, as part of the application-oriented subject Biology (as well as potentially to students of other 'importing' subjects). Should the number of places available in one quota exceed the number of applications, the remaining places will be allocated to applicants from the other quota. Should there be, within one module component, several courses with a restricted number of places, there will be a uniform regulation for the courses of one module component. In this case, places on all courses of a module component that are concerned will be allocated in the same procedure. In this procedure, applicants who already have successfully completed at least one other module component of the respective module will be given preferential consideration.</p> <p>A waiting list will be maintained and places re-allocated as they become available.</p> <p>Selection process group 1 (95%): Places will primarily be allocated according to the applicants' previous academic achievements. For this purpose, applicants will be ranked according to the number of ECTS credits they have achieved and their average grade of all assessments taken during their studies or of all module components in the subject of Biologie (Biology) (excluding Chemie (Chemistry), Physik (Physics), Mathematik (Mathematics)) at the time of application. This will be done as follows: First, applicants will be ranked, firstly, according to their average grade weighted according to the number of ECTS credits (qualitative ranking) and, secondly, according to their total number of ECTS credits achieved (quantitative ranking). The applicants' position in a third ranking will be calculated as the sum of these two rankings, and places will be allocated according to this third ranking.</p>		

Among applicants with the same ranking, places will be allocated according to the qualitative ranking or otherwise by lot.

Selection process group 2 (5%): Places will be allocated according to the following quotas: Quota 1 (50 % of places): total number of ECTS credits already achieved in modules/module components of the Faculty of Biology; among applicants with the same number of ECTS credits achieved, places will be allocated by lot. Quota 2 (25 % of places): number of subject semesters of the respective applicant; among applicants with the same number of subject semesters, places will be allocated by lot. Quota 3 (25 % of places): lottery.

Should the module be used only in the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits, places will be allocated according to the selection process of group 1.

#### Additional information

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#### Workload

90 h

#### Teaching cycle

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#### Referred to in LPO I (examination regulations for teaching-degree programmes)

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#### Module appears in

Bachelor' degree (1 major) Biology (2015)  
Bachelor' degree (1 major) Nanostructure Technology (2015)  
Bachelor' degree (1 major) Nanostructure Technology (2020)  
Bachelor' degree (1 major) Quantum Technology (2021)

Module title		Abbreviation
General Competences for Students of Quantum Technology		11-NASQ5-212-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
5	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
Contents		
General Qualifications for students in Quantum Technology.		
Intended learning outcomes		
The students have general competencies corresponding to the requirements of a module in Quantum Technology of the Bachelor's programme. They have knowledge of a current subdiscipline of quantum technology and the required understanding of this topic. They are able to classify the subject-specific contexts and know the application areas.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (2) + R (2)		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
Written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, 30 minutes per candidate) or report on practical course (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English		
Allocation of places		
--		
Additional information		
Approval from examination committee required.		
Workload		
150 h		
Teaching cycle		
--		
Referred to in LPO I (examination regulations for teaching-degree programmes)		
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Module appears in		
Bachelor' degree (1 major) Quantum Technology (2021)		

## Subject-specific Key Skills

(15 ECTS credits)



Module title			Abbreviation
Mathematical Methods of Physics			11-M-MR-202-m01
Module coordinator		Module offered by	
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy	
ECTS	Method of grading	Only after succ. compl. of module(s)	
6	(not) successfully completed	--	
Duration	Module level	Other prerequisites	
2 semester	undergraduate	--	
Contents			
German contents available but not translated yet.			
Grundlagen der Mathematik und elementare Rechenmethoden jenseits des Schulstoffes, insbesondere zur Einführung und Vorbereitung auf die Module der Theoretischen Physik und der Klassischen bzw. Experimentellen Physik			
Intended learning outcomes			
German intended learning outcomes available but not translated yet.			
Der/Die Studierende verfügt über die Kenntnisse der Grundlagen der Mathematik und der elementaren Rechen-techniken, welche in der Theoretischen Physik und der Experimentellen Physik benötigt werden.			
Courses (type, number of weekly contact hours, language — if other than German)			
V (2) + Ü (2) + V (2) + Ü (2) Module taught in: German or English			
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)			
Exercises (successful completion of approx. 50% of approx. 13 exercise sheets) or Talk (approx. 15 minutes)			
Allocation of places			
--			
Additional information			
--			
Workload			
180 h			
Teaching cycle			
--			
Referred to in LPO I (examination regulations for teaching-degree programmes)			
§ 53 I Nr. 1 a) § 77 I Nr. 1 a)			
Module appears in			
Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Mathematical Physics (2020) Bachelor's degree (1 major, 1 minor) Physics (Minor, 2020) First state examination for the teaching degree Grundschule Physics (2020) First state examination for the teaching degree Gymnasium Physics (2020) First state examination for the teaching degree Realschule Physics (2020) First state examination for the teaching degree Mittelschule Physics (2020)			
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Bachelor' degree (1 major) Quantum Technology (2021)  
exchange program Physics (2023)  
Bachelor' degree (1 major) Mathematical Physics (2024)

Module title		Abbreviation
Seminar Quantum Technology		11-N-HS-212-m01
Module coordinator		Module offered by
Managing Directors of the Institute of Applied Physics and the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
5	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	Admission prerequisite to assessment: regular attendance (minimum 85% of sessions).
<b>Contents</b>		
Current questions on advanced topics of quantum technology.		
<b>Intended learning outcomes</b>		
The students have in-depth knowledge of a specialist field of advanced quantum technology. They are able to independently acquire this knowledge and to summarise it in an oral presentation		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
S (2) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
a) talk (30 to 45 minutes) with discussion and b) written examination (approx. 120 minutes) Language of assessment: German and/or English		
<b>Allocation of places</b>		
--		
<b>Additional information</b>		
Registration: If a student registers for the exercises and obtains the qualification for admission to assessment, this will be considered a declaration of will to seek admission to assessment pursuant to Section 20 Subsection 3 Sentence 4 ASPO (general academic and examination regulations). If the module coordinators subsequently find that the student has obtained the qualification for admission to assessment, they will put the student's registration for assessment into effect. Only those students that meet the respective prerequisites can successfully register for an assessment. Students who did not register for an assessment or whose registration for an assessment was not put into effect will not be admitted to the respective assessment. If a student takes an assessment to which he/she has not been admitted, the grade achieved in this assessment will not be considered.		
<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module appears in</b>		
Bachelor' degree (1 major) Quantum Technology (2021) exchange program Physics (2023)		

Module title		Abbreviation
Data and Error Analysis		11-P-FR1-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
2	(not) successfully completed	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	Admission prerequisite to assessment: completion of exercises (approx. 13 exercise sheets per semester). Students who successfully completed approx. 50% of exercises will qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the semester.
Contents		
Types of errors, error approximation and propagation, graphic representations, linear regression, mean values and standard deviation.		
Intended learning outcomes		
The students are able to evaluate measuring results on the basis of error propagation and of the principles of statistics and to draw, present and discuss the conclusions.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (1) + Ü (1) Module taught in: Ü: German or English		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
written examination (approx. 120 minutes) Language of assessment: German and/or English		
Allocation of places		
--		
Additional information		
Registration: If a student registers for the exercises and obtains the qualification for admission to assessment, this will be considered a declaration of will to seek admission to assessment pursuant to Section 20 Subsection 3 Sentence 4 ASPO (general academic and examination regulations). If the module coordinators subsequently find that the student has obtained the qualification for admission to assessment, they will put the student's registration for assessment into effect. Only those students that meet the respective prerequisites can successfully register for an assessment. Students who did not register for an assessment or whose registration for an assessment was not put into effect will not be admitted to the respective assessment. If a student takes an assessment to which he/she has not been admitted, the grade achieved in this assessment will not be considered.		
Workload		
60 h		
Teaching cycle		
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Referred to in LPO I (examination regulations for teaching-degree programmes)		
§ 53 I Nr. 1 c) § 77 I Nr. 1 d)		
Module appears in		
Bachelor' degree (1 major) Mathematics (2015) Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015)		
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Bachelor' degree (1 major) Mathematical Physics (2015)  
 Bachelor' degree (1 major) Computational Mathematics (2015)  
 Bachelor' degree (1 major) Aerospace Computer Science (2015)  
 Bachelor' degree (1 major) Functional Materials (2015)  
 Bachelor's degree (1 major, 1 minor) Physics (Minor, 2015)  
 First state examination for the teaching degree Grundschule Physics (2015)  
 First state examination for the teaching degree Realschule Physics (2015)  
 First state examination for the teaching degree Gymnasium Physics (2015)  
 First state examination for the teaching degree Mittelschule Physics (2015)  
 Bachelor' degree (1 major) Mathematical Physics (2016)  
 Bachelor' degree (1 major) Aerospace Computer Science (2017)  
 First state examination for the teaching degree Grundschule Physics (2018)  
 First state examination for the teaching degree Realschule Physics (2018)  
 First state examination for the teaching degree Gymnasium Physics (2018)  
 First state examination for the teaching degree Mittelschule Physics (2018)  
 Bachelor' degree (1 major) Physics (2020)  
 Bachelor' degree (1 major) Nanostructure Technology (2020)  
 Bachelor' degree (1 major) Mathematical Physics (2020)  
 Bachelor's degree (1 major, 1 minor) Physics (Minor, 2020)  
 Bachelor' degree (1 major) Aerospace Computer Science (2020)  
 First state examination for the teaching degree Grundschule Physics (2020)  
 First state examination for the teaching degree Gymnasium Physics (2020)  
 First state examination for the teaching degree Realschule Physics (2020)  
 First state examination for the teaching degree Mittelschule Physics (2020)  
 Bachelor' degree (1 major) Functional Materials (2021)  
 Bachelor' degree (1 major) Quantum Technology (2021)  
 Bachelor' degree (1 major) Mathematics (2023)  
 exchange program Physics (2023)  
 Bachelor' degree (1 major) Mathematical Physics (2024)

Module title		Abbreviation
Advanced and Computational Data Analysis		11-P-FR2-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
2	(not) successfully completed	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	Students are highly recommended to complete module 11-P-FR1 prior to completing module 11-P-FR2.
Contents		
Advanced methods of data analysis and error calculation. Distribution function, significance tests, modelling. Computerised data analysis.		
Intended learning outcomes		
The students have advanced knowledge of the analysis of measuring data and error calculation. They have mastered methods of computerised data analysis are able to apply them to self-obtained measuring data and to discuss the results.		
Courses (type, number of weekly contact hours, language — if other than German)		
V (1) + Ü (1)		
Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
Exercises (successful completion of approx. 50% of approx. 10 exercise sheets) Assessment offered: Once a year, summer semester		
Allocation of places		
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Additional information		
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Workload		
60 h		
Teaching cycle		
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Referred to in LPO I (examination regulations for teaching-degree programmes)		
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Module appears in		
Bachelor' degree (1 major) Physics (2015) Bachelor' degree (1 major) Nanostructure Technology (2015) Bachelor' degree (1 major) Mathematical Physics (2015) Bachelor' degree (1 major) Mathematical Physics (2016) Bachelor' degree (1 major) Physics (2020) Bachelor' degree (1 major) Nanostructure Technology (2020) Bachelor' degree (1 major) Mathematical Physics (2020) Bachelor' degree (1 major) Functional Materials (2021) Bachelor' degree (1 major) Quantum Technology (2021) exchange program Physics (2023) Bachelor' degree (1 major) Mathematical Physics (2024)		

# Thesis

(10 ECTS credits)

Module title		Abbreviation
Bachelor Thesis Quantum Technology		11-BA-N-212-m01
Module coordinator		Module offered by
chairperson of examination committee		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
10	numerical grade	--
Duration	Module level	Other prerequisites
1 semester	undergraduate	--
<b>Contents</b>		
Mostly independent processing of an experimental, theoretical or engineering task in the field of nanostructure technology, especially according to known procedures and scientific aspects; writing of the Bachelor's thesis.		
<b>Intended learning outcomes</b>		
The students are able to independently work on an experimental, theoretical and engineering task from nanostructure technology under the guidance of a supervisor, especially in accordance with known methods and scientific aspects and to summarise their results in a final paper.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
No courses assigned to module		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)		
Bachelor's thesis (approx. 25 pages) Language of assessment: German or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
Time to complete: 12 weeks		
<b>Workload</b>		
300 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module appears in</b>		
Bachelor' degree (1 major) Quantum Technology (2021)		