OFFICIAL TRANSLATION OF

Fachspezifische Bestimmungen für den Studiengang Physics (M.Sc.) vom 5. Dezember 2018 (Amtliche Bekanntmachung Nr. 9 vom 06. Februar 2019)

THIS TRANSLATION IS FOR INFORMATION ONLY – ONLY THE GERMAN VERSION SHALL BE LEGALLY VALID AND ENFORCEABLE!

Subject-Specific Provisions for the Master of Science in Physics

dated 5 December 2018

On 9 January 2019, in accordance with Section 108 subsection 1 of the Hamburg higher education act (Hamburgisches Hochschulgesetz, HmbHG), dated 18 July 2001 (HmbGVBl. p. 171) as amended 18 May 2018 (HmbGVBI. p. 145, 154), the Executive University Board of Universität Hamburg ratified the subject-specific provisions (FSBs) for the Master of Science in Physics adopted by the Faculty of Mathematics, Informatics and Natural Sciences pursuant to Section 91 subsection 2 number 1 HmbHG.

Preamble

These subject-specific provisions supplement the Examination Regulations of the Faculty of Mathematics, Informatics and Natural Sciences dated 11 April 2012 and 4 July 2012, as amended, which govern the master of science (MSc) degree programs and provide a description of the modules for physics as a subject.

I. Supplemental provisions

Section 1
Program and examination objectives, academic degree, and implementation of the degree program

Section 1 subsection 1:

(1) The English-language Master of Science in Physics has a research-oriented profile.

(2) The master's degree program constitutes a further professional qualification enabling in-depth, research-related training in the physics degree program.

(3) Students are able to contemplate complex issues and address them using scientific methods, even beyond the current state of knowledge.

(4) The program provides the subject-specific methods required for the challenges of a changing professional world and interdisciplinary applications and also expands on skills and knowledge that enable students to work scientifically, apply and critically evaluate scientific knowledge, and act responsibly

(5) The Master of Science in Physics qualifies students to enroll in doctoral studies. The doctoral degree regulations provide further detailed information.
The degree program focuses predominantly on

a) specialized knowledge oriented to current research questions based on in-depth fundamental knowledge
b) methodological and analytical skills that lead to independent expansion of scientific knowledge centered on research methods
c) imparting in-depth expertise and scholarly knowledge that enables analysis and resolution of problems of basic research, applied research, and technology previously not addressed
d) enabling students to work independently with a problem-oriented, interdisciplinary, and responsible approach to solving problems from current research in physics and to conclusively present the results
e) professionally relevant key qualifications.

Section 4
Program and examination structure, modules, and ECTS credits

Section 4 subsections 2 and 3:
(1) The master's degree program is divided into two segments: a one-year advanced specialist learning phase and a one-year research phase.
The one-year specialist learning phase provides the advanced knowledge required for independent work in the field of physics. It consists of advanced modules (= required elective modules) made up of the following five advanced areas:

- accelerator and elementary particle physics
- nanostructure and solid state physics
- laser physics and photon science
- astronomy and astrophysics
- biomedical physics

Modules amounting to a total of 48 ECTS credits must be successfully completed. In these, the following requirements must be met:

- At least 16 ECTS credits must be earned for advanced modules in at least one of the five advanced areas listed. A maximum of 32 ECTS credits may be gained for any individual advanced area.
- Of the 48 ECTS credits in the advanced area, at least eight ECTS credits must come from modules in experimental physics, and a further minimum of eight ECTS credits from theoretical physics.

For the elective area, a total of 12 ECTS credits may be selected, usually over two semesters, from the courses offered at Universität Hamburg. The individual modules should have a logical connection to each other.

The one-year research phase is made up of three modules and should be seen as a single, indivisible unit. The introductory and preparatory projects together make up 30 ECTS credits and are part of the third subject semester. The final subject semester consists of a master's thesis worth 30 ECTS credits. The student must complete the introductory and preparatory projects in the third semester prior to completing the master's thesis to acquire knowledge of current research and special methods from the master's thesis subject area. Students complete the six-month master's thesis in the fourth semester. The thesis should demonstrate that the student is able to work under supervision on a physics problem taken from the latest research and use scientific methods to consistently and comprehensively present and interpret the problem, the means of solving it, and the solution itself.

Students who have successfully completed at least 44 ECTS credits during the first year of study are eligible to commence the research phase and the introductory project. On commencing the research phase, the following must be documented: The Department of Physics academic office must be informed of the date, area of research, and supervising/assigning teacher.

The master's thesis must be supervised by a university teacher from the Department of Physics. They must consent to the supervision before the research phase begins. The research phase may be completed in a working group of the Department of Physics; within the University in the Faculty of Mathematics, Informatics and Natural Sciences or the Faculty of Medicine, depending on the area of specialization; or in nonuniversity research institutions, provided the predominant methodology is that of physics. In this case, the research phase may begin only when the examinations board approves the application and when a member of the University teaching staff declares their consent to providing a second assessment of the master's thesis pursuant to Section 14 subsection 9.

(2) Modules chosen as part of the physics advanced phase may not simultaneously be counted toward the elective area.

(3) Module descriptions are provided in Annex A to the Subject-Specific Provisions for the Master of Science in Physics—Table of Modules and the module handbook for the Master of Science in Physics, which expands upon these subject-specific provisions.

Section 5
Course types

Section 5 sentence 2:
Courses may take any form pursuant to Section 5 of the Revised Examination Regulations for Master of Science Degree Programs. Typically, the advanced phase is made up of a combination of lectures and group work, such as exercises and practical courses and internships, and the research phase is made up of projects and seminars.

Section 13
Completed coursework and module examinations

Section 13 subsection 6:
Examinations shall be held in English.

Section 14
Master's thesis

Section 14 subsection 1:
A colloquium consisting of a presentation in English and an academic discussion of the subject matter of the thesis as part of an academic seminar is a mandatory component of the final module. The presentation comprises one-sixth of the grade for the final module. The presentation should be given no later than six weeks after submission of the thesis. The presentation and discussion are assessed by both assessors or by one of the two thesis assessors in the presence of an invigilator. The invigilator must be a doctoral graduate or have an equivalent qualification or higher. The assessment of the thesis should occur promptly, no later than six weeks after submission.

Section 14 subsection 2 sentence 1:
Students who have earned at least 75 ECTS credits in total may be allowed to commence work on the final module, the master's thesis.

Section 14 subsection 4:
The master's thesis must be written in English.

Section 14 subsection 5 sentence 1:
The workload for the master's thesis equates to 30 ECTS credits. The master's thesis must be completed within six months.

Section 15
Evaluation of examinations

Section 15 subsection 3 sentence 5:
If a module is comprised of multiple course examinations, the grade for the module is calculated as the arithmetic mean of all the grades. Exceptions are listed in the module table.

Section 15 subsection 3 sentence 9:
The overall final grade for the master's degree program is comprised of the grade for the advanced phase (50%), the grade for the thesis (45%), and the grade for the elective (5%).
The grade for the advanced phase is calculated as a weighted average of the highest grades amounting to 48 ECTS credits.
The average of the two assessor's grades for the written thesis constitute five-sixths of the grade for the final module (master's thesis) with the grade awarded for the colloquium constituting the remaining one-sixth.
The grade for the elective area is calculated as a weighted average of the highest grades amounting to 12 ECTS credits.
The examinations from the introductory project and the preparatory project are ungraded and are not used to calculate the overall final grade.

Section 15 subsection 4:
The overall final grade "pass with distinction" is awarded if a grade of 1.0 is earned for the master's thesis and all relevant module examinations, with the exception of at most one, are graded 1.0. Given the lack of comparability, ungraded modules such as those graded as "passed" will not be counted toward the calculation of the overall final grade.

Section 24
Effective date

These subject-specific provisions (FSBs) become effective on the day following their official publication by Universität Hamburg. They shall first apply to students commencing their studies in the Winter Semester 2019/20.

Hamburg, 6 February 2019
Universität Hamburg

Module Information					Courses			Examinations			
Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type / Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
Required Module (60 ECTS credits)											
every semester	third	see section 4 of these subject-specific provisions	Req	PHY-MF-EP	**Introductory project**		15		Conclusion of the project	no	15
Intended learning results: Students are familiar with current academic literature and possess greater depth of knowledge in an area of current research from which the subject of the master's thesis should arise. Students are able to independently gather necessary information, establish background information, and grasp a specific topic.											
every semester	third	PHY-MF-EP passed	Req	PHY-MF-VP	**Preparatory project**		15	PCom	lecture/colloquium	no	15
Intended learning results: By completing the preparatory assignments, students have sufficient knowledge of the subject area and the specific experimental and/or theoretical methods involved to enable successful application to issues from which the topic of the master's thesis should arise. Planning and structuring of the intended research project											
every semester	fourth	see section 14 of these subject-specific provisions subsection 2 of these subject-specific provisions	Req	PHY-MF-MA	**Master's thesis**		30		master's thesis (five-sixths), colloquium (one-sixth)	yes	30

Module Information	Courses	Examinations

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
Intended learning results: Candidates are able to familiarize themselves with an issue taken from current research, apply appropriate scientific methods with increasing independence, and present the results in an academically appropriate form.													
Advanced specialization phase (48 ECTS credits)													
Astronomy and astrophysics													
1	annually, winter semester	first or second	none	RE	PHY-MV-A-E14	**Cosmology**				none	written examination or oral examination	yes	6
							Cosmology Exercises in cosmology	L, P C	3 1				
Intended learning results: Students are familiar with problem-solving strategies, analytical thinking and theory development in physics and are able to apply mathematical and information technology strategies.													
1	annually, in both winter and summer semesters	first or second	none	RE	PHY-MV-A-E15	**Seminar Topics in Low Frequency Radio Astronomy**				none	presentation with written paper	yes	3
							Seminar Topics in Low Frequency Radio Astronomy	S	2				
Intended learning results: In addition to an introduction in the academic discourse, students also gain insights into current research in low frequency radio astronomy.													

Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
1	annually, winter semester	first or second	none	RE	PHY-MV-A-E17	**Extragalactic astrophysics**				none	written examination or oral examination	yes	6
							Extragalactic astrophysics	L,	3				
							Exercises in extragalactic astrophysics	PC	1				

Intended learning results:
Students are familiar with problem-solving strategies, analytical thinking and theory development in physics and are able to apply mathematical and information technology strategies.

1	every semester	first or second	none	RE	PHY-MV-A-E19	**Extragalactic astrophysics seminar**				none	presentation with written paper	yes	3
							Extragalactic astrophysics seminar	S	2				

Intended learning results:
Students are able to understand the presentation of research results, read and understand specialist articles, assess astronomical data, and know about theory development in physics.

1	every two years, summer semester	first or second	none	RE	PHY-MV-A-E23	**Galaxy evolution**				none	written examination or oral examination	yes	7
							Galaxy evolution	L,	3				
							Exercises in galaxy evolution	PC	2				

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE). or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
Intended learning results: Students have insights into the development of the universe, linear and nonlinear growth of cosmic structures, the creation of elliptical and spiral galaxies, and observational techniques for observing galaxies.													
1	annually, summer semester	first or second	none	RE	PHY-MV-A-E24	**Seminar on galaxy evolution**				none	presentation with written paper	yes	3
							Seminar on galaxy evolution	S	2				
Intended learning results: Students can discuss academic publications on the subject of galaxy creation and development, using material chosen from both theoretical and data-driven papers.													
1	every two years, summer semester	first or second	none	RE	PHY-MV-A-E27	**Chemical Evolution of the Universe**				none	written examination or oral examination	yes	5
							Chemical Evolution of the Universe	L,	2				
							Exercises in Chemical Evolution of the Universe	P C	2				
Intended learning results: Students have insights into all astrophysical processes relevant to the chemical development of the cosmos.													
1	every two years, summer semester	first or second	none	RE	PHY-MV-A-T01	**Computational Astrophysics**				none	written examination	yes	6

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE). or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
							Computational Astrophysics	L,	3				
							Exercises in Computational Astrophysics	PC	1				
Intended learning results: Students are able to make targeted use of numerical procedures and critically assess the results of computer programs.													
1	every two years, winter semester	first or second	none	RE	PHY-MV-A-T02	**Stellar Structure & Evolution**				none	written examination or oral examination	yes	6
							Stellar Structure & Evolution	L,	3				
							Exercises in Stellar Structure & Evolution	PC	1				
Intended learning results: Students know the physical construction of stars and their development.													
1	every semester	first or second	very good knowledge of Fortran90 and MPI, proven fundamental knowledge of PHOENIX	RE	PHY-MV-A-T03	**Theory and Application of PHOENIX**				active participation	oral examination	yes	3

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE). or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
							Theory and Application of PHOENIX	L	2				
Intended learning results: Students have an enhanced understanding of PHOENIX (including the applied methods, algorithms, and program modules) and can apply PHOENIX to simulated astrophysical problems.													
1	every two years, winter semester	first or second	none	RE	PHY-MV-A-T04	**Stellar and Planetary Atmospheres**				none	written examination or oral examination	yes	6
							Stellar and Planetary Atmospheres Exercises in Stellar and Planetary Atmospheres	L, P C	3 1				
Intended learning results: Students understand the construction of stars and planetary atmospheres, radiative transfer, the numerical modeling of atmospheres, creation of spectra, and their critical interpretation.													
1	every semester	second or third	none	RE	PHY-MV-A-T06	**MHD Simulations with the FLASH Code**				successful participation in exercises	oral examination	yes	3
							MHD Simulations with the FLASH Code	L	2				
Intended learning results: Students know how to work with the FLASH simulation code and applications in the astrophysical field.													

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
1	every two years, winter semester	first or second	none	RE	PHY-MV-A-T10	**Interstellar Medium and Star Formation**				none	written examination or oral examination	yes	6
							Interstellar Medium and Star Formation Exercises in Interstellar Medium and Star Formation	L, P C	3 1				

Intended learning results:
Students possess fundamental knowledge of the interstellar medium (including the make-up, physical properties, and dynamics) and the creation of stars (including requirements, time scales, thermodynamics, development of protostars, and gas jets).
Students can apply hydrodynamic and magnetic-hydrodynamic equations.

1	every two years, summer semester	first or second	none	RE	PHY-MV-A-T6	**Introduction to General Relativity and Astrophysical Applications**				none	written examination	yes	8
							Exercises in Introduction to General Relativity and Astrophysical Applications	L PC	4 2				

Intended learning results:
Students have a fundamental understanding of the general theory of relativity, understand and can describe curved space in multiple dimensions, and have an understanding of astrophysical phenomena based on . . .

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
Accelerator and elementary particle physics													
1	annually, summer semester	first or second	none	RE	PHY-MV-BE-E02	**Accelerator Physics II**				none	written examination or oral examination	yes	5
							Accelerator Physics II	L, P	2				
							Exercises in Accelerator Physics II	C	2				
Intended learning results: Students understand important aspects of the planning and development of accelerator facilities: influencing the quality of the beam, methods for improving beam properties, limitation of attainable energy, luminosity and beam currents, creation of high-intensity and coherent X-rays.													
1	annually, winter semester	first or second	none	RE	PHY-MV-BE-E05	**Experimental astroparticle physics**				present ation	oral examinat ion	yes	8
							Experimental astroparticle physics	L, P	4				
							Exercises in experimental astroparticle physics	C	2				
Intended learning results: Students are able to contextualize specific experiments and their results. Students are also able to critically examine how to best interpret measurement results. Students are able to understand how a measurement or observation for a physics question in the field of astroparticle physics is derived.													
1	annually, winter semester	first or second	none	RE	PHY-MV-BE-E09	**Accelerator Physics I**				none	written examination or oral examination	yes	5
							Accelerator Physics I	L, P	2				
							Exercises in Accelerator Physics I	C	2				

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
Intended learning results: Students are familiar with the fundamentals of accelerator physics. Students are able to design the basic elements of a simple accelerator and calculate its key parameters.													
1	annually, summer semester	first or second	none	RE	PHY-MV-BE-T02	**Physics of the standard model**				none	written examination or oral examination	yes	6
							Physics of the standard model Exercises in physics of the standard model	L, P C	3 1				
Intended learning results: Students are prepared for research projects, such as a master's thesis, in theoretical particle physics with a focus on the standard model particle physics.													
1	annually, winter semester	first or second	none	RE	PHY-MV-BE-T03	**Introduction to Supersymmetry and Supergravity**				none	written examination or oral examination	yes	6
							Introduction to Supersymmetry and Supergravity Exercises in Introduction to Supersymmetry and Supergravity	L, P C	3 1				

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
Intended learning results: Students are prepared for a research project, such as a master's thesis or doctoral dissertation, in theoretical particle physics with a focus on supersymmetry and supergravity.													
1	annually, summer semester	first or second	none	RE	PHY-MV-BE-T11	**Introduction to String Theory**				none	written examination or oral examination	yes	5
							Introduction to String Theory Exercises in Introduction to String Theory	L, P C	2 2				
Intended learning results: Students are prepared for a research project, such as a master's thesis or doctoral dissertation, in string theory.													
1	annually, winter semester	first or second	none	RE	PHY-MV-BE-T12	**Phenomenology of Physics beyond the Standard Model**				none	written examination or oral examination	yes	6
							Phenomenology of Physics beyond the Standard Model Exercises in Phenomenology of Physics beyond the Standard Model	L, P C	3 1				
Intended learning results: Students are prepared for a research project, such as a master's thesis or doctoral dissertation, in theoretical particle physics with a focus on standard model particle physics.													

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
1	every two years, summer semester	first or second	none	RE	PHY-MV-BE-T22	**Quantum Chromodynamics (Advanced Topic in Particle Physics)**				none	written examination or oral examination	yes	3
							Quantum Chromodynamics (Advanced Topic in Particle Physics)	L	2				

Intended learning results:
Students are familiar with the key characteristics of quantum chromodynamics in quantum field theory, particularly the role of symmetries and quantum loops.
Students are also able to evaluate the challenges of quantitatively describing the processes for modern particle colliders, particularly the LHC.

1	every two years, summer semester	first or second	none	RE	PHY-MV-BE-T25	**Introduction to Conformal Field Theory**				none	written examination or oral examination	yes	4
							Introduction to Conformal Field Theory Exercises in Introduction to Conformal Field Theory	L, P C	2 1				

Intended learning results:
Students are prepared for a research project, such as a master's thesis or doctoral dissertation, in theoretical particle physics with a focus on conformal quantum field theory.

1	every two years, summer semester	first or second	none	RE	PHY-MV-BE-T29	**Computer Algebra and Particle Physics**				none	written examination or oral examination	yes	6
							Computer Algebra and Particle Physics Exercises in Computer Algebra and Particle Physics	L, P C	3 1				

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
Intended learning results: Students have fundamental knowledge of algorithms relevant to theoretical particle physics and experience using computer algorithm systems.													
Biomedical physics													
1	annually, winter semester	first or second	none	RE	PHY-MV-BP-E01	**Biomedical Physics I**				none	written examination or oral examination	yes	5
							Biomedical Physics I	L,	2				
							Journal Club	PC	2				
Intended learning results: Students are familiar with current medical imaging (PET, SPECT, MRI, CT, multimodal) and basic radiotherapy techniques.													
1	annually, summer semester	first or second	none	RE	PHY-MV-BP-E02	**Biomedical Physics II**				none	written examination or oral examination	yes	5
							Biomedical Physics II	L,	2				
							Journal Club	PC	2				
Intended learning results: Students are familiar with structures of macromolecules, cells, and tissues, as well as with key factors of cellular and extracellular biochemistry as they relate to disease, including cancer.													

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
1	annually, winter semester	first or second	none	RE	PHY-MV-BP-E03	**Biomedical Physics III**				none	oral examination	yes	3
							Biomedical Physics III	L	2				

Intended learning results:
Students are familiar with the fundamentals of radiative transfer and its application in radiation therapy and radiation safety. Students also have insight into the role of medical imaging in radiation therapy.

1	annually, summer semester	first or second	none	RE	PHY-MV-BP-E04	**Biomedical Physics IV**				none	oral examination	yes	3
							Biomedical Physics IV	L	2				

Intended learning results:
Students are familiar with the fundamentals of the physics of radiation therapy. Students also have an overview of the physical and biological optimization of a radiation plan in the application of a range of radiation techniques and treatment plans for some types of tumors.

1	annually, winter semester	first or second	none	RE	PHY-MV-BP-E05	**Seminar on Biomedical Physics I**				none	presentation with written paper	yes	3
							Seminar on Biomedical Physics I	S	2				

Intended learning results:
Students are familiar with current medical imaging (PET, SPECT, MRI, CT, multimodal) and fundamental techniques of radiotherapy.

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
Nanostructure and solid state physics													
1	annually, summer semester	first or second	none	RE	PHY-MV-FN-E01	**Advanced Solid State Lecture**				none	written examination or oral examination	yes	8
							Advanced Solid State Lecture	L,	4				
							Exercises in Advanced Solid State Lecture	PC	2				
Intended learning results: Students have in-depth knowledge of the latest scientific research in solid state and nanostructure physics. They also possess sufficient in-depth expertise to conduct an experimental master's thesis in the field of solid state and nanostructure physics.													
1	annually, winter semester	first or second	none	RE	PHY-MV-FN-E02	**Nanostructure Physics I**				none	written examination or oral examination	yes	8
							Nanostructure Physics I	L,	4				
							Exercises in Nanostructure Physics I	PC	2				
Intended learning results: Students are able to summarize the main findings on the synthesis of and research into semiconductor nanostructures and devices.													
1	annually, summer semester	first or second	none	RE	PHY-MV-FN-E12	**Advanced Methods for Surface and Nanostructure Characterization**				none	written examination or oral examination	yes	5

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
							Advanced Methods for Surface and Nanostructure Characterization	L	2				
							Exercises in Advanced Methods for Surface and Nanostructure Characterization	PC	2				

Intended learning results:
Students understand a range of methods for the structural and chemical characterization of nanostructures and surfaces. Students are able to make sound decisions when selecting methods for the chemical and structural characterization of nanostructures and surfaces. Students know how use X-ray and electron diffraction methods to characterize the atomic structure of surfaces and nanostructures.

1	annually, winter semester	first or second	none	RE	PHY-MV-FN-E18	**Bio-nano Interfaces**				none	written examination or oral examination	yes	3
							Bio-nano Interfaces	L	2				

Intended learning results:
Students have an overview of the main biophysical interface processes and have fundamental and interdisciplinary knowledge for further lectures and final theses in this interdisciplinary field. After successful completion of the module, students know how cells transmit electronic signals, how ion channels and nanopores work, and what influence interfaces have on protein conformation.

1	annually, summer semester	first or second	none	RE	PHY-MV-FN-E23	**X-Ray Analytics and Microscopy in Nanoscience**				none	term paper	yes	3
							X-Ray Analytics and Microscopy in Nanoscience	L	2				

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
Intended learning results: Students are able to summarize the main current X-ray analysis and X-ray microscopic methods for the examination of functional nanomaterials.													
1	annually, winter semester	first or second	none	RE	PHY-MV-FN-E33	**Modern Scattering Methods in Nanomaterial Science**				none	presentation with written paper	yes	5
							Modern Scattering Methods in Nanomaterial Science Sample Preparations and Synchrotron Experiments, Data Analysis	L P P C	1 2 2				
Intended learning results: Students know the theoretical background behind and have practical experience with synchrotron radiation X-ray diffraction techniques used for characterizing nanoparticles.													
1	annually, summer semester	first or second	none	RE	PHY-MV-FN-E34	**Methods in nanobiotechnology II**				none	presentation (50%) and oral examination (50%)	yes	7
							Methods in Nanobiotechnology II Exercises in methods in nanobiotechnology II Practical: Methods in nanobiotechnology II	L, P C , P	2 2 2				
Intended learning results: Students know the modern methods and elements of nanobiotechnology and are prepared for scientific work in this subject.													

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
1	annually, summer semester	first or second	none	RE	PHY-MV-FN-E35	**Fundamentals of Photovoltaics**				none	written paper	yes	3
							Fundamental Photovoltaics	L	2				
Intended learning results: Students know the concept of photovoltaic energy generation and are prepared for scientific work in this subject.													
1	annually, summer semester	first or second	none	RE	PHY-MV-FN-E36	**Complex Materials**				PCom	presentation with written paper	yes	6
							Complex Materials Project	L PCom	3 2				
Intended learning results: Students know the theoretical background and have practical experience with complex materials.													
1	annually, winter semester	first or second	none	RE	PHY-MV-FN-E39	**Methods in Nanobiotechnology I**				none	presentation (50%) and oral examination (50%)	yes	7
							Methods in Nanobiotechnology I Exercises in Methods in Nanobiotechnology I Practical: Methods in Nanobiotechnology I	L, P C , P	2 2 2				
Intended learning results: Students are familiar with the modern methods and elements of nanobiotechnology and are prepared for scientific work in this subject.													

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
1	every two years, summer semester	first or second	none	RE	PHY-MV-FN-T13	**Nonequilibrium Statistics and Transport Theory**				none	written examination or oral examination	yes	8
							Nonequilibrium Statistics and Transport Theory	L, P	4 2				
							Exercises in Nonequilibrium Statistics and Transport Theory	C					

Intended learning results:
Students know the modern concepts of the quantum statistics of nonequilibrium systems and quantum transport theory and are prepared for scientific work in this field.

1	every semester	first or second	none	RE	PHY-MV-FN-T17	**Seminar on Selected Topics of the Quantum Theory of Condensed Matter**				none	presentation with written paper	yes	3
							Seminar on Selected Topics of the Quantum Theory of Condensed Matter	S	2				

Intended learning results:
Students have insight into modern subjects and methods in the theory of condensed matter. Students know how to combine knowledge from contemporary scientific publications and to reproduce a scientific presentation. Students have in-depth knowledge of a selected current issue in the theory of condensed material and can actively participate in scientific discussions.

1	every semester	first or second	none	RE	PHY-MV-FN-T18	**Seminar on Many-Body Theory and Quantum-Statistical Methods**				none	presentation with written paper	yes	3
							Seminar on Many-Body Theory and Quantum-Statistical Methods	S	2				

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
Intended learning results: Students are able to discuss current physics problems in the field of many-body theory and quantum-statistical methods and to develop and present a specialized topic.													
1	every semester	first or second	none	RE	PHY-MV-FN-T19	**Seminar on Quantum Dynamics of Nonequilibrium Nano-Systems**				none	presentation with written paper	yes	3
							Seminar on Quantum Dynamics of Nonequilibrium NanoSystems	S	2				
Intended learning results: Students know the modern concepts in the field of quantum statistics of nonequilibrium systems and quantum transport theory and are prepared for scientific work in this field.													
1	every two years, summer semester	first or second	none	RE	PHY-MV-FN-T24	**Quantum Statistics with Path Integrals**				none	written examination or oral examination	yes	8
							Quantum Statistics with Path Integrals Exercises in Quantum Statistics with Path Integrals	L, P C	4 2				
Intended learning results: Students know current methods in the field of path integrals for quantum many-body systems and are prepared to conduct scientific work in the field.													
1	every two years, summer semester	first or second	none	RE	PHY-MV-FN-T25	**Symmetry Groups in Physics**				none	written examination or oral examination	yes	8

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
							Symmetry Groups in Physics Exercises in Symmetry Groups in Physics	L, P C	4 2				
Intended learning results: Students know the fundamental tools of group theory and can apply group theory concepts to basic topics of theoretical physics.													
1	annually, summer semester	first or second	none	RE	PHY-MV-FN-T28	**Condensed Matter Theory: Special Topics**				none	written examination or oral examination	yes	8
							Condensed Matter Theory: Special Topics Exercises in Condensed Matter Theory: Special Topics	L, P C	4 2				
Intended learning results: Students have insight into recent issues and experience in dealing with specialized methods for the theory of condensed matter in the context of current research.													
Laser physics and photon science													
1	annually, winter semester	first or second	none	RE	PHY-MV-LP-E11	**Ultrafast Optical Physics I**				none	oral examination	yes	5
							Ultrafast Optical Physics I Exercises in Ultrafast Optical Physics I	L, P C	2 2				
Intended learning results: Students possess a fundamental knowledge of the description of ultrashort optical pulses, their generation, manipulation, diagnostics, and application in modern nonlinear optics and optical spectroscopy processes.													

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
1	annually, winter semester	first or second	none	RE	PHY-MV-LP-E16	**Modern Molecular Physics**				none	written examination or oral examination	yes	4
							Modern Molecular Physics	L,	2				
							Exercises in Modern Molecular Physics	PC	1				

Intended learning results:
Students are familiar with the fundamental concepts of modern experiments in molecular physics. Students have a detailed understanding of atoms and molecules and their interactions with external fields and other particles as well as an understanding of experimental concepts in molecular physics.

1	annually, summer semester	first or second	none	RE	PHY-MV-LP-E21	**Ultrafast Optical Physics II**				none	written examination or oral examination	yes	6
							Ultrafast Optical Physics II	L,	3				
							Exercises in Ultrafast Optical Physics II	PC	1				

Intended learning results:
Students have advanced knowledge in the field of ultrashort pulse generation, amplification, and manipulation and their application to spectroscopy, meteorology, and attosecond sciences. Students are able to quantitatively model and analyze ultrashort laser pulse oscillators and amplifiers as well as pulse propagation in linear and nonlinear media.

1	annually, summer semester	first or second	none	RE	PHY-MV-LP-E22	**Light-Matter Interactions: Atoms, Molecules & (Non)Linear Optics**				none	written examination or oral examination	yes	4

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
							Light-Matter Interactions: Atoms, Molecules & (Non)Linear Optics	L	2				
							Exercises in Light-Matter Interactions: Atoms, Molecules & (Non)Linear Optics	PC	1				
Intended learning results: Students are familiar with beam lifetimes, linewidths, polarization, and methods for their measurement (spectrometer, detectors, TCSPC, etc.) and have an understanding of various broadening mechanisms (pressure, Doppler, duration, etc.)													
1	annually, winter semester	first or second	none	RE	PHY-MV-LP-E27	**Nonlinear Optics**				none	written examination or oral examination	yes	6
							Nonlinear Optics	L, P C	3 1				
							Exercises in Nonlinear Optics						
Intended learning results: Students are familiar with the most important nonlinear optical processes. Students are able to simulate and design frequency conversion units, ultrafast parametric optical amplifiers, and measuring techniques based on nonlinear optical processes.													
1	annually, summer semester	first or second	none	RE	PHY-MV-LP-E29	**New Experiments with XFEL Sources**				none	written examination or oral examination	yes	4
							New Experiments with XFEL Sources	L, P C	2 1				
							Exercises in New Experiments with XFEL Sources						

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
Intended learning results: Students are able to better understand XFEL publications and develop their own ideas for conducting XFEL experiments.													
1	every semester	first or second	none	RE	PHY-MV-LP-T02	**Seminar: Many-Body Theory of Ultracold Atoms and Solid State Systems**				none	presentation with written paper	yes	3
							Seminar: Many-Body Theory of Ultracold Atoms and Solid State Systems	S	2				
Intended learning results: Students have the expertise to present a lecture on a topic in modern atomic physics, solid-state physics, or quantum optics.													
	every two years, summer semester	first or second	none	RE	PHY-MV-LP-T03	**Theory of Photon-Matter Interactions**				none	written examination (60%) and written paper (40%)	yes	8
							Theory of Photon-Matter Interactions	L, P	2				
							Exercises in Theory of Photon-Matter Interactions	C, S	2				
							Seminar on Theory of Photon-Matter Interactions		2				

Module Information						Courses				Examinations			
Duration in Semesters	Frequency	Recommended Semester	Module Prerequisites	Module Type: Required (Req), Required Elective (RE), or Elective (E)	Module Number/Code	Module	Course Title	Course Type	Cr. Hrs. per Week	Examination Prerequisites [1]	Type of Examination	Graded	ECTS Credits
Intended learning results: Students can develop a precise quantum mechanical description for photon-matter interactions relevant to practical situations. Students have a conceptual and quantitative understanding of experiments focusing on the behavior of electrons in electromagnetic fields. This includes experiments with optical lasers as well as with X-ray sources.													
Elective area (12 ECTS credits)													
1	every semester	first or second		E		**Elective area**					Final Module Examination	yes	12
								L, PC, S or laboratory course					
Intended learning results: There are no restrictions on the choice of subject. Students should follow their inclinations and interests. Students have basic insights into a subject area of their choice and interdisciplinary collaboration skills.													

[1] PCC: practical course completion; LCC: laboratory course completion; SC: seminar completion; PW project work