Study regulations for the Master's Programme in Physics

Preamble

On the basis of Section 14 paragraph 1 no. 2 of the Partial University Constitution (Trial version) of the Freie Universität Berlin of 27 October 1998 (FU Mitteilung [Gazette of the Freie Universität Berlin] 24/1998), the Faculty Council of the Faculty of Physics of the Freie Universität Berlin issued the following study regulations for the Master's Programme in Physics on 31 March and 4 May 2009:

Contents

Section 1 Area of application

These regulations apply to the aims, content and structure of the Master's programme in physics at the Freie Universität Berlin on the basis of the examination regulations of 31 March and 4 May 2009. The programme is consecutively organised and research-focused.

Section 2 Programme aims

The Master's programme in physics builds on the Bachelor programme in physics. It aims to deepen the students' knowledge of the subject itself and of the scientific methods used in physics. Related subjects are also covered, depending on the student's choice of elective courses. The programme aims to deepen and specialise the student's knowledge and skills in physics and to train students to perform independent scientific research. Graduates of the programme are generalists in the natural sciences and have acquired in particular the ability to deal successfully with issues in a wide range of scientific and technological fields. The potential professional field for graduates covers a wide area, ranging from fundamental or industrial research, application-oriented development and technical marketing to planning, testing and management positions in industry and administration. The Master's degree qualifies graduates to enter doctoral programmes, particularly in the natural sciences and technological fields.

Section 3 Plan and structure

(1) The Master's programme in physics comprises a coursework phase and a research phase. The coursework phase is designed to deepen and broaden the student's knowledge of physics and related subjects, depending on the student's choice of electives and to ensure they are familiar with the state of current research. The final year is designed as a continuous research phase in which students learn to carry out independent scientific work in a specialised field of physics and to access new topics. This phase also includes writing a Master's thesis.

(2) The coursework phase comprises

1. Compulsory modules
2. Compulsory electives
3. Electives

(3) The compulsory modules teach advanced fundamental principles of modern experimental and theoretical physics. The following compulsory modules must be taken:

1. Advanced Quantum Mechanics,
2. Advanced Laboratory Course for Master Students,
3. Selected Topics in Physics.

(4) The compulsory electives provide further education in central research fields of the Faculty of Physics at the Freie Universität Berlin. The following compulsory electives are offered, of which at least one must be taken:

1. Advanced Solid State Physics,
2. Advanced Atomic and Molecular Physics,
3. Advanced Biophysics,
4. Advanced Statistical Physics,
5. Quantum Field Theory and Many Body Physics.

(5) Before students embark on their specialisation in the research phase, the electives give them the chance to gain an insight into the current status of research in other areas of

physics. They offer additional education in current fields of research in physics or an overview of methods. The following modules are offered:

1. Theoretical Solid State Physics,
2. Modern Methods in Theoretical Physics,
3. Modern Methods in Experimental Physics,
4. Spectroscopic Methods,
5. Ultrafast Spectroscopy and Nonlinear Optics,
6. Surface Physics,
7. Nanophysics,
8. Special Topics in Magnetism,
9. Special Topics in Molecular Physics,
10. Special Topics in Molecular Biophysics,
11. Photobiophysics and Photosynthesis,
12. Macroscopic Quantum Phenomena,
13. Quantum Optics,
14. Nuclear Physics and Elementary Particles,
15. General Relativity,
16 History of Physics,
17. Advanced Astronomy and Astrophysics.

(6) Instead of the modules in paragraph 5, students may select as electives further modules from among the compulsory electives or complementary modules from other subjects. This option takes account of the fact that research in physics is becoming increasingly interdisciplinary. Modules from disciplines other than physics therefore enable students to gain trans-disciplinary competence and additional professional qualifications. The following modules in other disciplines are offered:

1. Mathematics
   - Elementare Stochastik (Elementary Stochastics)
   - Lineare Algebra II (Linear Algebra II)
   - Einführung in die numerische Mathematik (Introduction to Numerical Mathematics)

   Module descriptions can be found in the study regulations and examination regulations for the Bachelor programme in mathematics as amended from time to time.

   - Visualisierung (Visualisation)
   - Differentialgleichungen I (Differential Equations I)
   - Numerik II: Gewöhnliche Differentialgleichungen (Numerics II: Ordinary Differential Equations)
   - Numerik III: Partielle Differentialgleichungen (Numerics III: Partial Differential Equations)

   Module descriptions can be found in the study regulations and examination regulations for the Master's programme in mathematics as amended from time to time.

2. Computer Science
   - Informatik A (Computer Science A)

- Informatik B (Computer Science B)
- Softwarepraktikum (Software Practical Course)

Module descriptions can be found in the study regulations and examination regulations for the Bachelor programme in Education with Computer Science as the core subject, for the 60 and 30 credit points module offering in Computer Science within other programmes as amended from time to time.

- Grundlagen der Theoretischen Informatik (Fundamentals of Theoretical Information Technology)

Module descriptions can be found in the study regulations and examination regulations for the Bachelor programme in information technology as amended from time to time.

3. Chemistry

   - Anorganische Chemie I (Chemie der Metalle) (Inorganic Chemistry I (Chemistry of metals))
   - Anorganische Chemie II (Chemie der Nichtmetalle) (Inorganic Chemistry II (Chemistry of Non-Metals Nichtmetalle))
   - Anorganische Chemie III (Festkörperchemie) (Inorganic Chemistry III (Solid State Chemistry))
   - Quantenchemie (Quantum Chemistry)
   - Symmetrie in der Chemie (Symmetry in Chemistry)

   Module descriptions can be found in the study regulations and examination regulations for the Bachelor programme in chemistry as amended from time to time.

   - Organische Chemie I (Grundlagen) (Organic Chemistry I (Fundamentals))
   - Organische Chemie IIa (Reaktionsmechanismen der Organischen Chemie) (Organic Chemistry IIa (Reaction Mechanisms of Organic Chemistry))
   - Physikalische Chemie I (Chemische Thermodynamik) (Physical Chemistry I (Chemical Thermodynamics))

   Module descriptions can be found in the study regulations and examination regulations for the Bachelor programme in biochemistry as amended from time to time.

4. Earth Sciences

   - Geophysik (Geophysics)
   - Die Erde Teil I (The Earth Part I)

   Module descriptions can be found in the study regulations and examination regulations for the Bachelor programme in geological sciences as amended from time to time.

   - Erdbeben und Struktur der Erde (Earthquakes and the earth’s structure)
   - Seismik I (Seismics I)

   Module descriptions can be found in the study regulations and examination regulations for the Master’s programme in geological sciences as amended from time to time.

5. Biology

   - Grundlagen der Biologie (Fundamentals of Biology)

   Module descriptions can be found in the study regulations and examination regulations for the Bachelor programme in biology as amended from time to time.

6. Philosophy

   - Basismodul Grundfragen der Philosophie (Introductory Module: Essential Questions of Philosophy)
   - Einführung in die theoretische Philosophie (Introductory Module: Introduction to Theoretical Philosophy)
   - Basismodul Einführung in die praktische Philosophie (Introductory Module: Introduction to Practical Philosophy)

   Module descriptions can be found in the study regulations and examination regulations for the Bachelor programme and the 60 and 30 credits module offering in philosophy, as amended from time to time.

Other modules not listed here, either from the disciplines mentioned here or from other disciplines related to the main study discipline, may also be taken on application. The application must specify how the module relates to the overall qualification aimed at. The relevant examination board will decide on the application. Without the examination board's approval, non-physics modules can only be taken into account up to a maximum of 15 credit points. Modules which are exclusively part of the Bachelor programme in any discipline may only be taken into account up to a maximum of 15 credit points in any case.

(7) Modules totalling 35 credit points must be completed from among the modules mentioned in paragraphs 4, 5 and 6. The modules selected may not be identical with a module already credited towards the completion of the previous degree programme or similar in content to a previous module.

(8) On application, other study attainments than those mentioned in paragraphs 5-6 may be included if they are related to the main study discipline and equivalent in content and qualification aims. These may be completed wholly or in part at other universities in the area under the jurisdiction of the German Basic Law, in particular at other Berlin universities. The relevant examination board will decide on the application.

(9) The modules listed under paragraph 5 subsection 1-16 are offered at irregular intervals. At least seven of these modules will be offered in each academic year.

(10) During the research phase, students specialize in a current field of research in modern physics, learn the relevant methodology and complete their master's thesis in this field. They gain the ability to work independently to tackle scientific issues and to plan projects. The following modules must be completed during the research phase:

1. Scientific Specialization
2. Methodology and Project Planning

(11) The language of instruction in the Master's programme is English. Written reports, laboratory reports, examinations and the Master's thesis may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, individual classes may also be held in German.

(12) The module descriptions according to Annex 1 give information about content, qualification aims, teaching and learning units, the time required, forms of active participation, usual duration and how often the module is offered.

(13) The example of a study schedule in Annex 2 gives information about the recommended study plan.

Section 4 Study abroad

(1) Students are recommended to study abroad as part of their Master's studies. In the course of their studies abroad, students should take courses and examinations which

can be credited as equivalent to the modules which they would have taken during the same period at the Freie Universität Berlin.

(2) Before starting to study abroad, the student should reach an agreement with the chair of the examination board responsible for the programme and the relevant position at the university to be visited, covering the duration of the study period abroad, the parameters of the study and examination attainments to be completed and the credit points allocated to the study and examination attainment. Study and examination attainments which comply with the agreement will be credited.

(3) The second semester is recommended as a suitable time for study abroad.

Section 5 Coming into effect

These regulations come into effect on the day after their publication in the Mitteilung (Gazette of the Freie Universität Berlin).

Annex 1: Module descriptions

Explanations:

The following module descriptions specify the following for every module in the Master's programme in physics:

- Module name
- Module content and qualification aims
- Module teaching and learning units
- Students' study time estimated as necessary to complete the module successfully
- Forms of active participation
- The usual duration of the module

Statements on students' study time required take into account the following in particular:

- Active participation in the compulsory attendance phase
- Students' study time required to complete small tasks in the compulsory attendance phase
- Time for independent preparation and follow-up
- Working on study units in online study phases
- Students' study time required for working on practice exercises
- Preparation time for examinations
- The examinations

The notional times given for independent study (including preparation, follow-up and preparation for examinations) are intended as guidance to help the students in managing the time required for the module.

The statements on study hours correspond to the number of credit points allocated to the module as a unit of measurement for the student's approximate study hours required to complete the module successfully.

Active participation, regular attendance at the teaching and learning units and successful completion of the examinations in a module are all prerequisites for gaining the credit points allocated to each module.

The number of credit points and other examination-related information on each module can be found in Annex 1 of the examination regulations for the Master's programme in physics.

1. Compulsory modules

<table>
<tr><td colspan="4">Module: Advanced Quantum Mechanics</td></tr>
<tr><td colspan="4">Qualification aims:
The students deepen their knowledge of quantum mechanics. They understand the concepts and methods of advanced quantum mechanics and can describe these verbally and in mathematical terms and apply them confidently to fundamental issues in physics.</td></tr>
<tr><td colspan="4">Contents:
Advanced concepts of quantum mechanics are explored in depth in the module. The content includes a selection from the following topics: many-particle systems, second quantisation formalism, approximation methods, Bose and Fermi statistics, field quantisation, correlation functions, relativistic quantum theory and Dirac equations, scattering theory, current issues and methods of quantum theory (e.g. path integral formulation, quantum information)</td></tr>
<tr><td>Teaching and learning units</td><td>Compulsory attendance
(Semester hours per week = SH)</td><td>Forms of active participation</td><td>Study hours
(hours)</td></tr>
<tr><td rowspan="2">Lectures</td><td rowspan="2">4</td><td rowspan="2">–</td><td>Lecture attendance 60</td></tr>
<tr><td>Lecture preparation and follow-up 60
Exercises, attendance 30</td></tr>
<tr><td rowspan="2">Exercises</td><td rowspan="2">2</td><td rowspan="2">Successful completion of practice exercises</td><td>Completion of practice exercises 90
Preparation for examination, examination 60</td></tr>
<tr><td colspan="4">The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.</td></tr>
<tr><td colspan="4">Study time, total hours: 300</td></tr>
<tr><td colspan="4">Duration of module: 1 Semester</td></tr>
<tr><td colspan="4">Module offered: At least every second semester</td></tr>
</table>

Module: Advanced Laboratory Course for Master Students

Qualification aims:

The students have worked on complex issues in physics going beyond those covered in the Bachelor programme. They are familiar with and can apply the more advanced experimental methods used in current physics research to solve these issues. They are able to master a new field of work in a short time from current specialist literature and to communicate it comprehensibly in a presentation.

Contents:

Study of literature as introduction to a new field; close study of physics issues, modern experimental methods and measurement technologies; documentation of the process of the experiment; critical evaluation and discussion of findings; written presentation of issues, evaluation and findings; presentation and explanation of experimental methods, their possibilities and limitations

Topic fields: solid state physics (magnetism, surface physics, superconductivity), atomic and molecular physics, nuclear physics, biophysics

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Laboratory work	6	Carrying out practical experiments	Attendance Experiments: preparation and follow-up Preparation for examination, examination	90 60 90
Seminar	2	Participation in discussion	Attendance Preparation for examination, examination	30 30

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 300

Duration of module: 1 Semester

Module offered: every semester

Module: Selected Topics in Physics

Qualification aims:

After intensively studying the literature, the students have a deeper knowledge of a topic in physics and are able to prepare it for a scientific presentation and convey their knowledge to others through a scientific lecture and chairing a scientific discussion. They are able to reflect on the literature and to answer critical questions on the basis of their reading.

Contents:

Guided by their instructors, the students work on, present and discuss topics from a variety of fields relating to current issues and methods of modern physics on the basis of specialist literature.

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Seminar	1	Participation in discussion	Seminar attendance	15
			Lecture course attendance	15
			Preparation, follow-up	45
Reading course	1	Participation in discussion	Preparation for examination, examination	75

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 150

Duration of module: 1 Semester

Module held: every semester

2. Compulsory electives

<table>
<tr><td colspan="4">Module: Advanced Solid State Physics</td></tr>
<tr><td colspan="4">Qualification aims:
Students have a detailed, critical understanding of some areas of solid state physics and of the most up-to-date commonly used experimental methods. Students can apply their knowledge to concrete issues.</td></tr>
<tr><td colspan="4">Contents:
This module deepens the students‘ knowledge of fundamental concepts of solid state physics (describing the geometrical structure, electronic and vibronic conditions, elementary excitations, collective phenomena) on the basis of one or more relevant areas of solid state physics (semiconductor physics, physics of interfaces and nanostructures, photonics, superconductivity, magnetism, ferroelectricity).</td></tr>
<tr><td>Teaching and learning units</td><td>Compulsory attendance
(Semester hours per week = SH)</td><td>Forms of active participation</td><td>Study hours
(hours)</td></tr>
<tr><td>Lectures</td><td>4</td><td>–</td><td rowspan="2">Lecture attendance 60
Lecture preparation and follow-up 60
Exercises attendance 30
Completion of practice exercises 90
Preparation for examination, examination 60</td></tr>
<tr><td>Exercises</td><td>2</td><td>Successful completion of practice exercises</td></tr>
<tr><td colspan="4">The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.</td></tr>
<tr><td colspan="4">Study time, total hours: 300</td></tr>
<tr><td colspan="4">Duration of module: 1 semester</td></tr>
<tr><td colspan="4">Module offered: at least once per academic year</td></tr>
</table>

Module: Advanced Atomic and Molecular Physics

Qualification aims:

Students have a detailed and critical understanding of some areas of atomic and molecular physics and of modern spectroscopic methods. They can apply their knowledge to concrete issues.

Contents:

The module covers in more depth the fundamental concepts of atomic and molecular physics (quantum mechanical description of atoms and molecules, the interaction of atoms and molecules with electromagnetic fields) on the basis of one or more relevant areas of atomic and molecular physics (e.g. single atoms and molecules in traps, spectroscopy of atomic clusters, biomolecules, single molecule experiments in the condensed phase).

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Lectures	4	–	Lecture attendance	60
			Lecture preparation and follow-up	60
			Exercises, attendance	30
Exercises	2	Successful completion of practice exercises	Completion of practice exercises	90
			Preparation for examination, examination	60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 300

Duration of module: 1 semester

Module offered: at least once per academic year

Module: Advanced Biophysics

Qualification aims:

Students have a detailed and critical understanding of some areas of molecular biophysics and of modern spectroscopic methods. They can apply their knowledge to concrete issues.

Contents:

In this module, a range of biophysical concepts and methods are introduced or covered in more depth. The module focuses particularly on the application of selected methods of spectroscopy and diffraction to biologically relevant systems such as proteins, nucleic acid and membranes. The experimental approaches discussed include a selection of the methods listed below: absorption spectroscopy in the visible range, UV and IR, fluorescence spectroscopy, time-resolved emission and absorption spectroscopy, spectroscopy with linearly and circularly polarised light, vibrational spectroscopy, Fourier transform infrared spectroscopy, resonance Raman spectroscopy, x-ray and neutron diffraction, magnetic resonance and x-ray spectroscopy, dynamic light scattering, single molecule spectroscopy, optical tweezers.

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Lectures	4	–	Lecture attendance	60
			Lecture preparation and follow-up	90
			Lab. work, attendance	60
Laboratory work	4	Carrying out practical experiments	Experiments, preparation and follow-up	30
			Preparation for examination, examination	60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 300

Duration of module: 1 semester

Module offered: at least once per academic year

Module: Advanced Statistical Physics

Qualification aims:

Students understand the fundamental concepts and methods of statistical physics, in particular quantum statistics, and the theoretical principles of thermodynamics and can describe and apply these both in words and mathematically.

Contents:

Equilibrium ensembles, thermodynamic potentials, laws of thermodynamics, thermodynamic processes, ideal quantum gases, phase transformations, interacting systems, non-equilibrium statistical physics

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Lectures	4	–	Lecture attendance	60
			Lecture preparation and follow-up	60
			Exercises, attendance	30
Exercises	2	Successful completion of practice exercises	Completion of practice exercises	90
			Preparation for examination, examination	60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 300

Duration of module: 1 semester

Module offered: At least once per academic year

Module: Quantum Field Theory and Many Body Physics

Qualification aims:

Students understand the concepts and methods of quantum field theory with the focus on many body physics. They can reproduce these verbally, present them mathematically and apply them to issues of many body physics.

Contents:

Green‘s functions, diagrammatic perturbation theory and Feynam diagrams, non-perturbative methods, selected applications in condensed matter or relativistic field theory

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Lectures	4	–	Lecture attendance Lecture preparation and follow-up Exercises, attendance	60 60 30
Exercises	2	Successful completion of practice exercises	Completion of practice exercises Preparation for examination, examination	90 60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 300

Duration of module: 1 semester

Module offered: at least once per academic year

3. Electives

<table>
<tr><td colspan="4">Module: Theoretical Solid State Physics</td></tr>
<tr><td colspan="4">Qualification aims:
Students understand the concepts and methods of theoretical solid state physics. They can present these verbally and mathematically and apply them to current issues of solid state physics.</td></tr>
<tr><td colspan="4">Contents:
Phonons, electrons, Fermi liquid theory, electron-phonon interaction, magnetism, transport theory, disordered systems, fundamental concepts in the description of solids and their excitations, applications (e.g. superconductivity, magnetism), quantum field theory methods in the description of solids, (perturbation theory, mean field approximation, functional integrals), linear answer and transport properties, highly correlated systems, current topics</td></tr>
<tr><td>Teaching and learning units</td><td>Compulsory attendance
(Semester hours per week = SH)</td><td>Forms of active participation</td><td>Study hours
(hours)</td></tr>
<tr><td>Lectures</td><td>4</td><td>–</td><td rowspan="2">Lecture attendance 60
Lecture preparation and follow-up 60
Exercises, attendance 30
Completion of practice exercises 90
Preparation for examination, examination 60</td></tr>
<tr><td>Exercises</td><td>2</td><td>Successful completion of practice exercises</td></tr>
<tr><td colspan="4">The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.</td></tr>
<tr><td colspan="4">Study time, total hours: 300</td></tr>
<tr><td colspan="4">Duration of module: 1 semester</td></tr>
<tr><td colspan="4">Module offered: The elective modules in the Master’s programme in physics are offered at irregular intervals, with the exception of the Advanced Astrophysics/Fortgeschrittene Astrophysik module. At least seven of these modules will be offered in each academic year.</td></tr>
</table>

Module: Modern Methods in Theoretical Physics

Qualification aims:

The module enables the students to select the field they wish to concentrate on. Students master methods applied in current theoretical research and are able to apply them independently.

Contents:

A selection of the following topics is covered: group theory and symmetries in physics, density functional theory, path integral formulation, density matrix theory.

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Lectures	2	–	Lecture attendance	30
			Lecture preparation and follow-up	45
			Exercises, attendance	30
Exercises	2	Successful completion of practice exercises	Completion of practice exercises	75
			Preparation for examination, examination	60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 240

Duration of module: 1 semester

Module offered: The elective modules in the Master's programme in physics are offered at irregular intervals, with the exception of the Advanced Astrophysics/Fortgeschrittene Astrophysik module. At least seven of these modules will be offered in each academic year.

Module: Modern Methods in Experimental Physics

Qualification aims:

The module enables the students to select the field they wish to concentrate on. Students gain an overview of the methods currently applied in experimental research and are able to independently evaluate their advantages and disadvantages for a particular issue.

Contents:

A selection of the following topics is covered: spectroscopic methods (optical spectroscopy, electron spectroscopy, x-ray spectroscopy, magnetic resonance spectroscopy), imaging methods, correlation measurements, time-resolved methods.

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)
Lectures	2	–	Lecture attendance 30 Lecture preparation and follow-up 45
Exercises	1	Participation in discussion	Exercises, attendance 15 Preparation for examination, examination 60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 150

Duration of module: 1 semester

Module offered: The elective modules in the Master's programme in physics are offered at irregular intervals, with the exception of the Advanced Astrophysics/Fortgeschrittene Astrophysik module. At least seven of these modules will be offered in each academic year.

Module: Spectroscopic Methods

Qualification aims:

Students are familiar with the most important spectroscopic methods of modern physics. They can evaluate and interpret spectroscopic data and gain a theoretical understanding of how spectroscopic sources, detectors and experiments work. They can apply their knowledge to concrete issues.

Contents:

Spectroscopy is one of the most important investigation methods of experimental physics. This module introduces spectroscopic methods of examining atoms, molecules and solids. It covers the theoretical and practical principles of modern spectroscopy, the interpretation of original data and the critical evaluation of results.

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)
Lectures	2	–	Lecture attendance 30 Lecture preparation and follow-up 45
Exercises	1	Participation in discussion	Exercises, attendance 15 Preparation for examination, examination 60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 150

Duration of module: 1 semester

Module offered: The elective modules in the Master's programme in physics are offered at irregular intervals, with the exception of the Advanced Astrophysics/Fortgeschrittene Astrophysik module. At least seven of these modules will be offered in each academic year.

Module: Ultrafast Spectroscopy and Nonlinear Optics

Qualification aims:

The aim of this module is to gain fundamental knowledge in the field of nonlinear optics and the dynamics of elementary optically induced processes. Students have an overview of modern methods of ultrafast spectroscopy and nonlinear optics and how to apply them to particular problems.

Contents:

Principles of the interaction of light and matter, wave packet dynamics, electron dynamics and elementary scattering processes, collective excitations in solids. Experimental methods of ultrafast spectroscopy and selected applications, e.g. femtochemistry, coherent control, photoelectron spectroscopy, attosecond physics, diffraction methods, structural dynamics

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Lectures	2	–	Lecture attendance	30
			Lecture preparation and follow-up	45
Exercises	1	Participation in discussion	Exercises attendance	15
			Preparation for examination, examination	60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 150

Duration of module: 1 semester

Module offered: The elective modules in the Master's programme in physics are offered at irregular intervals, with the exception of the Advanced Astrophysics/Fortgeschrittene Astrophysik module. At least seven of these modules will be offered in each academic year.

Module: Surface Physics

Qualification aims:

Students are familiar with current issues in research on solid surfaces and interfaces as well as with the methods in current use and their possibilities. They are able to interpret and critically evaluate findings with reference to the current state of knowledge.

Contents:

On the basis of selected examples, the module identifies the principles and applications, the current state of research and the possibilities and limitations of modern experimental methods in the field of research into surfaces and interfaces. Topics covered may include: structure and electronic properties of surfaces and interfaces, adsorption and desorption, surface chemistry / surface reactions, growth and structure of ultra-thin films, self-organisation on surfaces, imaging microscopic methods, charge dynamics on surfaces and in adsorbate systems, creation and manipulation of nanostructures on surfaces, surface plasmons.

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Lectures	2	–	Lecture attendance Lecture preparation and follow-up	30 45
Exercises	1	Participation in discussion	Exercise, attendance Preparation for examination, examination	15 60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German**.**

Study time, total hours: 150

Duration of module: 1 semester

Module offered: The elective modules in the Master's programme in physics are offered at irregular intervals, with the exception of the Advanced Astrophysics/Fortgeschrittene Astrophysik module. At least seven of these modules will be offered in each academic year.

Module: Nanophysics

Qualification aims:

Students are familiar with the current state of research and the future challenges in the modern, interdisciplinary field of nanophysics. They are able to interpret and evaluate experimental and theoretical findings.

Contents:

The module uses examples to introduce the principles of nanophysical systems, important investigation methods and possible applications. The teaching event may be oriented on particular nanosystems, groups of physical topics or investigation methods. Original literature and textbooks are used to discuss the current state of research.

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)
Lectures	2	–	Lecture attendance 30 Lecture preparation and follow-up 45
Exercises	1	Participation in discussion	Exercises, attendance 15 Preparation for examination, examination 60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 150

Duration of module: 1 semester

Module offered: The elective modules in the Master's programme in physics are offered at irregular intervals, with the exception of the Advanced Astrophysics/Fortgeschrittene Astrophysik module. At least seven of these modules will be offered in each academic year.

Module: Special Topics in Magnetism

Qualification aims:

Students are familiar with current research issues in the field of magnetism and currently used methods and their possibilities. They are able to interpret and critically evaluate findings in relation to the current state of knowledge.

Contents:

On the basis of selected examples, the module identifies the principles and applications, the current state of research and the possibilities and limitations of modern experimental methods in the field of research into magnetism. Topics covered may include: magnetic nanostructures, new magnetic materials, magneto-transport phenomena / spin electronics, magnetisation dynamics, magnetic interface phenomena / magnetic interfaces, micromagnetism / magnetic domains, molecular magnetism.

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Lectures	2	–	Lecture attendance	30
			Lecture preparation and follow-up	45
Exercises	1	Participation in discussion	Exercises, attendance	15
			Preparation for examination, examination	60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 150

Duration of module: 1 semester

Module offered: The elective modules in the Master's programme in physics are offered at irregular intervals, with the exception of the Advanced Astrophysics/Fortgeschrittene Astrophysik module. At least seven of these modules will be offered in each academic year.

Module: Special Topics in Molecular Physics

Qualification aims:

Students are familiar with current issues in molecular physics and in particular the application of modern spectroscopy techniques to the examination of issues of molecular physics. They are able to interpret and critically evaluate findings in relation to the current state of knowledge.

Contents:

The module gives a more thorough introduction to selected modern concepts in molecular physics, using examples. Specific topics may include single molecule technologies, electron and nuclear magnetic resonance spectroscopy, oscillation spectroscopy and ultrafast spectroscopy.

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Lectures	2	–	Lecture attendance	30
			Lecture preparation and follow-up	45
Exercises	1	Participation in discussion	Exercises, attendance	15
			Preparation for examination, examination	60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 150

Duration of module: 1 semester

Module offered: The elective modules in the Master's programme in physics are offered at irregular intervals, with the exception of the Advanced Astrophysics/Fortgeschrittene Astrophysik module. At least seven of these modules will be offered in each academic year.

Module: Special Topics in Molecular Biophysics

Qualification aims:

Students are familiar with current research issues in the field of molecular biophysics and with new methods and the possibilities they offer. They are able to interpret and critically evaluate findings in relation to the current state of knowledge.

Contents:

On the basis of selected examples, the module identifies the principles and applications, the current state of research and the possibilities and limitations of modern concepts and methods in the field of molecular biophysics. Topics covered are oriented on the main current research issues in biophysics in the faculty and may include: advanced approaches to vibrational, x-ray or electron spin resonance spectroscopy into biomolecules; biomolecules on surfaces or in membranes; tracing the function of photoreceptors or biocatalysts at atomic level.

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Lectures	2	–	Lecture attendance	30
			Lecture preparation and follow-up	45
Exercises	1	Participation in discussion	Exercises, attendance	15
			Preparation for examination, examination	60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 150

Duration of module: 1 semester

Module offered: The elective modules in the Master's programme in physics are offered at irregular intervals, with the exception of the Advanced Astrophysics/Fortgeschrittene Astrophysik module. At least seven of these modules will be offered in each academic year.

Module: Photobiophysics and Photosynthesis

Qualification aims:

On the basis of selected examples, students are familiar with current issues of biophysics research in the field of photobiophysics and photosynthesis. They know the new methods and the possibilities they offer and are able to interpret and critically evaluate findings in relation to the current state of knowledge.

Contents:

The conversion and utilisation of light in biological systems is of fundamental importance for life on earth. Topics are: overview of photosynthesis and photosynthetic organisms; photophysical principles of light absorption, fluorescence emission and energy transfer in photosynthetic antenna systems, light-driven processes in co-factor protein complexes, selected methods of research into photosynthesis, artificial photosynthesis and bio-hydrogen production.

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Lectures	2	–	Lecture attendance	30
			Lecture preparation and follow-up	30
			Exercises, attendance	15
Exercises	1	Laboratory experiments with discussions	Preparation and follow-up of exercises	15
			Preparation for examination, examination	60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 150

Duration of module: 1 semester

Module offered: The elective modules in the Master's programme in physics are offered at irregular intervals, with the exception of the Advanced Astrophysics/Fortgeschrittene Astrophysik module. At least seven of these modules will be offered in each academic year.

Module: Macroscopic Quantum Phenomena

Qualification aims:

The module enables the students to select the field they wish to concentrate on. The emphasis is on the acquisition of modern theoretical concepts and methods. Students are able to understand these concepts, to state them verbally and to independently carry out some fundamental calculations.

Contents:

Macroscopic quantum phenomena are an active research field in modern theoretical physics. The module covers physical systems in which quantum mechanical effects determine the dynamics or structure of the system on a macroscopic scale. The theoretical foundations for the description of these phenomena are presented using examples such as superconductivity, Bose-Einstein condensation, magnetism or quantum Hall effects.

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Lectures	2	–	Lecture attendance	30
			Lecture preparation and follow-up	45
Exercises	1	Participation in discussion	Exercises, attendance	15
			Preparation for examination, examination	60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 150

Duration of module: 1 semester

Module offered: The elective modules in the Master's programme in physics are offered at irregular intervals, with the exception of the Advanced Astrophysics/Fortgeschrittene Astrophysik module. At least seven of these modules will be offered in each academic year.

Module: Quantum Optics

Qualification aims:

The module aims to equip students with fundamental knowledge of light-matter interaction and its application to particular problems. Students have an overview of the tools of quantum optics, are able to describe the methods and concepts both verbally and mathematically and can apply them independently to current issues.

Contents:

Principles of quantum optics: quantisation of electro-magnetic field; description of light fields; semi-classical and quantum mechanical treatment of the light-matter interaction; entanglement and decoherence and selected applications, e.g. interferometry; light detection, laser cooling, atom optics, EPR paradox and Bell's inequality, quantum state reconstruction, quantum information

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Lectures	2	–	Lecture attendance	30
			Lecture preparation and follow-up	45
Exercises	2	Successful completion of practice exercises	Exercises, attendance	30
			Completion of practice exercises	75
			Preparation for examination, examination	60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 240

Duration of module: 1 semester

Module offered: The elective modules in the Master's programme in physics are offered at irregular intervals, with the exception of the Advanced Astrophysics/Fortgeschrittene Astrophysik module. At least seven of these modules will be offered in each academic year.

Module: Nuclear Physics and Elementary Particles

Qualification aims:

Students have a fundamental understanding of the concepts of nuclear physics and an overview of the current state of knowledge in elementary particle research.

Contents:

Types of radiation and their interaction with matter; radiation detectors; properties of nuclei and nuclear reactions; application of methods of nuclear physics and particle physics; relativistic kinematics; symmetries and the conservation principles; quark model; standard models of electroweak interaction; neutrino physics

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Lectures	2	–	Lecture attendance	30
			Lecture preparation and follow-up	45
Exercises	1	Participation in discussion	Exercises, attendance	15
			Preparation for examination, examination	60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 150

Duration of module: 1 semester

Module offered: The elective modules in the Master's programme in physics are offered at irregular intervals, with the exception of the Advanced Astrophysics/Fortgeschrittene Astrophysik module. At least seven of these modules will be offered in each academic year.

Module: General Relativity

Qualification aims:

Students understand the concepts and methods of the general theory of relativity and can apply them. They are able to describe the mathematical prerequisites and physical assumptions for the general theory of relativity and to present fundamental conclusions.

Contents:

Riemannian geometry, the equivalence principle, Einstein equations, applications of the general theory of relativity, (Schwarzschild solution, gravitational collapse and black holes, gravitational waves), cosmology

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Lectures	2	–	Lecture attendance Lecture preparation and follow-up	30 45
Exercises	1	Participation in discussion	Exercises attendance Preparation for examination, examination	15 60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 150

Duration of module: 1 semester

Module offered: The elective modules in the Master's programme in physics are offered at irregular intervals, with the exception of the Advanced Astrophysics/Fortgeschrittene Astrophysik module. At least seven of these modules will be offered in each academic year.

Module: History of Physics

Qualification aims:

The module aims to convey a historical understanding of the basic terms of physics and its methods of operation. This understanding is intended to contribute in particular to maintaining the awareness of the mutability of these basic terms and to introduce innovative research perspectives on the basis of historical examples. In addition, students gain an overview of the development of physics from its beginnings up to today; the overview is deepened on the technological level by particular examples. The module also aims to give students an understanding of how research in physics is embedded in its particular cultural and social structures. The most important aims are a thoughtful use of terms and methods, an eye for development potential and a keen sense of links between physical knowledge and its contexts.

Contents:

- knowledge of physics in classical times: Aristotle and Archimedes
- the development of physics in non-European cultures: the Chinese example
- the heritage of antique physics in the Arabic and Latin Middle Ages
- the scientific revolution of the early modern period
- the analytical tradition of the 18th and 19th centuries
- the consolidation of classical physics
- reflection on the culture of the discipline in relation to gender aspects
- the physical revolution of the 20th century

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Lectures	2	–	Lecture attendance	30
			Lecture preparation and follow-up	45
Exercises	1	Participation in discussion	Exercises, attendance	15
			Preparation for examination, examination	60

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 150

Duration of module: 1 semester

Module offered: The elective modules in the Master's programme in physics are offered at irregular intervals, with the exception of the Advanced Astrophysics/Fortgeschrittene Astrophysik module. At least seven of these modules will be offered in each academic year.

Module: Advanced Astronomy and Astrophysics

Qualification aims:

The module conveys deeper knowledge in modern areas of astronomy and astrophysics through alternating wide-ranging lectures. In the laboratory work, practical skills relating to astronomic observation methods and numerical methods for astrophysical issues are conveyed.

Contents:

- alternating lectures on various special topics in astronomy and astrophysics (e.g. relativistic astrophysics, cosmology, physics of stellar atmospheres, cosmic electrodynamics, ISM, astronomical observation methods, planetary physics, stellar structure and stellar development)
- practical exercises in astronomy (e.g. astrometry, stellar spectroscopy, determining distances, galactic rotation, observations with the centre's own telescopes)
- numerical methods for astrophysical issues

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Lecture 1	2	–	Lecture attendance	60
			Lecture preparation and follow-up	90
Lecture 2	2	–		
			Lab work attendance	60
Astrophysical laboratory work	4	Practical experiments with written accounts	Completion of practical exercises/experiment accounts	120
			Preparation for examination, examination	30

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 360

Duration of module: The module can be completed in 1 or 2 semesters

Module offered: at least once per academic year

4. Research phase

Module: Scientific Specialization

Qualification aims:

Independent orientation in the scientific research field of the Master's thesis. Students are familiar with the current state of scientific knowledge in this field and are able to assess the advantages and disadvantages of various approaches to a particular issue and to describe these with reasons in discussion. They have the special knowledge of the discipline necessary to complete their Master's thesis.

Contents:

In this module, the students familiarise themselves in detail with a modern field of research prescribed by their research phase supervisor on the basis of original literature (scientific journals and monographs). The focus is on the scientific content, the critical evaluation of literature, scientifically correct descriptions and the rules of good scientific practice. On the basis of the literature studies, open issues are defined and the investigations necessary to answer them are discussed and planned. The skills of expert presentation and critical discussion are practised in seminars.

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Individual mentoring	4	Documentation and evaluation of original literature, calculations	Mentoring attendance	60
			Independent study	180
			Seminar attendance	30
Seminar	2	Participation in discussion	Seminar preparation and follow-up	30
			Preparation for examination, examination	150

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 450

Duration of module: 6 months

Module offered: every semester

Module: Methodology and Project Planning

Qualification aims:

Students are familiar with the particular physical methods and skills necessary to complete their Master's thesis and can apply them in practice. They are able to plan a research project, to present the planning in written form giving reasons and to defend it in the face of critical questions.

Contents:

In this module, students learn selected theoretical and/or experimental methods and skills necessary to complete their Master's thesis under expert guidance. Depending on whether the work is experimental or theoretical in orientation, the focus is on the confident and precise use of measurement apparatus, algorithms, programmes and aids and the reliable application of the necessary skills. Building on the mastery of these methods, the planning of a scientific project is drawn up and presented in written form.

Teaching and learning units	**Compulsory attendance** (Semester hours per week = SH)	**Forms of active participation**	**Study hours** (hours)	
Individual mentoring	4	Presentation of planned project, discussion participation	Mentoring attendance Individual study Lab work attendance	60 180
Experimental or theoretical laboratory work	7	Carrying out and reporting on experiments	Preparation for examination, examination	105 105

The language of instruction: English. Written reports, laboratory reports and examinations may be submitted or taken in German by arrangement with the instructor responsible. If none of the participating students objects, the module may be held partly or entirely in German.

Study time, total hours: 450

Duration of module: 6 months

Module offered: every semester

Annex 2: Example of programme plan

1. Study starts in winter semester:

<table>
<tr><th>Semester</th><th colspan="4">Module</th><th>Master's thesis</th></tr>
<tr><td>1</td><td colspan="2">Advanced Quantum Mechanics[1]</td><td>Advanced Laboratory Course for Master Students[1]</td><td>Compulsory elective[1]</td><td rowspan="3"></td></tr>
<tr><td>2</td><td>Selected Topics in Physics[1]</td><td colspan="3">Elective[1]</td></tr>
<tr><td>3</td><td colspan="2">Scientific Specialization</td><td colspan="2">Methodology and Project Planning</td></tr>
<tr><td>4</td><td colspan="4"></td><td>Master's thesis</td></tr>
</table>

[1] The modules of the first and second semester can be taken in any order

2. Study starts in the summer semester:

<table>
<tr><th>Semester</th><th colspan="3">Module</th><th>Master‘s thesis</th></tr>
<tr><td>1</td><td>Advanced Laboratory Course for Master Students[1]</td><td colspan="2">Compulsory elective[1]</td><td rowspan="2">Elective[1]</td></tr>
<tr><td>2</td><td>Advanced Quantum Mechanics[1]</td><td>Selected Topics in Physics[1]</td><td rowspan="2"></td></tr>
<tr><td>3</td><td colspan="2">Scientific Specialization</td><td>Methodology and Project Planning</td></tr>
<tr><td>4</td><td colspan="3"></td><td>Master’s thesis</td></tr>
</table>

[1] The modules of the first and second semester can be taken in any order

Examination regulations for the Master's Programme in Physics

Preamble

On the basis of Section 14 paragraph 1 no. 2 of the Partial University Constitution (Trial version) of the Freie Universität Berlin of 27 October 1998 (FU Mitteilung [Gazette of the Freie Universität Berlin] 24/1998), the Faculty Council of the Faculty of Physics of the Freie Universität Berlin issued the following examination regulations for the Masters Programme in Physics on 31 March and 4 May 2009:

Contents

Section 1 Area of Application

These regulations supplement the statutes for general examination issues (SfAP) of the Freie Universität Berlin and apply to the requirements and procedures for examination attainment in the Master's programme in Physics.

Section 2 Examination Board

The examination board appointed for the Master's programme in Physics is responsible for organising the examinations and other tasks listed in Section 2 SfAP.

Section 3 Prescribed period of study

The prescribed period of study is four semesters.

Section 4 Scope of examination and study attainment

(1) A total of 120 credit points must be attained in examinations and study of which

1. 25 credit points in the compulsory modules (Section 3 paragraph 3 of the study regulations),
2. a total of 35 credit points in the compulsory elective modules (Section 3 paragraph 4 of the study regulations) and in the elective modules (Section 3 paragraphs 5 and 6 of the study regulations),
3. 60 credit points in the research phase (Section 3 paragraph 7 of the study regulations) of which 30 credit points are allocated to the Master's thesis.

(2) Information on the examination attainment to be achieved in the course of individual modules, the admission requirements to the individual modules, the obligation to attend the teaching and learning units regularly and the credit points allotted to each module can be found in Annex 1.

Section 5 Research phase

(1) During the 12-month research phase, students specialize in a current field of research in modern physics under the supervision of an instructor, learn the relevant methodology and complete their master's thesis in this field. The master's thesis is intended to demonstrate that the student is able to tackle an issue from the fields of theoretical or experimental physics independently at advanced scientific level using scientific methods and to present the findings in an appropriate form, to place them in their scientific context and to document them.

(2) Students are admitted to the research phase modules on application if they

1. have successfully completed the modules "Advanced Quantum Mechanics" and "Advanced Laboratory Course for Master Students" and
2. have successfully completed the modules for at least 45 credit points envisaged for the first two semesters (coursework phase) as set out in the example of the programme plan (modules for 60 credit points as set out in Section 3 paragraph 3-6 of the study regulations).

Students are not admitted to the research phase if they have failed to attain the required credit points or have failed the examination at the final attempt or are in a pending examination procedure at another university in the area under the jurisdiction of German Basic Law in the same study programme or in a module which is identical to or

comparable with a module to be taken in the Master's programme in Physics and for which the grade is to be included in the total number of credits.

(3) The application for admission to the research phase must include proof of the fulfilment of the requirements according to paragraph 2 clause 1 and a statement that none of the cases according to paragraph 2 clause 2 applies to the applicant. The relevant examination board will decide on the application. The application must also include written confirmation by an authorised examiner of his/her willingness to take on the supervision of the research phase including the master's thesis. If not, the examination board will appoint a supervisor. The application for admission to the research phase may be withdrawn once within the first three weeks and submitted again.

(4) In the research phase, students initially take two parallel compulsory modules, "Scientific Specialization" and "Methodology and Project Planning", which must both be completed within six months. If they fail a module examination, a repeat examination must be scheduled within six weeks. Students must successfully complete both of these modules to be admitted to the master's thesis.

(5) The research phase supervisor sets the topic for the master's thesis for students under his/her supervision after they have been admitted to the research phase, at the latest after they have completed the two modules "Scientific Specialization" and "Methodology and Project Planning" in agreement with examination board. The topic content must be coordinated with the modules. The students have the opportunity to suggest their own topic; the right to take this topic is not guaranteed. The topic and scope of work must be such that they can be completed within the time permitted. Issue of the topic and compliance with the completion deadline must be recorded.

(6) The master's thesis is to be completed within six months and begins immediately after completion of the two modules "Scientific Specialization" and "Methodology and Project Planning". In exceptional cases the examination board may extend the time allowed for the master's thesis by up to eight weeks, if the supervisor agrees. The student must apply for the extension giving reasons.

(7) The master's thesis should comprise about 60 pages, including footnotes and bibliography.

(8) Alongside the master's thesis, a seminar comprising 2 semester hours per week is held in which each student holds one talk of approx. 30 minutes on the progress of his/her research.

(9) Three bound copies of the master's thesis are to be submitted within the completion time. When they submit their thesis, students must also confirm in writing that they have written the thesis personally and independently and have used no aids other than the sources and aids listed. One copy of the master's thesis may with the student's agreement be taken into the Institute's library on completion of the programme.

(10) The master's thesis is to be evaluated by two authorised examiners appointed by the examination board. One of the two should be the supervisor of the master's thesis. At least one of the authorised examiners should be professor in the Faculty of Physics at the Freie Universität Berlin.

(11) If the examination board agrees, the research phase may also be carried out externally in a suitable company or scientific institution, on condition that the scientific supervision is guaranteed by an examiner as in paragraph 10.

Section 6 Retaking examinations

(1) Examinations passed with "sufficient" (4.0) or better may not be retaken.

(2) A master's thesis not passed with the grade "sufficient" (4.0) or better may be retaken once.

Section 7 Final degree

(1) The prerequisite for the award of the final degree is proof of the attainments required according to Section 4 paragraph 1. The final degree is not awarded if the student has failed to attain the required credit points or has failed the examination or is in a pending examination procedure at another university in the area under the jurisdiction of German Basic Law in the same programme of studies or in a module which is identical to or comparable with a module to be taken in the Master's programme in Physics and for which the grade is to be included in the total number of credits.

(2) The application for confirmation of the final degree must include proof of the fulfilment of the requirements according to paragraph 2 clause 1 and a statement that none of the cases according to paragraph 2 clause 2 applies to the applicant. The relevant examination board will decide on the application.

(3) If a student has completed more modules than necessary to attain the total of 120 credit points in addition to the Master's thesis, the following procedure takes place according to the provisions in Section 4 paragraph 1 of these regulations and with Section 3 of the study regulations:

1. If all study attainments were achieved within the prescribed period of study, the modules with the best final grades will be included in the calculation of the overall grade.
2. If the student exceeded the prescribed period of study, the modules will be included in the calculation of the overall grade in the order in which they were completed. In the case of modules completed within the same semester, the module with the best grade will be included. If the inclusion of modules unavoidably entails an overall total of over 120 credit points, the module with the lowest grade will only be partially included in the calculations of the overall grade with the number of points required to reach the overall total of 120.

The date at which a module is considered to be completed is the date of the successful completion of the last examination in the course of the module.

(4) If the final degree is achieved within the prescribed period of study, additional modules with the lowest grades of around 10 credit points will not be included in the calculation of the overall grade as long as the student at least passed the module.

(5) If a student only needs to successfully complete one more module according to Section 3 paragraph 3-5 of the study regulations in order to gain their final degree, the examination for this module may on application be taken as an oral examination if the student has already taken and failed an examination for this module. The oral examination lasts 30 minutes. In exceptional cases students may apply, giving reasons and with their instructor's agreement, for the same procedure to be applied to other modules according to Section 3 paragraph 3-5 of the study regulations for the Master's programme in Physics.

(6) Students who have passed the examinations in the Master's programme in Physics receive a report and a certificate (Annex 2 and 3) and a diploma supplement (in English and German). A further diploma supplement with information on individual modules and their parts (transcript) will also be produced. In addition, English versions of the report and certificate may be issued on application.

(7) The report contains the overall grade and the individual grades for areas of study according to Section 4 no. 1, no. 2 and 3, no. 4 excluding the Master's thesis and the Master's thesis. Grades for the fields of study are calculated as the average value (weighted with the credit points) of the module grades included in the grade calculation. The overall grade is calculated as the average value (weighted with the credit points for the fields of study) of the grades for the fields of study and the Master's thesis. All doc-

documents bear the date of the day on which the final examination was passed.

Section 8 Coming into effect

These regulations come into effect on the day after their publication in the Mitteilung (Gazette of the Freie Universität Berlin).

Annex 1 (to Section 4 paragraph 2): examinations, admission requirements, attendance obligation and credit points

Explanations:

The following gives information about the modules for the Master's programme in physics on:

- Admission requirements for each module,
- Examination forms,
- Regular attendance obligation
- Credit points allocated to each module.

Where obligatory regular attendance is specified in the following, it is a requirement for the attainment of the credit points for each module alongside active participation in the learning and teaching units and successful completion of the examination. Regular attendance entails at least 85% attendance at the learning and teaching units in the module for which attendance is obligatory. If regular attendance at a module's learning and teaching units is not obligatory, it is nevertheless strongly recommended. Instructors may not demand obligatory attendance for learning and teaching units if participation in these is merely recommended in the following.

The credit points allotted to a module are determined by the total number of study hours estimated to be necessary to complete the module successfully. This includes both hours of attendance and phases of individual study (preparation and follow-up, examination preparation etc.). One credit point is equivalent to approximately 30 hours.

A module examination must be taken for each module. Instead of one module examination, several module part examinations may be set. Students are only awarded credit points for the successful completion of the whole module – after regular active participation at learning and teaching units and successful completion of the module examination or module part examinations.

Information on contents and qualification aims, module teaching and learning units, the student workload estimated as necessary to complete the module successfully, forms of active participation, the usual module duration and the frequency with which it is offered may be found in the Study Regulations of the Master's programme in Physics.

1. Compulsory modules

Module: Advanced Quantum Mechanics		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		Yes
Credit points: 10		

Module: Advanced Laboratory Course for Master Students			
Admission requirements: none			
Teaching and learning units	**Module part examinations**	(weighting/CP)	**Attendance obligatory**
Laboratory work	Written reports of approx. 20 pages on eight practical experiments. The grade for the module part examination is the arithmetical average of the report grades	8	yes
Seminar	Oral presentation of about 20 minutes	2	yes
Credit points: 10			

Module: Selected Topics in Physics		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Seminar	Talk of about 30 minutes	yes
Reading course		yes
Credit points: 5		

2. Compulsory elective modules

Module: Advanced Solid State Physics		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 10		

Module: Advanced Atomic and Molecular Physics		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 10		

Module: Advanced Biophysics		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Written reports of approx. 20 pages on four practical experiments. The module grade is the arithmetical average of the report grades.	Attendance recommended
Laboratory work		yes
Credit points: 10		

Module: Advanced Statistical Physics		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 10		

Module: Quantum Field Theory and Many Body Physics		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 10		

3. Elective modules

Module: Theoretical Solid State Physics		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 10		

Module: Modern Methods in Theoretical Physics		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 8		

Module: Modern Methods in Experimental Physics		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 5		

Module: Spectroscopic Methods		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 5		

Module: Ultrafast Spectroscopy and Nonlinear Optics		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 5		

Module: Surface Physics		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 5		

Module: Nanophysics		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 5		

Module: Special Topics in Magnetism		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		Yes
Credit points: 5		

Module: Special Topics in Molecular Physics		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 5		

Module: Special Topics in Molecular Biophysics		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 5		

Module: Photobiophysics and Photosynthesis		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Four oral examinations of approx. 15 minutes each. The student has passed the module examination when the average grade calculated from the four examinations is at least “sufficient” (4.0)	Attendance recommended
Exercises		yes
Credit points: 5		

Module: Macroscopic Quantum Phenomena		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 5		

Module: Quantum Optics		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 8		

Module: Nuclear Physics and Elementary Particles		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 5		

Module: General Relativity		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 5		

Module: History of Physics		
Admission requirements: none		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture	Examination (time allowed: 90 minutes)	Attendance recommended
Exercises		yes
Credit points: 5		

Module: Advanced Astronomy and Astrophysics		
Admission requirements: none; successful completion of the Bachelor module “Introduction to Astronomy and Astrophysics” recommended		
Teaching and learning units	**Module examination**	**Attendance obligatory**
Lecture 1	30 minute oral examination	Attendance recommended
Lecture 2		Attendance recommended
Laboratory work		yes
Credit points: 12		

4. Research phase

<table>
<tr><td colspan="3">Module: Scientific Specialization</td></tr>
<tr><td colspan="3">Admission requirements: successful completion of the modules “Advanced Quantum Mechanics” and “Advanced Laboratory Course for Master Students” and other modules required for the Master’s programme in Physics according to the study regulations for the coursework phase for at least 25 credit points</td></tr>
<tr><td>Teaching and learning units</td><td>Module examination</td><td>Attendance obligatory</td></tr>
<tr><td>Individual mentoring</td><td rowspan="2">Overall grade for a scientific talk (approx. 30 minutes) and subsequent discussion (approx. 30 minutes)</td><td>yes</td></tr>
<tr><td>Seminar</td><td>yes</td></tr>
<tr><td colspan="3">Credit points: 15</td></tr>
</table>

<table>
<tr><td colspan="3">Module: Methodology and Project Planning</td></tr>
<tr><td colspan="3">Admission requirements: successful completion of the modules “Advanced Quantum Mechanics” and “Advanced Laboratory Course for Master Students” and other modules required for the Master’s programme in Physics according to the study regulations for the coursework phase for at least 25 credit points</td></tr>
<tr><td>Teaching and learning units</td><td>Module examination</td><td>Attendance obligatory</td></tr>
<tr><td>Individual mentoring</td><td rowspan="2">Written report of approx. 20 pages</td><td>yes</td></tr>
<tr><td>Experimental or theoretical laboratory work</td><td>yes</td></tr>
<tr><td colspan="3">Credit points: 15</td></tr>
</table>

Annex 2 (to Sec. 7 par. 6): Certificate of Academic Record (example)

Freie Universität Berlin
Department of Physics

Certificate of Academic Record

Ms./Mr. [First name, surname]

Born in [Place of Birth] on [Day/Month/Year]

has successfully completed the Master Degree Programme in

Physics

in accordance with the examination regulations of 31 March and 4 May 2009 (FU-Mitteilungen 36/2009) with the final grade

[Grade as Number and Text]

and has earned the required amount of 120 credit points. The individual components of the programme were graded as follows:

Areas of Study	Credit Points	Grade
Compulsory Modules	25	
Compulsory electives and electives	35	
Research phase (excluding Master's thesis)	30	
Master's thesis	30	

The topic of the [Bachelor/Master] thesis was: [XX] (Thesis supervisor: [XX])

Berlin, [Day/Month/Year] (Seal))

The Dean

Chairperson
of the Examination Board

Grading Scale: 1.0 – 1.5 very good; 1.6 – 2.5 good; 2.6 – 3.5 satisfactory; 3.6 – 4.0 sufficient; 4.1 – 5.0 insufficient
The credit points comply with the European Credit Transfer System (ECTS)

Annex 3 (to Sec. 7 par. 6):
Degree Certificate (example)

Freie Universität Berlin
Department of Physics

Degree Certificate

Ms/Mr [First name, surname]

born in [Place of Birth] on [Day/Month/Year]

has successfully completed the Master Degree Programme in

Physics

In accordance with the university examination regulations of 31 March and 4 May 2009 (FU-Mitteilungen Nr. 36/2009)

the Degree of

Master of Science (M.Sc.)

is hereby awarded.

Berlin, , [Day/Month/Year] (Seal)

Dean

Chair
of the Examination Board