KONFERENZ DER FACHBEREICHE PHYSIK

On the design of Bachelor's and Master's degree programmes in physics

Handout of the
Conference of the Physics Departments (KFP)

adopted by the plenary assembly of the KFP on 8 November 2010 in Berlin

Contents

Introduction

In order to ensure that the education of physicists at universities in Germany in the tiered, consecutive degree programmes introduced as part of the Bologna reforms continues to take place at the proven and recognised level of the previous Diplom degree programme, the Plenary Assembly of the Conference of Physics Departments (KFP) adopted recommendations on the Bachelor's and Master's degree programmes in physics[1] on 18 May 2005, which serve as an orientation framework for the departments.

Within the framework set by the Conference of Ministers of Education and Cultural Affairs of a total of five years for consecutive degree programmes leading to a Master's degree, the three-year Bachelor's course achieves a basic professional qualification with a broad general education in physics, but nowhere near the qualification profile of the previous Diplom degree. The KFP therefore recommends that all physics students complete a two-year Master's programme in order to acquire knowledge and skills at the highest international level.

The conversion of physics degree programmes in Germany to the tiered system of Bachelor's and Master's degrees is now almost complete and the first graduates have successfully completed the new degree programmes. The experience of the physics departments to date with the design, organisation and accreditation of the tiered degree programmes has shown that the KFP recommendations of 2005 are still relevant and helpful in providing a general framework for the objectives of the degree programmes and the skills to be acquired by students on the Bachelor's and Master's degree programmes.

However, the faculties require additional information and coordination for the further development of the degree programmes and the upcoming accreditation procedures. For this reason, this handout was developed, which summarises the study objectives and the skills to be acquired in a detailed form. It also contains several sample curricula for the Bachelor's degree programme, which are intended to illustrate how the recommendations of the KFP of 2005 can be implemented against the background of the legal requirements of the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder and accreditation practice. In the area of the Master's degree programme, the implementation of the KFP recommendations has not yet caused any difficulties due to the wide range of specialisation options and the prescribed structure of the one-year research phase, so that model curricula are not necessary here. It has also been possible to dispense with information on the content of the physics degree programme that goes beyond the KFP recommendations, as these are still undisputed.

The handout "Zur Konzeption von Bachelor- und Master-Studiengängen im Fach Phy- sik" (On the conception of Bachelor's and Master's degree programmes in physics) is intended to help ensure that the study and examination regulations for the subject of physics continue to be coordinated in the best possible way in order to ensure the comparability of degrees in physics at universities in Germany as well as student mobility.

[1] Cf. www.kfp-physik.de/dokument/Empfehlungen_Ba_Ma_Studium.pdf.

Study objectives Bachelor

Successfully completing a Bachelor's degree programme should, on the one hand, enable early entry into professional life (professional qualification) and, on the other hand, enable graduates to continue their studies. With their knowledge and skills, graduates of the Bachelor's degree course in Physics have a qualification on a solid scientific-mathematical basis, certain interdisciplinary qualifications and a high degree of flexibility, which provides an excellent basis for further qualification and specialisation in particular. Graduates do not have the educational level of the previous Diploma programme in Physics. In principle, they are suitable for admission to a corresponding master's degree programme, the quality of which corresponds to the previous physics diploma. In detail, this means

- They have a sound knowledge of classical physics (mechanics, electrodynamics, thermodynamics, vibrations, waves and optics) and are familiar with the fundamentals of quantum, atomic and molecular, nuclear, elementary particle and solid-state physics.
- They know important mathematical methods used in physics and can use them to solve physical problems.
- They have largely understood the fundamental principles of physics, their internal context and mathematical formulation and have acquired methods based on these that are suitable for the theoretical analysis, modelling and simulation of relevant processes.
- They have applied their knowledge to examples of physical tasks and in some cases deepened it, thereby acquiring a foundation for problem-solving skills.
- They are capable of a basic understanding of physical problems. As a rule, however, this will not enable a deeper understanding of current research areas.
- They are thus able to independently classify physical and sometimes also interdisciplinary problems that require a goal-oriented and logically sound approach on the basis of scientific knowledge and to analyse and solve them using scientific and mathematical methods.
- They are familiar with the basic principles of experimentation, can use modern physical measurement methods and are able to correctly assess the significance of the results.
- As a rule, they have also acquired an overview of selected other scientific or technical disciplines.
- They are able to apply their knowledge in different areas and act responsibly in their professional activities. They can also recognise new trends in their specialist area and incorporate their methodology into their further work, if necessary after appropriate training.
- They are able to constantly supplement and deepen the knowledge acquired in the Bachelor's degree programme on their own responsibility. They are familiar with suitable learning strategies (lifelong learning); in particular, they are in principle capable of pursuing a consecutive Master's degree programme.
- During their studies, they have gained initial experience with interdisciplinary qualifications (e.g. time management, learning and working techniques, willingness to co-operate, teamwork, etc.).

skills, communication skills, rules of good scientific practice) and can further develop these skills.

- They have learnt communication techniques and are familiar with the basic elements of English technical language.
- They are able to solve a simple scientific problem and present their results in an oral presentation and in writing (demonstrated in the Bachelor's thesis).

Study objectives Master

Building on a first university degree, the Master's programme leads to the acquisition of additional analytical and methodological skills. At the same time, the specialised knowledge and skills from the first degree are deepened and expanded. Graduates of the Master's degree programme in Physics have acquired specialist knowledge in several sub-subjects of physics at the highest international level and are capable of independent scientific work. They thus fulfil the comprehensive job description of a physicist, which is valued for its breadth and flexibility. In principle, they are qualified to move on to a doctoral phase. In detail, this means

- They have deepened their mathematical and scientific knowledge, broadened their overview of interrelationships within physics and with neighbouring disciplines and specialised in a particular area of physics in such a way that they can keep up with current international research.
- They have also applied their knowledge to complex physical problems and tasks in an exemplary manner and can analyse, formulate and solve them as far as possible on a scientific basis.
- You will be able to plan, set up and carry out experiments to solve complex physical problems and interpret the results (focus on experimental physics) or use simulation and modelling on the basis of fundamental physical principles (focus on theoretical physics).
- They have acquired social skills during their studies. These interdisciplinary skills are largely integrated into the specialised courses and are primarily acquired during the research phase.
- During the one-year research phase, you will have acquired the ability to familiarise yourself with a popular technical-physical special field, to research and understand the current international specialist literature on the subject, to design and carry out experiments or theoretical methods in the field, to classify the results in the light of a wide variety of physical phenomena and to draw conclusions from them for technical developments and the progress of science.
- After the research phase, they have the necessary stamina to deal with failures, unexpected difficulties and delays in research and development projects and, if necessary, to reach the goal with a modified strategy.
- They are able to work in areas other than the specialisation they studied in the Master's degree programme and to apply their basic knowledge of physics together with the scientific methods and problem-solving strategies they have learned.
- They are able to comprehensively discuss complex physical issues and their own research results in the context of current international research and present them in written (Master's thesis) and oral form (lecture with free discussion).
- They are aware of their responsibility towards science and the possible consequences of their activities for the environment and society and act in accordance with the principles of good scientific practice.[2]

---

[2] Cf. the memorandum presented by the German Research Foundation (DFG) in December 1997 entitled "Proposals for Safeguarding Good Scientific Practice" Recommendations of the Commission on *Self-Regulation in Science* (/www.dfg.de/download/pdf/dfg_im_profil/reden_stellungnahmen/download/empfehlung_wiss_ pra-xis_0198.pdf).

Learning outcomes, didactic methods and suitable forms of assessment

The study objectives of a physics degree programme are achieved by students acquiring a variety of knowledge, skills and competences during their studies using different didactic methods. For the sake of clarity, the definition of the terms as used by the European Union is listed here again[3] :

> *"Learning outcomes": statements about what a learner knows, understands and is able to do after completing a learning process. They are defined as knowledge, skills and competences;*
>
> *"Knowledge": the result of processing information through learning. Knowledge refers to the totality of facts, principles, theories and practice in a field of work or learning. In the European Qualifications Framework, knowledge is described as theory and/or factual knowledge;*
>
> *"Skills" means the ability to apply knowledge and use know-how to perform tasks and solve problems. In the European Qualifications Framework, skills are described as cognitive skills (logical, intuitive and creative thinking) and practical skills (dexterity and use of methods, materials, tools and instruments);*
>
> *"Competence" means the proven ability to use knowledge, skills and personal, social and methodological abilities in work or learning situations and for professional and/or personal development. In the European Qualifications Framework, competence is described in terms of the assumption of responsibility and autonomy.*

In this section, certain learning outcomes that are to be achieved in a physics degree programme are grouped together. "Area" is a placeholder for the sub-area of physics covered in the corresponding module. For each of these groups, diagnostic methods (types of courses) are proposed with which (or a combination of) the objectives can be achieved. Other, innovative forms of courses to promote the above-mentioned competences are also conceivable.

During the degree programme, coursework and examinations are used to determine the extent to which students have achieved the learning objectives. This can be expressed both by the form of examination used and by the content of the examination. In the following, examination forms that are suitable for testing are suggested for each group of learning outcomes. The suggested forms of examination can be supplemented by other (innovative) forms of examination in order to cover the specified learning objectives as fully as possible.

[3] See, for example, the "Recommendation of the European Parliament and of the Council of 23 April 2008 on the establishment of the European Qualifications Framework for lifelong learning" (PE-CONS 3662/1/07 REV 1): http://register.consilium.europa.eu/pdf/de/07/st03/st03662-re01.de07.pdf

Physics Bachelor programme

Group 1: Subject-specific learning outcomes

Learning outcomes

- The students have a sound factual knowledge of the field.
- The students have understood the logical structure of the field and know the mathematical description of the physical laws.
- Students are able to derive the relevant laws of the field and justify them with key experiments.
- The students know the prominent examples of the field.
- The students have acquired a clear idea of physical phenomena in the field and are able to communicate in a clear way about physical issues in the field.

Didactic methods:

- Lecture (partly with demonstration experiments)
- Self-study from textbooks
- Learning in a group

Suitable forms of examination:

- Oral examination
- Written exam (with appropriate type of questions)

Group 2: Mathematical modelling

Learning outcomes

- Students are able to mathematically formulate and solve specific tasks in the field.
- Students can use suitable calculation techniques to solve problems.
- Students are able to find and implement analytical solutions for physical problems.
- Students are able to make suitable approximations in the solution approach.
- The students are familiar with the processing of sample tasks from the field.
- The students know the prominent examples of the field and are able to solve selected examples with an appropriate degree of difficulty.
- Students are able to independently expand their knowledge in the field and obtain suitable literature for this purpose.

Didactic method:

- Exercises

Suitable forms of examination:

- Exam
- Oral examination

Group 3: Experimental techniques

Learning outcomes

- Students are familiar with the basic principles of experimentation.
- Students are proficient in the operation of standard measuring devices.
- Students are able to apply modern measurement methods.
- Students are familiar with the functionality and accuracy of various measuring devices.
- Students are familiar with computer-aided measurement data acquisition.
- Students can interpret measurement data correctly.
- Students will be able to carry out appropriate error estimations and master the calculation of error propagation.
- Students are familiar with the adaptation of functions to measurement data (linear regression, fit procedures, etc.).
- Students master the clean and complete logging of measurement data.
- Students are able to present measurement results clearly in tabular and graphical form.
- The students have practised the application of theoretical principles to concrete experiments.
- The students have acquired a clear idea of physical phenomena in the field and are able to communicate in a clear way about physical issues in the field.

Didactic method:

- Laboratory practicals
- Project internships

Suitable forms of examination:

- Academic achievement (certified test protocols)
- Laboratory report
- Practical examination with experiment and evaluation, if applicable[4]

[4] As a rule, a work placement should be completed by successful participation. If an examination seems appropriate, it could be organised according to the following example: At the end of a practical course, each group draws one of the completed experiments by lot and carries it out again under examination conditions (suitable literature is provided). There is a short questioning of each group or, if necessary, each individual. Each person prepares their own report immediately after carrying out the experiment. The grading is based on the oral questioning and the quality of the protocol, if necessary also taking into account the skilfulness and accuracy of the experiment.

Group 4: Communication

<u>Learning outcomes</u>

- Students are able to independently research literature on a given topic.
- Students master the independent acquisition of knowledge from books and specialised journals.
- Students are able to acquire a field of knowledge independently.
- Students can structure and give a presentation appropriately.
- Students can create an appealing presentation (PowerPoint or similar).
- Students are able to lead a scientific discussion (on their own topic as well as on the topics of other seminar participants).
- Students are proficient in German and, to a limited extent, English technical language in free speech.

<u>Didactic methods:</u>

- Seminars

<u>Suitable forms of examination:</u>

- Seminar lecture

Group 5: Linking competences

<u>Learning outcomes</u>

- The students have consolidated and deepened their overview of the various subject areas.
- Students have recognised parallels in the theoretical concepts (e.g. waves, va riation principle) and can use these to tackle new types of problems.
- Students know the effects of findings from one area on other areas.
- Students have a solid overview of the logical thought structure of physics and can correctly categorise newly acquired knowledge.
- The students have an idea of physics as a whole and its various manifestations on different length and energy scales.

Didactic methods:

- Seminars on cross-cutting topics
- Advanced internship
- Lectures (with corresponding notes)
- Self-study using textbooks
- Learning in groups
- Learning through teaching

Suitable forms of examination:

- Oral examination (interdisciplinary)
- Accompanying portfolio, if applicable, e.g. as coursework

Group 6: Project work / teamwork

Learning outcomes

- The students have learnt problem-oriented work.
- The students are able to create a realistic schedule for their own project.
- The students have trained key skills such as independence and teamwork.
- Students are able to familiarise themselves independently with a topic.
- Students are able to present their project orally and in writing.

Didactic methods:

- Project internships
- Research internships
- Bachelor thesis

Suitable forms of examination:

- Project report
- Project presentation as a lecture
- Final thesis

Group 7: Numerical methods

Learning outcomes

- Students are familiar with the use of computers to solve complex tasks.
- Students are familiar with numerical solution methods used in physics.

- Students are able to write programmes (in at least one programming language) to solve physical problems.
- Students are able to present calculated results appropriately.

Didactic methods:

- Lecture
- Exercise
- Computer internship

Suitable forms of examination:

- Project report
- Project presentation as a lecture

Group 8: Measurement techniques

Learning outcomes

- Students know the function of electronic components and circuits.
- Students can use electronics correctly to record measurement data.
- Students are familiar with the basics of control, regulation and measurement technology.
- Students can use computers to record measurement data and control experiments

Didactic methods:

- Electronics internship
- Project internships
- Integration into other internships

Suitable forms of examination:

- Project report
- Project presentation as a lecture

Group 9: Scientific work

Learning outcomes

- Students can familiarise themselves with a sub-area of a specialist field under supervision.
- Students are able to familiarise themselves with a measurement method or a theoretical concept. They can work on their own small project using scientific methods.
- Students understand selected specialised literature on their project.
- The students gained an insight into the working methods of a research team.

- Students can write a scientific paper.
- Students can give a scientific presentation.
- The students have learnt to deal with critical questions in a scientific discussion and to defend their own results.
- Students know the rules of good scientific practice.

Didactic methods:

- Guided scientific activity
- Bachelor thesis

Suitable forms of examination:

- scientific lecture
- Bachelor thesis

Physics Master's programme

Group 10: Experimental Physics

Learning outcomes

- The students have familiarised themselves with a selected special field of experimental physics and are able to start working in an experimental research group in this field.
- The students have an overview of the established knowledge in the specialised field.
- Students are familiar with significant developments in the field from recent years and decades and have an idea of current unresolved issues in the field.
- Students know the experimental techniques used in the field and can judge which techniques are suitable for measuring certain physical quantities.
- Students are familiar with the advantages and disadvantages of individual experimental techniques and know how the different techniques complement each other.
- Students know the relevant models and approximations for describing physical phenomena in the field.
- Students are aware of the limitations of the models used.

Didactic methods:

- Lecture on a specialised area of experimental physics

Suitable forms of examination:

- Oral examination

Group 11: Theoretical Physics

Learning outcomes

- The students have familiarised themselves with a selected special field of theoretical physics and are able to start working in a theoretical research group in this field.
- The students have an overview of the established knowledge in the specialised field.
- Students are familiar with significant developments in the field from recent years or decades and have an idea of current unresolved issues in the field.
- Students are familiar with the theoretical methods used in this field.
- Students are familiar with the mathematical techniques used to derive and apply the methods.
- Students are familiar with analytical and numerical methods that can be used to solve problems in the field.

- Students will be able to estimate the numerical computational effort required when using a specific method to solve problems of varying complexity.
- Students know the limits of feasibility with today's computing power for various problems in the field.
- Students are familiar with different approximations that can be used to solve problems and can weigh up their advantages and disadvantages.

Didactic methods:

- Lecture on a specialised area of theoretical physics
- Exercise if necessary

Suitable forms of examination:

- Exam
- Oral examination

Group 12: Scientific discourse

Learning outcomes

- Students are able to independently research literature on a given, current topic from modern physics, some of which is still the subject of research.
- Students are able to work independently on a current field of knowledge.
- Students can structure and deliver a lecture on a complex topic in modern physics in such a way that a physically literate audience can follow the lecture well. They can also interest the audience in a complex specialised topic by structuring the lecture.
- Students are able to create an appealing presentation (PowerPoint or similar).
- Students are able to lead a scientific discussion (on their own topic as well as on the topics of other seminar participants).
- Students are proficient in German and English technical language in free speech.

Didactic methods:

- Seminar on a specialised area

Suitable forms of examination:

- Seminar lecture

Group 13: Communication

Learning outcomes

- The students have acquired social skills that enable them to integrate themselves into a research or development team.
- Students can communicate easily in German and English within the team.
- Students are able to recognise and assess future problems, technologies and scientific developments and incorporate them into their work thanks to the technical depth and breadth of the skills they have acquired.
- Students can work independently in a scientific manner and organise, implement and manage complex projects.
- Students have acquired scientific, technical and social skills (ability to abstract, systematic thinking, teamwork and communication skills, international and intercultural experience, etc.) and are thus particularly well prepared to take on management responsibility.

Didactic methods:

- Integration into a research group during the one-year research phase
- Participation in group discussions and research seminars
- Participation in a symposium, if applicable
- Participation in the colloquium
- Courses on key qualifications (e.g. Studium Generale)

Suitable forms of examination:

- The skills acquired are included in the assessment of the three modules from the research phase.

Group 14: Scientific work

Learning outcomes

- Students can familiarise themselves independently with a new field of research.
- Students are able to familiarise themselves with the measurement methods or theoretical concepts of a research area.
- Students can gain an overview of the specialist literature on a research project.
- Students can integrate themselves into a research team.
- Students master the operation of complex measuring equipment or can use extensive computer programmes to solve problems numerically.
- Students can work in an international team.
- Students can write a scientific paper.

- Students can give a scientific presentation and present their own results in the context of the current state of science in the field.
- Students can also deal with critical questions in a scientific discussion and defend their own results in a well-founded manner.
- The students can create a poster presentation and discuss their results scientifically.
- The students act according to the rules of good scientific practice.

Didactic methods:

- Research activities
- Master thesis

Suitable forms of examination:

- scientific lecture
- Report on research project
- Poster presentation
- Written presentation as in a publication
- Master thesis

Group 15 (specialising in experimental physics): Measurement techniques

Learning outcomes

- Students will be able to understand the function of complex measuring equipment and operate it safely.
- Students can adjust complex measurement setups and optimise them for measurement.
- Students are able to work with technicians and engineers to design devices that are intended to fulfil a specific function in a complex measuring process.
- Students know strategies to ensure that the measurement functions correctly in complex measurement processes.
- The students have gained experience in searching for errors and faults in complex measurement processes.

Didactic methods:

- Research-related internships
- Experimental research during the one-year research phase
- Master's thesis in experimental physics

Suitable forms of examination:

- The competences are included in the assessment of the three modules from the research phase.

Group 16 (specialising in theoretical physics): Numerical Methods

Learning outcomes

- Students can use complex computer programmes from theoretical physics to answer open questions from current research.
- Students are able to further develop parts of complex computer programmes and integrate new functions into the programmes.
- Students are familiar with strategies for testing whether complex computer programmes work without errors.
- The students have gained experience in searching for errors in the development of computer programmes in theoretical physics.
- Students can correctly estimate the accuracy of the calculated results with regard to the approximations made and the numerical methods used.
- Students have gained an in-depth understanding of mathematical principles and their application to experimental observations.
- Students can use computer algebra to solve complex theoretical approaches.

Didactic methods:

- Research in theoretical physics during the one-year research phase
- Master's thesis in theoretical physics

Suitable forms of examination:

- The competences are included in the assessment of the three modules from the research phase

Sample curricula Bachelor

The sample curricula for the Bachelor's degree programme presented below are completely equal, but each has its own special features. While in version A the practical courses are integrated into the experimental physics modules, version B assigns separate modules to the beginner and advanced practical courses. Version C contains a higher proportion of applied physics, version D comprises integrated modules that combine courses in theoretical and experimental physics for a sub-area of physics.
Finally, version E is designed in such a way that some of the modules extend over two semesters.

Example curriculum version A

Experimental Physics: Mechanics, Heat 10-12
CP 4-5 SWS Lecture
2 SWS Practical
course (beginners)
Written exam + academic achievement (practical course)

Experimental Physics: Electricity, Waves, Optics 10-12
CP 4-5 SWS Lecture
2 SWS Practical
course (beginners)
Written exam + academic achievement (practical course)

Experimental Physics: Atoms, Molecules, Quanta 10-12
CP 4 SWS Lecture
2 SWS Exercise
Internship (beginner/advanced)
Oral examination or written examination + coursework (practical course)

Experimental Physics: Nuclei, Elementary Particles 10-
12 CP 4 SWS Lecture
2 SWS Exercise
Internship (advanced)
Oral examination or written examination + coursework (practical course)

Experimental Physics: Condensed Matter 10-12 CP 4
SWS Lecture
2 SWS Exercise
Internship (advanced)
Oral examination or written examination + coursework (practical course)

Experimental project internship 10-12 CP
4-6 weeks of independent project-orientated work
Project report/project presentation plus oral examination on the whole of experimental physics

Theoretical Physics: Mathematical Methods 4-8 CP 2-4
SWS Lecture
1-2 SWS Exercise
Written exam

Theoretical Physics: Mechanics 6-10 CP

4 SWS Lecture
2 SWS Exercise
Written or oral exam

<u>Theoretical Physics: Electrodynamics</u> 6-10
CP 4 SWS Lecture
2 SWS Exercise
Written or oral exam

<u>Theoretical Physics: Quantum Mechanics</u> 6-10
CP 4 SWS Lecture
2 SWS Exercise
Written or oral exam

<u>Theoretical Physics: Thermodynamics / Statistical Physics</u> 6-10 CP
4 SWS Lecture
2 SWS Exercise
Written or oral exam

<u>Theoretical project internship</u> 10-12 CP
4-6 weeks of independent project-oriented work, e.g. application of numerical methods with own programming or application of finished theoretical programmes to physical problems, etc.
Project report/project presentation plus oral examination on the whole of theoretical physics

<u>Mathematics: Analysis one-dimensional</u> 8-10
CP 4 SWS Lecture
2 SWS
Exercise
Written exam

<u>Mathematics: Analysis multidimensional</u> 8-10
CP 4 SWS Lecture
2 SWS
Exercise
Written exam

<u>Mathematics: Linear Algebra</u> 8-10 CP
4 SWS Lecture
2 SWS
Exercise
Written exam

<u>Mathematics: Differential Equations/Functional Theory</u> 8-10 CP
4 SWS Lecture
2 SWS
Exercise
Written exam

<u>Physics seminar</u> 6-8 CP 2 SWS
Seminar
Evaluation of the seminar presentation

<u>Specialised supplementary elective area</u> 15-30 CP
Modules from the fields of chemistry, engineering, mathematics, computer science, or specialisation modules on physical topics or work placement

Key qualifications, Studium generale 5-10 CP
Topics such as project management, personnel management, scientific ethics, economics, business start-ups, etc.

Bachelor thesis 12 CP
Scientific work close to research Final thesis plus
presentation on the thesis

Summary Version A:

Credit points:
Experimental Physics (incl. practicals): 60-72
CP Theoretical Physics: 38-60 CP
Mathematics32-40 CP
Elective area: 20-40 CP
Seminar6-8 CP
Bachelor thesis12 CP

Examinations:
15 written or oral examinations (including 2 cross-topic examinations) 2 seminar presentations
1 Project report
1 Final thesis
+ Elective area

For comparison, recommendations KFP:

Lectures / Exercises in Experimental Physics	30 - 40 CP	CP50 - 80
Internships for beginners	10 - 20 CP	
Advanced internships	10 - 20 CP	
Lectures / Exercises Theoretical Physics	30 - 40 CP	
Lectures / Exercises Mathematical Foundations	30 - 40 CP	
Elective lectures / exercises	20 - 40 CP	
Bachelor thesis with colloquium	10 - 20 CP	

Example curriculum version B

Experimental Physics: Mechanics, Heat 6-8
CP 4-5 SWS Lecture
2 SWS
Exercise
Written exam

Experimental Physics: Electricity, Waves, Optics 6-8
CP 4-5 SWS Lecture
2 SWS
Exercise
Written exam

Experimental Physics: Atoms, Molecules, Quanta 6-8
CP 4 SWS Lecture
2 SWS Exercise
Oral exam or written exam

Experimental Physics: Nuclei, Elementary Particles 6-
8 CP 4 SWS Lecture
2 SWS Exercise
Oral exam or written exam

Experimental Physics: Condensed Matter 6-8 CP 4
SWS Lecture
2 SWS Exercise
Oral exam or written exam

Beginners' internship part I 6-10 CP Academic
achievement

Beginners' internship part II 8-12 CP
Oral examination on the whole of classical experimental physics
+ academic achievement (internship)

Advanced internship 10-14 CP
Oral examination on the whole of experimental physics + coursework (practical course)

Theoretical Physics: Mathematical Methods 4-8 CP 2-4
SWS Lecture
1-2 SWS Exercise
Written exam

Theoretical Physics: Mechanics 6-10
CP 4 SWS Lecture
2 SWS Exercise
Written or oral exam

Theoretical Physics: Electrodynamics 6-10
CP 4 SWS Lecture
2 SWS Exercise
Written or oral exam

Theoretical Physics: Quantum Mechanics 6-10
CP 4 SWS Lecture

2 SWS Exercise
Written or oral exam

Theoretical Physics: Thermodynamics / Statistical Physics 6-10 CP
4 SWS Lecture
2 SWS Exercise
Written or oral exam

Theoretical Physics: Seminar 8-10 CP
Topics that connect many areas of theoretical physics, e.g. certain solution methods, principles, symmetries or the like.
Seminar presentation plus oral examination on the entire field of theoretical physics

Mathematics for Physicists I 8-10
CP 4 SWS Lecture
2 SWS
Exercise
Written exam

Mathematics for Physicists II 8-10
CP 4 SWS Lecture
2 SWS
Exercise
Written exam

Mathematics for Physicists III 8-10
CP 4 SWS Lecture
2 SWS
Exercise
Written exam

Physics seminar 6-8 CP 2 SWS
Seminar
Evaluation of the seminar presentation

Specialised supplementary elective area 20-30 CP
Modules from the fields of chemistry, engineering, mathematics, computer science, or specialisation modules on physical topics

Key qualifications, Studium generale 5-10 CP
Topics such as project management, personnel management, scientific ethics, economics, business start-ups, etc.

Professional internship 8-10 CP
Report/presentation (ungraded)

Bachelor thesis 12 CP
Scientific work close to research Final thesis plus
presentation on the thesis

Summary Version B:

Credit points:

Experimental Physics (lecture/exercise):	30-40 CP
Internships:	24-36 CP
Theoretical physics:	36-58 CP
Mathematics:	24-30 CP
Elective area:	25-40 CP
Seminar	6-8 CP
Internship:	8-10 CP
Bachelor thesis:	12 CP

Examinations:

16 written or oral examinations (including 3 cross-topic examinations) 2 seminar presentations
1 Final thesis
+ Elective area

For comparison, recommendations KFP:

Lectures / Exercises in Experimental Physics	30 - 40 CP
Internships for beginners	10 - 20 CP
Advanced internships	10 - 20 CP
Lectures / Exercises Theoretical Physics	30 - 40 CP
Lectures / Exercises Mathematical Foundations	30 - 40 CP
Elective lectures / exercises	30 - 40 CP
Bachelor thesis with colloquium	10 - 20 CP

Example curriculum version C
(less theory, but more applied physics)

Experimental Physics: Mechanics, Heat 10-12
CP 4-5 SWS Lecture
2 SWS Practical
course (beginners)
Written exam + academic achievement (practical course)

Experimental Physics: Electricity, Waves, Optics 10-12
CP 4-5 SWS Lecture
2 SWS Practical
course (beginners)
Written exam + academic achievement (practical course)

Experimental Physics: Atoms, Molecules, Quanta 10-12
CP 4 SWS Lecture
2 SWS Exercise
Internship (beginner/advanced)
Oral examination or written examination + coursework (practical course)

Experimental Physics: Nuclei, Elementary Particles 10-
12 CP 4 SWS Lecture
2 SWS Exercise
Internship (advanced)
Oral examination or written examination + coursework (practical course)

Experimental Physics: Condensed Matter 10-12 CP 4
SWS Lecture
2 SWS Exercise
Internship (advanced)
Oral examination or written examination + coursework (practical course)

Applied physics: e.g. semiconductors, materials science, etc. 10-12 CP 4
SWS Lecture
2 SWS
Practical
exercise
Oral examination or written examination + coursework (practical course)

Experimental project internship 10-12 CP
4-6 weeks of independent project-orientated work
Project report/project presentation plus oral examination on the whole of experimental physics

Seminar on Experimental Physics or Applied Physics 6-8 CP 2
SWS Seminar
Assessment of the seminar presentation (if necessary, oral examination on the entire experimental physics instead of above. In this case, the seminar presentation is only coursework)

Theoretical Physics: Mathematical Methods and Theoretical Mechanics 8-10 CP 2
SWS Lecture Mathematical Methods (1st semester)
1 SWS exercise
4 SWS Lecture Theoretical Mechanics (2nd
semester) 2 SWS Exercise
Exam

Theoretical Physics: Electrodynamics 6-8 CP
4 SWS Lecture
2 SWS Exercise
Written or oral exam

Theoretical Physics: Introduction to Quantum Mechanics and Statistical Physics 8-12 CP 3 SWS Lecture Introduction to Quantum Mechanics (4th semester)
1-2 SWS exercise
3 SWS Lecture Introduction to Thermodynamics and Statistical Physics (5th semester) 1-2 SWS Exercise
Oral examination (if necessary, incorporating prior knowledge from mechanics and electrical engineering as this can be well justified in terms of content → networking)

Mathematics for Physicists I 8-10
CP 4 SWS Lecture
2 SWS
Exercise
Written exam

Mathematics for Physicists II 8-10
CP 4 SWS Lecture
2 SWS
Exercise
Written exam

Mathematics for Physicists III 8-10
CP 4 SWS Lecture
2 SWS
Exercise
Written exam

Specialised supplementary elective area 20-30 CP
Modules from the fields of chemistry, engineering, mathematics, computer science, or specialisation modules on physical topics

Key qualifications, Studium generale 5-10 CP
Topics such as project management, personnel management, scientific ethics, economics, business start-ups, etc.

Professional internship 8-10 CP
Report/presentation ungraded

Bachelor thesis 12 CP
Scientific work close to research Final thesis plus
presentation on the thesis

Summary version C
(less theory, but more applied physics)

Credit points:
Experimental Physics (incl. practicals): 76-92
CP Theoretical Physics: 22-30 CP
Mathematics24-30 CP
Elective area: 25-40 CP
Work placement: 8-10 CP
Bachelor thesis12 CP

Examinations:
13 written or oral examinations (including 2 cross-topic examinations) 2 seminar presentations
2 reports (project and work placement) 1 final thesis
+ Elective area

For comparison, recommendations KFP:

Lectures / Exercises in Experimental Physics	30 - 40 CP	CP50 - 80
Internships for beginners	10 - 20 CP	
Advanced internships	10 - 20 CP	
Lectures / Exercises Theoretical Physics	30 - 40 CP	
Lectures / Exercises Mathematical Foundations	30 - 40 CP	
Elective lectures / exercises	30 - 40 CP	
Bachelor thesis with colloquium	10 - 20 CP	

Example curriculum version D
(Integrated courses experiment/theory)

Integrated course: Mechanics 10-15
CP 6-8 SWS Lecture
2-4 SWS Exercise
Written exam

Integrated course: Heat, thermodynamics, statistical physics 10-15 CP
6-8 SWS Lecture
2-4 SWS Exercise
Oral exam or written exam

Integrated course: Electricity, Electrodynamics 10-15
CP 6-8 SWS Lecture
2-4 SWS Exercise
Oral exam or written exam

Integrated course: Atoms, molecules, quantum mechanics 10-
15 CP 6-8 SWS Lecture
2-4 SWS Exercise
Practical course
(beginner/advanced) Oral exam or
written exam

Experimental Physics: Nuclei, Elementary Particles 6-
8 CP 4 SWS Lecture
2 SWS Exercise
Oral exam or written exam

Experimental Physics: Solids 6-8 CP 4
SWS Lecture
2 SWS Exercise
Oral exam or written exam

Beginners' internship part I 8-10 CP Academic
achievement

Beginners' internship part II 8-10 CP
Academic achievement + practical examination with experimentation and evaluation

Advanced internship 10-12 CP Academic
achievement

Mathematics for Physicists I 8-10
CP 4 SWS Lecture
2 SWS
Exercise
Written exam

Mathematics for Physicists II 8-10
CP 4 SWS Lecture
2 SWS
Exercise
Written exam

Mathematics for Physicists III 8-10
CP 4 SWS Lecture
2 SWS
Exercise
Written exam

Mathematics for Physicists IV 8-10
CP 4 SWS Lecture
2 SWS
Exercise
Written exam

Physics seminar 6-8 CP 2 SWS
Seminar
Evaluation of the seminar presentation

Project internship (experimental or theoretical) 6-8 CP 4-6
weeks of independent project-orientated work Project report
or project presentation

Specialised supplementary elective area 20-30 CP
Modules from the fields of chemistry, engineering, mathematics, computer science, or specialisation modules on physical topics

Key qualifications, Studium generale 5-10 CP
Topics such as project management, personnel management, scientific ethics, economics, business start-ups, etc.

Professional internship 8-10 CP
Report/presentation (ungraded)

Bachelor thesis 12 CP
Scientific work close to research Final thesis plus
presentation on the thesis

Summary version D

Credit points:

Integrated courses:	40-60 CP
Further experimental physics and practical courses:	38-48 CP
Seminar and project	12-16 CP
Mathematics	32-40 CP
Elective area:	25-40 CP
Internship:	8-10 CP
Bachelor thesis	12 CP

Examinations:
10 written or oral examinations
2 seminar presentations
2 reports (project and work placement) 1 final thesis
+ Elective area

For comparison, recommendations KFP:

Lectures / Exercises in Experimental Physics	30 - 40 CP	CP50 - 80
Internships for beginners	10 - 20 CP	
Advanced internships	10 - 20 CP	
Lectures / Exercises Theoretical Physics	30 - 40 CP	
Lectures / Exercises Mathematical Foundations	30 - 40 CP	
Elective lectures / exercises	30 - 40 CP	
Bachelor thesis with colloquium	10 - 20 CP	

Example curriculum version E
(some modules over two semesters)

Experimental Physics: Classical Physics 12-15 CP (over two semesters)
(mechanics, heat, electricity, optics)
8-10 SWS Lecture
4 SWS Exercise
If necessary 2 SWS tutorial
Coursework: Written exam in 1st
semester Oral exam in 2nd semester
Justification for the two partial examinations: Different examination form tests different learning outcomes

Experimental Physics: Modern Physics 8-12 CP (over two semesters)
(Theory of relativity, quanta, atoms, molecules)
6-8 SWS Lecture
2-4 SWS Exercise
Academic achievement: Written exam
in 3rd semester Oral exam in 4th
semester
Justification for the two partial examinations: Different examination form tests different learning outcomes

Experimental Physics: Nuclei, Elementary Particles, Astrophysics
5-7 CP 3-4 SWS Lecture
1-2 SWS Exercise
Written or oral exam

Experimental Physics: Solid State Physics 5-
7 CP 3-4 SWS Lecture
1-2 SWS Exercise
Written or oral exam

Experimental practical course I 5-10 CP (over two
semesters) Practical course (beginners) 1st + 2nd semester
Academic achievement: Successful completion of the
practical examination
The summary of the 1st + 2nd semester is adapted to the summary of the experimental physics lecture.

Experimental practical course II 5-10 CP (over two
semesters) Practical course (beginners) 3rd + 4th semester
Academic achievement: Successful completion of the
practical examination

Experimental practical course for advanced students I 5-
10 CP 5 semesters
Academic achievement: Successful completion of the
experiments Lecture

Experimental practical course for advanced students II 5-
10 CP 6 semesters
Academic achievement: Successful completion of the
experiments Poster

Theoretical Physics I: 9-18 CP (over two semesters)
Mathematical Methods and Theoretical Mechanics 6-8
SWS Lectures
3-4 SWS Exercise

1 SWS tutorial (if applicable)
Academic achievement: Written
exam 1st semester Oral exam 2nd
semester
The summary of the 1st + 2nd semester is adapted to the summary of the experimental physics and the practical course.

Theoretical Physics II: 12-18 CP (over two semesters)
Electrodynamics and quantum mechanics
8 SWS Lecture
4 SWS Exercise
Academic achievement: Written exam
1st semester Oral exam 2nd semester
The summary of the 3rd/4th semester is adapted to the summary of the internship.

Theoretical Physics IV: Statistical Physics 6-10 CP
3-4 SWS Lecture
1-2 SWS Exercise
Written or oral examination

Mathematics: Analysis one-dimensional 8-10
CP 4 SWS Lecture
2 SWS
Exercise
Written exam

Mathematics: Analysis multidimensional 8-10
CP 4 SWS Lecture
2 SWS
Exercise
Written exam

Mathematics: Linear Algebra 6-10 CP
3-4 SWS Lecture
1-2 SWS Exercise
Written exam

Mathematics: Differential Equations/Functional Theory 6-10 CP
3-4 SWS Lecture
1-2 SWS Exercise
Written exam

Physics seminar 6-8 CP 2 SWS
Seminar
Evaluation of the seminar presentation

Specialised supplementary elective area 25-30 CP
Modules from the fields of chemistry, engineering, mathematics, computer science, or specialisation modules on physical topics or work placement

Key qualifications, Studium generale 5-10 CP
Topics such as project management, personnel management, scientific ethics, economics, business start-ups, etc.

Bachelor thesis 12 CP
Scientific work close to research Final thesis plus
presentation on the thesis

Summary version E (some modules over two semesters)

Credit points:
Experimental Physics: 30-49 CP
Practicals20-40 CP
Theoretical Physics: 27-46 CP
Mathematics 28-40 CP
Seminar6-8 CP
Elective area: 30-40 CP
Bachelor thesis12 CP

Examinations:
11 written or oral examinations (including at least 4 oral examinations) 4 written examinations as coursework
2 practical examinations (work placement)
3 seminar presentations
1 poster
1 Final thesis
+ Elective area

For comparison, recommendations KFP:

Lectures / Exercises in Experimental Physics	30 - 40 CP
Internships for beginners	10 - 20 CP
Advanced internships	10 - 20 CP
Lectures / Exercises Theoretical Physics	30 - 40 CP
Lectures / Exercises Mathematical Foundations	30 - 40 CP
Elective lectures / exercises	30 - 40 CP
Bachelor thesis with colloquium	10 - 20 CP

For information: Credit points in the different course categories in the Bachelor's degree programme in Physics at German universities in 2007