Table of contents
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# Contents

**1. Introduction ..... 3**
1.1 The University of Zurich and its physics institutes ..... 3
**1.2 What will I learn in a physics degree? ..... 3**
**1.3 Why study physics at the University of Zurich? ..... 3**
**1.4 Physics Students Organization ..... 4**
**1.5 Job prospects ..... 4**
**1.6 Women in Physics ..... 5**
**2. Studying physics at the University of Zurich ..... 5**
**2.1 Overview ..... 5**
**2.2 Bachelor's degree ..... 6**
**2.2.1. Compulsory and core elective modules in the 3rd to 6th semester ..... 9**
**2.2.2. Elective modules in the BSc180 ..... 12**
**2.2.3. Booking of the lecture-free period ..... 13**
**2.3 Material covered in the modules of a bachelor's degree in physics ..... 14**
**2.3.1 Compulsory modules in the 1st to 2nd semester ..... 14**
**2.3.2 Compulsory and core elective modules in the 3rd to 6th semesters ..... 16**
**2.3.3 Core elective courses in the 4th - 6th semester ..... 18**
**2.4 Master's degree ..... 19**
**2.4.1 Physics of Condensed Matter ..... 22**
**2.4.2 Particle Physics ..... 24**
**2.4.3. Astrophysics and cosmology ..... 26**
**2.4.4. Bio- and medical Physics ..... 28**
**2.5. Examinations and performance assessments ..... 31**
**2.6 Minors for students with a major in physics ..... 31**
**2.6.1 Mathematics ..... 32**
**2.6.2 Astrophysics ..... 33**
**2.6.3 Chemistry ..... 33**
**2.6.4 Computational Sciences, 60 CP ..... 34**
**2.6.5 Neuroinformatics ..... 34**
**2.6.6 Minor in Simulations in the Natural Sciences, 30 CP ..... 35**
2.7 Physics as a minor for students with another major ..... 35
2.8 Teaching degree for Swiss "Maturität" schools (university-track secondary schools) ..... 38
**3. How to organize your studies ..... 38**
**3.1 Duration of Studies ..... 38**
**3.2 Personal mentoring, Advising ..... 39**

3.3 Time commitment for your studies and a part-time job ... 39
3.4 Research internships ... 39
3.5 Military ... 39
3.6 Mobility ... 39
4 Addresses and Information Services ... 40
5. Frequently asked questions and answers regarding a degree at the MNF ... 40
5.1 What documents contain the regulation of a degree at the MNF? ... 40
5.2 How is a program constructed? What academic degrees can I attain? ... 41
5.3 What is a minor? ... 41
5.4 How does the credit point system work? ... 41
5.4.1 How many credit points do I need? How much time do I have? ... 41
5.4.2 Can I compile my credit points freely? ... 42
5.4.3 How can I find my credit point status? ... 42
5.5 How is the degree structured? What are modules? ... 42
5.5.1 What types of modules are there? ... 42
5.5.2 Who is responsible for modules (including examinations or other performance records)? ... 42
5.5.3 How do I register for a module? ... 43
5.5.4 How do I earn my credit points? ... 43
5.6 What are module examinations? How are they conducted? ... 43
5.6.1 Do I have to register for individual module exams? Can I cancel my registration? ... 43
5.6.2 Will I receive an invitation for each of my module examinations? ... 43
5.6.3 When are the module examinations held? ... 43
5.6.4 How and when will I receive the results of my module examinations? ... 43
5.6.5 What are my possibilities for repetition? ... 44
5.6.6 What happens if I fail to attend an exam or a repetition exam? What should I do in this case? ... 44
5.6.7 How are performance controls conducted in modules for which no exam is intended? ... 44
5.7 What do we need to know about bachelor or master’s thesis? ... 44
5.8 Will I receive a bachelor’s or master’s degree automatically if I fulfil the necessary requirements? ... 45
5.9 How will my diploma look? ... 45
5.10 Can I switch university every semester? ... 45
6. Glossary and Abbreviations ... 45

# 1. Introduction

## 1.1 The University of Zurich and its physics institutes

The University of Zurich was founded in the year 1833. It is renowned worldwide as a center for education and research. With 3500 faculty members working at approximately 140 institutes, about 26000 students and 4000 graduations per year the UZH is the largest university in Switzerland. The university is committed to the unity of education and research and maintains all areas of foundational scientific research. The university also provides scientific services.

Education and research in physics have played an important role in the scientific life of Zurich since its founding. Amongst the physics professors at the University of Zurich, we find well-known names such as Rudolf Clausius, Max von Laue (Nobel Prize 1914), Albert Einstein (Nobel Prize 1922), Peter Debye (Nobel Prize 1936), Ervin Schrödinger (Nobel Prize 1933), Gregor Wentzel, Walter Heitler, Hans H. Staub and K. Alex Müller (Nobel Prize 1987).

Today, both the institutes of physics www.physik.uzh.ch/ and the institute of computational science, www.ics.uzh.ch/ are located on the campus of the University of Zurich-Irchel. Currently, there are approximately 200 students (including PhD students) majoring in physics. 20 professors and about 100 assistants teach these students, along with students in other subjects (studying physics as a minor, as well as those studying biology, chemistry and medicine). On average, 50 students begin studying physics every year, which enables faculty to provide them with intensive individual assistance. Our flexible degree regulations allow students to adapt their course work to individual needs.

The employees of both physics institutes are involved actively in many different areas of foundational studies in physics. This includes experimental and theoretical physics, magnetism and superconductivity, surface science, bio- and nanophysics, astrophysics and cosmology. More detailed information about the work of individual research teams can be found on the aforementioned institute websites.

### 1.2 What will I learn in a physics degree?

Physics is a good starting point for the study of sciences: Physics serves as a foundation for most areas of the natural sciences. The most important prerequisites for studying physics are an interest in the basic questions of nature, enthusiasm and a small measure of natural ability. We offer a broad general education in experimental and theoretical physics, which also includes practical experience in measurement techniques, in experimental methods as well as an education in mathematics and application-focused informatics.

Our degree does not only prepare physicists for scientific research. After graduation, you will be well positioned for work in business, in banks and insurances, as research managers and patent attorneys, in telecommunication and in optics firms, as analytical systems thinkers and generalists.

### 1.3 Why study physics at the University of Zurich?

The material covered by a degree in physics is the same as at all Swiss universities. Therefore, personal criteria are most important when choosing your location of study, such as:

- Independence
- Mentorship and the number of fellow students
- The emphasis on particular fields of study

- Type of master thesis

In Zurich you can study physics at either the ETH or the university. The quality of education is equivalent and the degrees are equally recognized internationally. Since it is possible to switch university during your course of study, it is possible to choose later. Additionally, students at the UZH and the ETH have the right to attend all events at the other university and receive credit at no additional costs. More information can be found at http://www.mnf.uzh.ch/en/studium/reglemente.html

The UZH places strong emphasis on practical experience, for instance by demanding a high degree of independence in students when constructing, measuring and analyzing their experiments in lab. Studies begin with a relatively comprehensive phenomenological introduction with the lectures physics I – III, along with a mandatory shop course. The compulsory portion of the math curriculum corresponds to the international standard. A master thesis at the university should take approximately 9 months. It is a good preparation for independent scientific work.

The Faculty of Science at the University of Zurich conducts individual module exams independently for every course (usually, lectures are concluded with a module exam, see chapter 5). Thus, students can chose to complete their degree part-time.

The UZH values a broad education. Therefore, students may choose to complete a minor of 30 or 60 credit points. In this case, the major course load will be reduced to 150 or 120 credit points respectively. It is also possible to complete all 180 credit points within the major. Students receive grades in their minor, which will appear in their diploma.

To obtain a master's degree, you must study for a minimum of 9 semesters in total. Thanks to the small number of students majoring in physics, the department can closely mentor all its students. Independent work is as a rule highly emphasized.

### 1.4 Physics Students Organization

The Physics Students' Organization at the University of Zurich (fpu) consists of a team of students in different years. The function of the students' organization is to support students in various ways: Academically, by conducting various information events (for instance, regarding the choice of a minor), mentorship of students in their first semester, maintenance of exam protocols, address lists and of a small library in the students organization room. Moral support is provided by the traditional Winter Dinner, basement parties, barbecues in summer and the coffee machine in the students' organization room. The students' organization also strives to facilitate the exchange of information between students and professors of experimental and theoretical physics and represents the concerns of students to higher committees (for instance, when it comes to the development of degree structure). The students' organization room is located in 36 J 28 (Building 36, Floor J, Room 28) and is open to all as a place to study and socialize and is highly frequented.

Email: fpu@physik.uzh.ch Homepage: fpu.physik.uzh.ch

### 1.5 Job prospects

Physicists can be found in many different professions in a modern society. Consequently, the professional lives of physicists can vary greatly. Physicists often work in jobs where you have to understand and analyze complex systems. This can include technological or natural systems, sections of the economy and even management of large companies.

Various studies have shown that about half of all physicists end up working in research. They are hired by universities, government research centres such as the European CERN in

Geneva or the Swiss EAWAG, as well as in the research divisions of industry. Approximately 30% of physicists work in industry in the field of management and consulting, in informatics or in “high tech” fields and about 20% work in education at tertiary and secondary education institutions.

### 1.6 Women in Physics

Women studying physics have neither more nor fewer difficulties than their male peers. One can perhaps observe tendencies for men to be more interested in technological and experimental problems, while women like to use their mathematical and analytical abilities. Because women decide to study physics out of real interest and used to have to fight against prejudice, many female physicists become very successful. A few years ago, women actually still had to cope with resistance and prejudice. In today’s generation, however, such problems no longer exist. A student’s success, for women as well as men, depends on their own interest and hard work.

Currently, the fraction of women amongst physics students at the University of Zurich is 20 - 25%. Until the year 2000, it was only 10%, but the number has continuously increased since then.

## 2. Studying physics at the University of Zurich

These guidelines summarize all information, including from higher-order regulations, which is relevant for studying physics at the University of Zurich (see chapter 5)

### 2.1 Overview

As of a few years, the university has been using the European Credit Transfer and Accumulation System (ECTS). A degree is composed of individual, thematically more or less independent units (modules), which each have some form of a performance assessment (this often means exams and grades). The structure of studies follows the Bologna-Model. The clear structuring encourages and eases the possibility for students to complete a portion of their degree at a different European University without delays.

Six semesters of study are necessary for a bachelor’s degree. The bachelor’s degree gives students a solid foundational education in physics and is completed with a bachelor’s thesis. The degree “Bachelor of Science UZH in Physics” (BSc UZH in Physics) serves as a basis for a variety of master’s programs. Three versions of the bachelor’s program are offered: a single major, meaning that all 180 credit points are completed in Physics, or with a minor of 30 or of 60 credit points (with 150 or 120 credits in the major, respectively)

In a master’s program, students specialize in a current field of research. The program lasts 3 semesters if students select a minor. The main focus of the program is on a master thesis in form of a research project at an advanced level of scientific work. The MSc degree, “Master of Science UZH in Physics,” qualifies you for academic work in physics and fulfils the scientific portion of a teaching degree for Swiss “Maturitätsschulen” (university-track secondary schools).

Following a MSc degree, you can complete a mentored, but continually more independent research project over 3 to 4 years to earn a doctoral degree, “Doctor scientiarum naturalium” (Dr.sc.nat. = Ph.D.). A Ph.D. is accepted worldwide as a qualification for independent research.

Students also have the option to reorient their direction of study after completion of their bachelor degree in physics. For instance, students can choose a new subject at the mathematical-natural scientific faculty for their master's degree (e.g. Computational Science, Environmental Studies, Computational Biology and Bioinformatics, Neuroinformatics, etc., see [www.mnf.uzh.ch/studium/studierende/studienlehrgaenge.html](www.mnf.uzh.ch/studium/studierende/studienlehrgaenge.html)) or switch to a different university.

The time spent to acquire a degree specified above are based on a full-time investment. Extensions are possible if you for instance are also working part-time (see chapter 3).

### 2.2 Bachelor's degree

A bachelor's degree in physics consists of three parts (see Table 1)

- Introductory modules I to III in physics with exemplary experiments and accompanying lab work.
- Higher level courses in areas of experimental physics, sometimes accompanied by a lab.
- A cycle of fundamental lectures in theoretical physics, some of which are core elective modules

This foundational education is rounded off with lectures in the fundamentals of mathematics, along with core elective and elective modules and their pro-seminars. During the lecture-free period we offer intensive courses, usually on practical topics such as informatics, electronics or workshops in mechanics.

By regulation, a bachelor can be completed in 6 semesters. 180 credit points are necessary for completion. In the bachelor, there are three options for completing a major in Physics: students may select a major for 180, 150 or 120 credits points. The latter two options must be accompanied by a minor program worth either 30 or 60 credit points.

The following table provides an overview of the number of credit points that must be earned in the form of compulsory, core elective and elective modules or as part of the minor in each of these three program options:

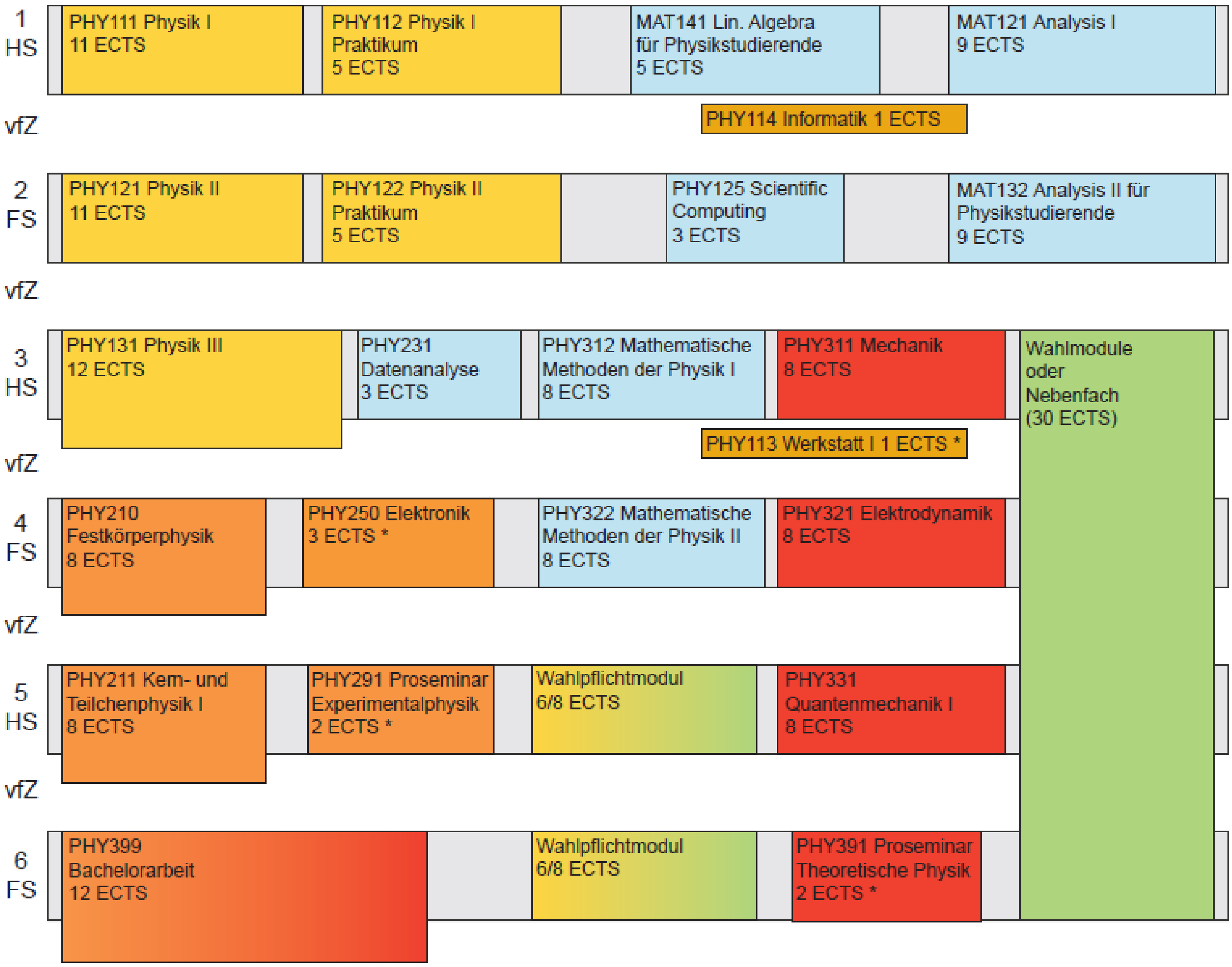
| | BSc180 | BSc150 | BSc120 |
|---|---|---|---|
| Compulsory lectures Physics | 150 CP<br>(including 4 CP in proseminars) | 140 CP | 110 CP |
| Core elective lectures Physics | 12 to 16 CP | 10 CP from two core elective blocks | 10 CP from two core elective blocks |
| Remaining ECTS | Elective modules offered in any subject at the University, for 14 to 18 CP | 30 CP minor | 60 CP minor |

1Courses at the language centre will not receive credit.

When a student successfully completes all requirements, they will receive the diploma "Bachelor of Science UZH in Physics."

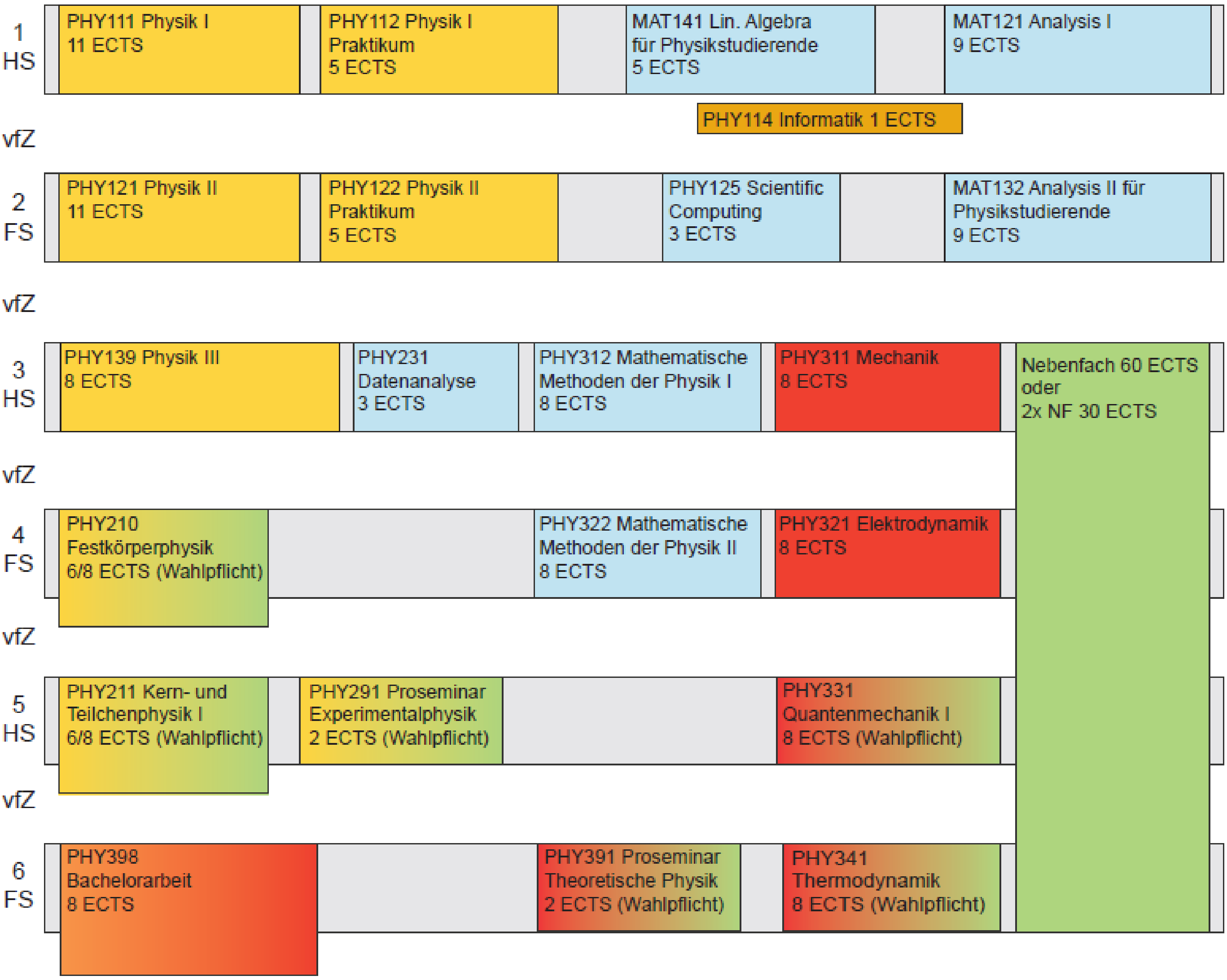
Student's GPA for their bachelor's degree is composed of a weighted average of all graded modules according to how many credit points they were worth. Grades from a student's major in physics and minor are recorded separately.

Übersicht über den Studiengang bis zum Bachelordiplom: Monofach bzw. Hauptfach 150 ECTS




(*) Wahlpflichtmodul für Hauptfach 150
HS: Herbstsemester
FS: Frühjahrsemester
vfZ: vorlesungsfreie Zeit
ECTS: ECTS-Punkte (European Credit Transfer System)

## Studienplan bis zum Bachelor ("Major/Minor"): Hauptfach 120 ECTS




HS: Herbstsemester
FS: Frühjahrsemester
vfZ: vorlesungsfreie Zeit
ECTS: ECTS-Punkte (European Credit Transfer System)

### Compulsory modules in the 1st and 2nd semester

The first year of a bachelor's degree emphasizes the phenomenology of classical physics during students' foundational education in mathematics and physics. This also serves the purpose of bringing students from different backgrounds onto the same level. Following modules are compulsory modules (CM) in the respective program options (BSc180, BSc150, BSc120):

Table

| Sem. | Modul | Class time (SWS or weeks) | | | | BSc180 | BSc150 | BSc120 | CW* Exam | Grade | KP |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lect-ures | Pract. course (Übung) | Pract. training | Block course | | | | | | |
| 1 | PHY111 Physics I | ~~6~~ | 2 | | | CM | CM | CM | 2 | yes | 11 |
| 1 | PHY112 Practical Training I | | | 3 | | CM | CM | CM | | yes | 5 |
| 1 | MAT121 Analysis I | 4 | 2 | | | CM | CM | CM | 6 | yes | 9 |
| 1 | MAT141 Lineare Algebra for the Natural Sciences | 3 | 1 | | | CM | CM | CM | 6 | yes | 5 |
| vfZ | PHY114 Informatics for Physics Students | | | | 2 | CM | CM | CM | | no | 1 |
| 2 | PHY121 Physics II | ~~6~~ | 2 | | | CM | CM | CM | 26 | yes | 11 |
| 2 | PHY122 Practical Training II | | | 3 | | CM | CM | CM | | yes | 5 |
| 2 | MAT132 Analysis II for Physics Students | 4 | 2 | | | CM | CM | CM | 27 | yes | 9 |
| 2 | PHY125 Scientific Computing | 1 | | 2 | | CM | CM | CM | | no | 3 |

*) Calendar week, during with the first exam is scheduled.

- PHY114: half day
- The requirement of MAT141 Linear Algebra for physics students can also be fulfilled with MAT111 Linear Algebra I and MAT112 Linear Algebra II. Students with a minor in Mathematics or taking Mathematics as their second teaching subject (regarding the Teaching Diploma for Upper Secondary Schools) must take MAT112.
- Students, who transferred to the UZH from a different university and had not passed lectures in Linear Algebra and/or Analysis, are considered to be repeating the compulsory modules MAT121, MAT122 and MAT141 (and MAT111, MAT112 Linear Algebra I & II).

### 2.2.1. Compulsory and core elective modules in the 3rd to 6th semester

In the second year, students take Physics III, which provides a phenomenological introduction to Quantum Mechanics. Students are also introduced to theoretical physics. In addition, students study more Mathematics and a few practical topics of their choice. BSc120 and BSc150 include two core elective blocks. In the table below, these will be referred to with the abbreviation CB1 and CB2. Students must complete one module in each core elective block. BSc180 includes only one core elective block. Students completing BSc180 must complete two of the six core elective modules.

| Sem. | Module | Class time (SWS or weeks) | | | BSc 180 | BSc 150 | BSc120 | CW exams | Grade | CP |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Lectures | Exercises | Block course | | | | | | |
| 3 | PHY131 Physics III | 5 | 2 | 3 | CM | CM | CM* | 2 | yes | 12 |
| 3 | PHY231 Data analysis | 1 | 2 | | CM | CM | CM | 51 | no | 3 |
| 3 | PHY311 Mechanics | 4 | 2 | | CM | CM | CM | 6 | yes | 8 |
| 3 | PHY312 Mathematical Methods in Physics I | 4 | 2 | | CM | CM | CM | 51 | yes | 8 |
| vfZ | PHY 113 Work shop I | | | 2 | CM | CB2 | -- | | no | 1 |
| 4 | PHY250 Elektronics | 2 | | | CM | CB2 | -- | -- | no | 3 |
| 4 | PHY210 Solid State Physics | 3 | 1 | 1 | CM | CM | CB1 | 23 | yes | 8 |
| 4 | PHY322 Mathematical Methods in Physics II | 4 | 2 | | CM | CM | CM | 25 | yes | 8 |
| 4 | PHY321 Elektrodynamics | 4 | 2 | | CM | CM | CM | 27 | yes | 8 |
| 5 | AST241 Introduction to Astrophysics | 3 | 1 | | CB | CB1 | -- | | yes | 6 |
| 5 | PHY211 Nuclear and Particle Physics I | 3 | 1 | 1 | CM | CM | CB1 | 2 | yes | 8 |
| 5 | PHY291 Proseminar in Experimental Physics | | 1 | | CM | CB2 | CB2 | -- | no | 2 |
| 5 | PHY331 Quantum Mechanics I | 4 | 2 | | CM | CM | CB1 | 6 | yes | 8 |
| 5 | PHY341 Thermodynamics | 3 | 1 | | CB | CB1 | CB1 | 7 | yes | 6 |
| 6 | PHY212 Physics of soft matter | 3 | 1 | | CB | CB1 | -- | 26 | yes | 6 |
| 6 | PHY213 Nuclear and Particle Physics II | 3 | 1 | 1 | CB | CB1 | -- | 25 | yes | 8 |
| 6 | PHY351 Quantum Mechanics II | 3 | 2 | | CB | CB1 | -- | 26 | yes | 8 |
| 6 | PHY352 Continuum Mechanics | 3 | 2 | | CB | CB1 | -- | 25 | yes | 8 |
| 6 | PHY361 Physics against cancer | 3 | 1 | | CB | CB1 | -- | 25 | yes | 6 |
| 6 | PHY391 Proseminar Theoretical Physics | | 1 | | CM | CB2 | CB2 | | yes | 2 |
| 6 | PHY399 Bachelor's thesis | | | 9 | CM | CM | -- | | yes | 12 |
| 6 | PHY398 Bachelor's thesis BSc120 | | | 6 | -- | -- | CM | | yes | 8 |

*Students in the BSc120 program complete PHY139 Physics III without lab. The module PHY139 is identical to PHY131, the only difference being the missing practical training. PHY139 and PHY131 are equivalent with regard to credits and repeat examinations.

- PHY113: half day
- For more details regarding exams and records of performance in modules without exams, see section 2.5.
- The experimental modules include lab experiments, which are conducted during intensive courses in the lecture-free period (for dates, see section 2.2.5). Students set up experiments, obtain measurements and analyze data. The ability of students to analyze data and calculate error, taught in PHY231, and in the practical trainings, is assumed. Students finally complete a written lab report.
- Students, who are minoring in Mathematics, can substitute PHY312 and PHY322 with different lectures in Mathematics. We especially recommend Complex Analysis.
- In the experimentally and the theoretically focused pro-seminars, each student is required to hold a presentation.

**Bachelor's Thesis**

For their bachelor's thesis, students actively participate in the work of a research group in experimental or theoretical physics. Students record the results of their thesis in a written report and present them to their seminar group. Both the report and presentation will be graded. You can find suggested topics for a bachelor's thesis at www.physik.uzh.ch/de/studium/bachelor-Masterarbeiten.html. You should complete your bachelor's thesis during the last semester of your bachelor's program, as it is required to be able to sign up for a master's program (see section 2.4).

The amount of work necessary for a bachelor's thesis including preparation time (reading relevant literature and discussion with advisors) and compiling of the thesis and presentation is equivalent to 12 credit points (meaning approximately 9 weeks full time studies). You must design a time plan for your work with your advisor before beginning your project. Remember that the experimental work required for a thesis is intrinsically subject to its own schedule when making your time plan. When you have agreed upon a time plan, it must be recorded in writing along with the date on which you will begin and a definitive deadline.

(An information sheet and application form can be found at http://www.physik.uzh.ch/en/study/studienberatung/formulare.html )

### 2.2.2. Elective modules in the BSc180

In the BSc180, remaining credit points missing from the total of 180 CP must be earned in elective modules. Students may select module in any subject area at the University or ETH. The Physics department offers the following modules:

| Sem. | Nr. | Title | Class time (SWS or weeks) | | | Exam period | Grade | CP |
|---|---|---|---|---|---|---|---|---|
| | | | Vor-lesung | Übun-gen | Block-kurs | | | |
| lecture free period | PHY123 | Work shop course II | | | 2 | | no | 1 |
| lecture free period | PHY224 | Programming in C++ | | | 2 | | no | 1 |
| lecture free period | PHY251 | Electronics course | | | 2 | | no | 3 |
| SS/FS | PHY261 | Tutorial | | 6 | | | no | 5 |
| | PHY271 | Additional practical training | | | | | no | 2 |

- PHY123 and PHY224: half day
- PHY261: Leading practical trainings or practical courses (Übung). The minimum requirement is a full time work load (on average 6 SWS) over two semesters in at least two different topics. PHY111/PHY121 (Physics I/II) and PHY112/122 (Practical training I/II) are prerequisites.
- PHY271: In general, students are awarded 2 CP for every experiment they successfully complete. Students are expected to work on these experiments independently and are not bound by a particular schedule.

The courses for the minor SIM (Simulations in the Natural Sciences, see chapter 2.6.6., page 39) are also recommended as individual elective modules.

Any extra credits from the core elective block (sections 2.3.3.) can also be counted here.

Courses at the language center cannot count as elective modules.

**Elective modules at the ETH**

All UZH students, who complete a performance assessment at the ETH, must be registered as "auditors" (www.rektorat.ethz.ch/de/studium/non-degree-angebote/fachstudierende.html) at the ETH, must book the units of performance and must additionally sign up for the end of semester or end of session exams via myStudies (www.mystudies.ethz.ch). Just like ETH students, UZH students can view their grades on myStudies. In addition, UZH students receive a written confirmation of any performance assessments they took by post.

### 2.2.3. Booking of the lecture-free period

Following table shows how to book the lecture-free period with intensive courses, labs and module exams. We offer certain courses on multiple dates depending on the number of students that sign up. The dates will be released during the preceding semester in the lecture catalogue. Intensive courses in workshop and informatics are independent modules and students must sign up for them on time.

After the fall semester (Christmas until mid-February)

| **Calendar week** | | **2** | **3** | **4** | **5** | **6** | **7** |
|---|---|---|---|---|---|---|---|
| **1. Semester** | Module exam | Physics I | | | | Analysis I / Lin. Alg. | |
| | Block course | | Informatics for Physics Students | | Informatics for Physics Students 1 | | Informatics for Physics Students 2 |
| **3. Semester** | Module exam | Physics III | | | | Mechanics | |
| | Block course | | Practical Training for Physics III / Work shop I, course 1 | Practical Training for Physics III / Work shop I, course 2 | Work shop I, course 1 | | Work shop I, course 2 |
| **5. Semester** | Module exam | Nuclear and Particle | | | CE: Astrophysics | QM I | CE: Thermodynamics |
| | Block course | | Practical training KT | Practical training KT | | | |

After the spring semester (Early June until mid-September)

| **Calendar week** | | **23** | **24** | **25** | **26** | **27** | **28** | **29** | **30** | **31** | **32** | **33** | **34** | **35** | **36** | **37** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2. Semester** | Module exam | | | | Physics II | Analysis II | | | | | | | | | | |
| | Block course | | | | | | | | | | | | Progra m. in | | **Program. in C++** | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | C++ | | | |
| **4. Semester** | Module exam | Solid state | | MMP II | | Electrodynamics | | | | | | | | | | |
| | Block course | | Practical training to FK | | | | | | | | | | Workshop II | | Electronics course/ Workshop II | |
| **6. Semester** | Module exam | | | WP | | | | | | | | | | | | |
| | Block course | | | | | | Practical training for KT II | Practical training for KT II | | | | | | | | |

- CE: core elective courses (nuclear and particle physics II, physics of the soft matter, quantum mechanics II), see section 2.2.1, page 12)
- Block courses Workshop I/II and Informatics for Physics Students and Programming in C++ take place during two weeks for half the day.

## 2.3 Material covered in the modules of a bachelor's degree in physics

The material covered in a course is not regulated in detail. It depends on each lecturer. In later semesters, material may even be adapted to the requests of students. Hence, the following description is only intended as a general orientation. More detailed information will be posted on the lecture catalogue every semester (https://studentservices.uzh.ch/uzh/anonym/vvz/).

### 2.3.1 Compulsory modules in the 1st to 2nd semester

**Physics I and II (PHY111, PHY121)**

Mechanics:
- Kinematics and dynamics of mass points
- Dynamics of point systems and rigid bodies
- Mechanics of gases and fluids

Thermodynamics:
- Terms, equations of state
- Elements of kinetic gas theory
- First and second law of thermodynamics
- Application of the laws

Electricity and Magnetism:
- Electrostatics, stationary currents
- Magnetics fields, time variable currents
- Maxwell equations

Wave theory:

- Wave dispersion (elastic and electromagnetic waves)
- Breaking, bending and interference in acoustics and optics

Further topics:
- Mathematical tools (vector fields, complex notation)
- Additional lecture experiments for Physics I & II
- Additional topics for Physics I & II (e.g. tops, hydrodynamics)
- Theory of special relativity
- Maxwell equations in differential form
- Radiation of illuminated charges (e.g. dipole or synchrotron radiation)

**Labs for Physics I and II (PHY112, PHY122)**
Selected experiments, including writing of a report and completion of an error calculation:
- Measurement of physical quantities and error calculation
- Absorption of radiation and radioactivity
- Determining of mechanical quantities and material constants
- Mechanical oscillations and resonance
- Steam pressure curve of water
- Specific warmth and adiabatic index
- Determining of fundamental constants
- Alternating current circuits
- Magnetic field measurements
- Waves and interference, optical representation
- Spectroscopy

**Scientific Computing (PHY125)**
- Programming in Python
- Important algorithms and program libraries for linear algebra, differential equations and probability/statistics
- Various examples in Physics

**Analysis I and II (MAT121, MAT132)**
- Differential and integral calculus for real value functions with one variable
- Number systems: Completion from Q to R; complex numbers
- Sequences and series; Constancy of functions; Sequences and series of functions; Intermediate value theorems
- Differential calculus; local behavior of functions (Extrema); Mean value theorems; Riemann integration; Fundamental theorem; Improper integrals
- Elementary functions
- Power series and Taylor series, multivariate differential calculations
- Derivatives of multivariate graphs; partial deriatives, Taylor series; local behavior of a graph; convexity
- Theorem of inverse functions; theorem of implicit functions; real manifold; local extrema with constraints
- Integral calculations in $R^n$; transformation equation; length and area content
- Vector analysis: vector fields, rotations, divergence, Stokes' theorem; divergence theorem; Green's theorem

**Linear Algebra for the Natural Sciences (MAT141)**
- Linear equations: Gaussian Algorithms
- Matrixes: calculation rules; inverse of a regular matrix; symmetrical and unitary matrixes
- Determinants: definitions; Connection to the solving of systems of equations
- Vector spaces over real/complex numbers; linear subspaces; base; dimension; normed vector spaces, Hilbert spaces with finite dimensions (scalar products)
- Linear functions and their connection to matrixes; linear functions between Hilbert

spaces with finite dimension; coordinate transformations
- Eigenvalue problems: Eigenvalues, Eigenvectors, Eigenvalue problems of symmetrical matrixes

**Courses during the lecture-free period from the 1st to 3rd semesters (PHY113 and PHY114)**

Workshop (PHY113); Fundamentals in precision mechanics, using tools, learning how to use drills, milling machines and lathes by producing small appliances

Informatics for Physics Students (PHY114): Introduction to important tools for Physics students (Linux, Python, plots)

### 2.3.2 Compulsory and core elective modules in the 3rd to 6th semesters

**Physics III (PHY131)**
Laws of thermal radiation:
- Radiation of black bodies
- Interaction of electromagnetic radiation with matter (particle and wave effects): Bending of radiowaves on spacial grids, photoelectric effects, compton effects, pair production and annihilation

Foundations in quantum mechanics:
- de Broglie waves, Heisenberg uncertainty principles, Schrödinger equations, expected values, Eigenvalues, Eigenfunctions
- simple potential wells, tunnel effects
- Hydrogen atom
- Angular momentum and magnetic moments, fine structure, Zeeman effect
- Spin, fermions and bosoons
- Multiparticle wave functions, Pauli principle
- Periodics system, covalent bonds

**Data Analysis (PHY231)**
- Evaluation measurement results
- Statistical distributions (binomial, Poission, exponential, chi2, Lorentz, 2-dimential Gaussion distributions), correlations, folding
- Monte-Carlo methods
- Polynomial adaptations and adaptations of non-linear functions to measurements
- Least-square methods and maximum-likelihood methods
- Using Python

**Physics of Condensed Matter (PHY210)**
- Structure of crystalls: periodicity, symmetry operations, Bravais lattice, simple crystal structures, bending by crystals
- bonds in crystals: noble gas bonds, ion bonds, etc.
- Lattice oscillations: phonons
- Specific heat: Einstein and Debye theories
- Free electron gas: Energy levels and state density, specific heat, electrical conductivity, electron scattering mechanisms, heat conductivity of metals
- Electron band models: quasi-free electrons in crystals, approximations sollutions close to zone borders, classifications of solids based on conductivity, effective mass, electron holes

Selected topics in:
- Semiconductors: conductivity in crystallographic defects, diffusion and recombination of charge carriers, rectifiers, quantum-hall effect

- Optica properties: complex di-electrical constants, plasma oscillations, inter-band transitions, optoelectronic building elements
- Magnetism: para- and diamagnetism, ferromagnetism, anti-ferromagnetism, spin-glas
- Supraconductivity: Phenomenology, basics of the theories

**Nuclear and Particle Physics (PHY211)**

- Particles and interactions in standard models, Feynman diagram
- Natural entities
- Rutherford scattering, differential cross sections, Mott scattering and form factor nuclear masses, nuclear models, radioactive decay, nuclear stability, elastic scattering on nucleons
- Cross sections and relativistic kinematics
- Depth elasticity scattering
- Quarkmodels of hadrons, Isospin
- Particle production in e+e collisions
- Quarkonia
- Dirac equations and Feynman laws
- Conservation laws
- Weak interactions
- Electro-weak interactions

**Electronics**

- Current, voltage, resistance
- Semiconductors
- Signals and systems
- Analog electrical networks
- Sensors
- Elements of digital electronics
- Signal transfer
- Data acquisition systems

**Mathematical Methods in Physics I and II (PHY312 and PHY322)**

Topics in function theory (3rd semester)

- Complex numbers
- analytical functions
- line integrals
- residuals
- Laurent series

Topics in higher analysis (3rd - 4th semester)

- Series by orthogonal functions
- Fourier series
- Partial differential equations
- Differential equations in mathematical Physics
- Special functions: sphere surface areas, Bessel, Hermite, etc.
- Fourier and Laplace transformations
- Distributions
- Green functions
- Integral equations
- Variation calculations

Topics in functional analysis (4th semester)

- Banach and Hilbert spaces
- Linear operations and Eigenvalue problems
- Spectral representation by operators

Topics in group theory (4th semester)
- Groups and their representations

**Mechanics (PHY311)**
- Kinematics and dynamics in systems with mass points
- Coordinate transformations and reference systems in motion
- Conservation laws
- Kepler problems
- Rigid bodies
- Lagrange formulations in mechanics, constraints
- Variation principles
- Invariance properties and conservation laws
- Hamilton equations of motion
- Canonical transformations and Hamilton-Jacob theories

**Electrodynamics (PHY321)**
- Electrostatics
- Magnetostatics
- Maxwell equations in vacuum and in macroscopic media
- Relativistic kinematics
- Producing electromagnetic waves, multipolar radiation
- Reflecting and breaking electromagnetic waves, metal optics
- Dispersion
- Diffractions theory

**Quantum Mechanics I (PHY331)**
- Wave mechanics with applications in simple systems
- Probability interpretations, measurements processes and indeterminate relations
- Formal structures in quantum mechanics (various forms of laws of motion)
- Spin and angular momentum
- Time-independent problems and identical particles, application of atom and molecule constructions
- Quantum information processing

### 2.3.3 Core elective courses in the 4$^{th}$ - 6$^{th}$ semester

**Physics of soft matter (PHY212)**
Selected topics in:
- Forming condensed matter from atoms
- Diffusion and atomic interactions
- Methods for directly observing and measuring interactions between atoms
- Foundations in polymer physics
- DNA as a bio-polymer
- Instruments in molecular biology
- Methods for measuring the properties of individual DNA molecules
- Rheology, elasticity
- Pattern formation and non-linear dynamics
- Optics and microscopy

**Nuclear and Particle Physics II (PHY213)**
- Electroweak unification
- Parity violation in weak interactions, beta decay of neutrons

- CP violation
- Eichinvarianz and the Higgs Boson
- The standard model: Weinberg-Salam Theory
- Experimental methods: accelerators, interactions of radiation with matter, detectors
- Neutrino mass and mixtures, solar and atmospheric neutrinos
- Thermic history of the universe, primordial nucleosynthesis
- Element synthesis in stars

**Introduction to Astrophysics (PHY241)**

- Gravitational constant
- Celestial mechanics and chaos
- Schwarzschild space-time and black holes
- Chandrasekhar mass scales
- Nuclear fusion in stars
- Main sequence of stars
- Friedmann equation and the expanding universe
- Cosmic microwave background

**Thermodynamics (PHY341)**

- The three laws of thermodynamics
- Thermodynamic potentials and equilibrium
- Phase equilibrium and other applications
- Introductions to a kinetic gas theory
- Molecular chaos, Boltzmann equations
- Elementar transport theory
- Irreversibility

**Quantum Mechanics II (PHY351)**

- Scattering theory
- Time-dependent perturbation theory
- Interactions between light and matter
- Many-body-problem and identical particles
- Atom and molecule construction
- Quantum mechanics many-body-systems
- Quantum statistics
- Bose-Einstein-Condensation

**Continuum mechanics (PHY352)**

- Deformation and stress tensor
- Grating violations and plastic deformation
- Navier-Stokes-Equation
- Dynamics of vortexes
- Reynold number
- Prandt boundary layer
- Couette flow and Taylor instability
- Development of turbulence

## 2.4 Master's degree

During a master's program in physics at the University of Zurich, students may begin to specialize in a current field of research. The program begins in the fall and continues, under normal circumstances, for three semesters.

The department of physics at the UZH essentially has three different areas of research: Condensed Matter (mainly experimental, in the groups Aegeter, Chang, Fink, Osterwalder and Schilling, theoretical in the group Neupert), Particle Physics (experimental in groups Baudis, Canelli, Kilminster, Serra and Straumann, theoretical in groups Gehrmann and Isidori) and Astrophysics and Cosmology (primarily theoretical in groups Helled, Jetzer, Mayer, Moore, Lake, Teyssier and Yoo). In addition, it is possible to specialize in bio- and medical physics (in groups Aegerter, Fink, Krishnan, Kozerke, Schneider, Schuler and Unkelbach). You may find a summary of current research in annual reports at www.physik.uzh.ch/de/berichte.html and at the websites of each research team at www.physik.uzh.ch//de/forschung.html and www.ics.uzh.ch.

Graduates receive a degree of "Master of Science UZH in Physics". 90 credit points are necessary to obtain a master's degree. During the first and second semester, the program consists of lectures, practice sessions and labs in students' chosen area of specialization as well as an elective field of study.

In the master's program, lectures are taught in English and German.

**Continuing on to a master's program with a major in Physics**

With a "Bachelor of Science UZH in Physics" or a bachelor's degree in physics from any other Swiss university, you are automatically admitted to our master's program in physics. You must have successfully completed all compulsory and core elective modules (including your bachelor's thesis) to sign up for the master's program.
Depending on the concentration students select, as well as the modules completed during their bachelor's studies, they will need to complete certain modules (see below).
Students will receive credit towards their master's degree for at most 30 credit points from their bachelor's degree. Students may only begin work on their master's thesis once they have completed their bachelor's degree.
Faculty members individually evaluate bachelor's degrees from foreign universities. Any documents must be handed in together with the application for matriculation at the Dean's Office (Studiendekanat) or at the Admission's Office (Kanzlei) for Students with a Foreign Degree. Depending on what students have studied previously, they may be required to complete additional coursework during the master's program.

**Continuing from a BSc150 major in Physics to a consecutive master's program**

Students with a BSc degree with a major in Physics for 150 CP can continue with a consecutive master's program without any additional requirements if the core elective module they selected was in their master's concentration (Condensed Matter, Particle Physics, Astrophysics/Cosmology). The respective allocations are listed below. If students completed a core elective module outside their concentration, they will be asked to complete this modules as an additional requirement within the elective portion of their master's program.
Core elective modules for the various concentrations:
Condensed Matter:

- selected core elective module: Physics of soft matter (PHY212) or Thermodynamics (PHY341)

Particle Physics:

- selected core elective module: Nuclear and Particle Physics II (PHY213)

Astrophysics and Cosmology:

- no additional requirements for minors in Astrophysics, otherwise Introduction to Astrophysics (AST241) as the selected core elective module

Bio- and medical physics:

- selected core elective module: Physics of soft matter (PHY212) or Physics against cancer (PHY361)

**Continuing from a BSc120 major in Physics to a consecutive master's program**

Students with a BSc degree with a major in Physics for 120 CP will be asked to complete further requirements in addition to their degree. These neeed to be completed as part of the elective portion of the master's program. The additional requirements will differ depending on their selected master's concentration. If the core elective module completed during their bachelor's degree was not in their concentration (see list below), this will also be included as an additional requirement (to be completed before beginning the master's program).

Condensed Matter:

- selected core elective module: Solid State Physics (PHY210)
- additional requirements: Physics of soft matter (PHY212) or Thermodynamics (PHY341)

Particle Physics:

- selected core elective module: Nuclear and Particle Physics I (PHY211)
- additional requirements: Nuclear and Particle Physics II (PHY213)

Astrophysics and Cosmology:

- no additional requirements for 60 and 30 CP minors in Astrophysics, otherwise the additional requirement is Astrophysics (AST241)

Bio- and medical Physics:

- selected core elective module: Nuclear and Particle Physics I (PHY211)
- additional requirements: Physics of soft matter (PHY212) or Physics against cancer (PHY361)

In addition to these requirements, all students must discuss the courses they intend to complete with their master thesis advisor, who may set additional requirements.

**Master's thesis and exam**

The central focus of the master's program is a master's thesis. It consists of an independent research contribution within one of the research teams in physics at our university. The work required for a master's thesis along with the preparation for the module exam corresponds to 55 credit points, usually approximately 9 months of full time work. All master's theses must be documented in a written report, which will be graded.

Theses may also be completed with an external research team (for instance Biomedical Imaging, Medical Physics). Students must submit a written request along with a work outline to a faculty member in the UZH's physics department, who has to be willing to accept responsibility for the thesis and designate the courses the students should attend. Such a thesis must centre on a question within the field of physics. Theses with external research groups need to meet the requirements of a master's thesis in physics at the UZH in duration, quality, mentorship and grading. The corresponding credit points will therefore be counted as credit points earned at the University of Zurich.

The module exam for the master's thesis consists of two parts, which each take about 30 minutes and are both graded. Firstly, students present their master's thesis in a public presentation. In the second part, which is not open to the public, students must defend their thesis against a minimum of two faculty members. They are asked questions focusing on the field of the thesis.

The overall grade for a student's master's thesis is composed of a weighted average of their written report (2/3) and their module exam (1/3). A student must achieve at least a 4.0 for both his thesis and his exam.

Dates for the master's thesis and module exam are set individually in consultation with the responsible faculty member. The forms necessary to sign up can be found at http://www.physik.uzh.ch/en/study/studienberatung/formulare.html.

**Research seminar**

You are required to attend research seminars on the topic of your chosen field of research in all master's programs. The seminar organizer must confirm your attendance. Relevant forms may be found at http://www.physik.uzh.ch/en/study/studienberatung/formulare.html.

**Choice of additional lecture modules**

Besides following the regulations of each master's program, we recommend you seek a conversation with the various research teams before choosing your program of study. In special cases, it is possible and useful – in consultation with the responsible professors – to substitute modules of the master's program with specialized courses in your chosen field of research.

**Minor**

Students must earn 90 CP for a master's degree in Physics. A minor for 30 CP may be completed on a voluntary basis. See section 2.6.

**Grading**

Student's GPA for their master's degree is composed of a weighted average of the grades of all modules belonging to the master's program in accordance to how many credit point they each were worth.

### 2.4.1 Physics of Condensed Matter

Coordinator: Professor Andreas Schilling

This master's program offers an advanced education in experimental Condensed Matter. The first semester consists of lectures, which are accompanied by practice sessions and labs. In the second semester, students are required to spend less time in lectures. Therefore, they can begin work on their master's thesis once they have written a careful research proposal in direct consultation with a faculty member. The master's thesis is an independent research project, which takes 9 months under normal circumstances and is completed at the end of the third semester.

**Compulsory modules**

| **Sem.** | **Nr.** | **Title** | **Class Time** | | | **Performance assessment** | **Grading** | **CP** |
|---|---|---|---|---|---|---|---|---|
| | | | Lectures | Practice sessions | Lab | | | |
| 1 | PHY401 | Condensed Matter | 4 | 2 | | Module exam | Yes | 10 |
| 1 or 2 | PHY403 | Master's Thesis Proposal | | | | Report | No | 2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2 and 3 | PHY447 | Research seminar | 1.5 | | | Participation | No | 2 |
| 2 and 3 | PHY448 | Master's Thesis | | | | Grading for thesis (2/3) and module exam (1/3) | Yes | 50 |

The remaining credit points missing from the total of 90 must be earned through core elective and elective modules offered at the UZH, ETHZ or another university. Whether a module will be awarded credit is determined individually in consultation with the coordinator of the master's program "Condensed Matter."

**Core elective modules**

Within the field of Condensed Matter, students must take at least one experimentally oriented foundations course as well as a theoretically oriented lecture course.

**Elective modules**

The remaining modules (elective modules) should cover specialized areas in the field of Condensed Matter, which contribute to the master's thesis.

**Course contents for compulsory and core elective modules**

*PHY401 Condensed Matter*
Phenomenology of
- energy bands and fermi areas
- optical properties
- supra-conduction
- di-electrics and ferro-electrics
- magnetic properties
- surface effects
- electron optics and applications of focussed electron radiation
- production of structures at the micro- and nanometer scale
- lithographic structuring methods
- mesoscopic physics

*PHY403 Proposal for a master's thesis*
Students must hand in their proposal before beginning with their master's thesis. It should be 2-5 pages long and be structured as follows: summary, motivation, how much you have researched, research plan (including measurement methods)

*PHY447 Research seminar*
Students are required to regularly attend a research seminar on a topic related to their thesis work during their second and third semester. Instead of attending a single seminar, students may also opt combined lectures from a variety of seminars (for instance from the Colloquium in Physics).

*PHY411: Theory of Condensed Matter*
- electrons and phonons
- spectra, band theory
- application of group theory
- second quantization

- Many-body-theory
- electron-phonon interactions
- supra-conduction
- magnetism

You can find a list of additional core elective and elective modules in the lecture catalogue with commentary at www.physik.uzh.ch/de/studium/vorlesungsunterlagen.html, “Physics of Condensed Matter.” You may receive credit for other independently selected modules as long as the coordinator of the master’s program has approved them.

### 2.4.2 Particle Physics

Coordinator: Professor T. Gehrmann

This master’s program offers an advanced education in theoretical and experimental Particle Physics. Faculty members at the ETH and the UZH jointly offer courses in this program. After introductory lectures, practice sessions and labs, students begin their master’s thesis that should take 9 months.

**Compulsory modules**

| Sem. | Nr. | Title | Class Time | | | Performance assessment | Grading | CP |
|---|---|---|---|---|---|---|---|---|
| | | | Lectures | Practice sessions | Lab | | | |
| 1 | PHY451 | Phenomenology I | 3 | 2 | | Module exam | Yes | 10 |
| 2 and 3 | PHY497 | Research seminar | 1.5 | | | Participation | No | 2 |
| 2 and 3 | PHY498 | Master’s thesis | | | | Grade from thesis (2/3) and module exam (1/3) | Yes | 50 |

**Core elective modules**

Students must choose one of the two of the following modules to fulfil the core elective requirement.

| Sem. | Nr. | Title | Class Time | | | Performance assessment | Grading | CP |
|---|---|---|---|---|---|---|---|---|
| | | | Lectures | Practice sessions | Lab | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | PHY551 | Quantum Field Theory | 4 | 2 | | Module exam | Yes | 10 |
| 2 | PHY452 | Elementary particle theory | 3 | 2 | | Module exam | Yes | 8 |

**Elective modules**

The remaining credits needed to fulfill the requirement of 90 credit points must be earned in elective modules. Students can also choose additional courses amongst the core elective listing. Every year, specialized lectures are offered on topics of current research. Credits earned in intensive courses for graduate education will also be counted.

| Sem. | Nr. | Title | Class Time | | | Performance assessment | Grading | CP |
|---|---|---|---|---|---|---|---|---|
| | | | Lectures | Practice session | Lab | | | |
| 1 or 2 | PHY463 | Research lab | | | 4-6 Wo | Module exam | Yes | 6 |
| 1 | PHY461 | Exp. Methoden and Inst. | 2 | 2 | | Module exam | Yes | 6 |
| 2 | PHY568 | Flavor Physics | 2 | 1 | | Module exam | Yes | 5 |
| 2 | PHY465 | Experimental astro particle physics | 2 | 2 | | Module exam | Yes | 6 |
| 3 | PHY563 | Electroweak Theory | 2 | 1 | | Module exam | Yes | 5 |
| 3 | PHY564 | QCD | 2 | 1 | | Module exam | Yes | 5 |
| 2 | PHY552 | Quantum field theory II | 3 | 2 | | Module exam | Yes | 8 |
| 3 | PHY567 | Higgs Physics | 2 | 1 | | Module exam | Yes | 5 |
| 3 | PHY572 | Advanced Topics in Field Theory | 2 | 1 | | Module exam | Yes | 5 |
| 3 | PHY573 | Quantum field theory III | 2 | 1 | | Module exam | Yes | 5 |

**Course content of core elective and elective modules**

*PHY451/452 Phenomenology of Particle Physics I and II*
(will be held jointly by theoreticians and experimentalists)

- Relativistic kinematics
- Cross sections and phase space
- Elements in quantum electrodynamics
- Unitary symmetries and QCD
- Electroweak interactions
- Physics of flavours
- Limits of the standard model (GUT and SUSY, etc.)

*PHY551 Quantum Field Theory*
- Relativistic wave functions
- Quantification of free fields
- Re-normalization
- Perturbation theory

*PHY461 Experimental Methods and Instruments in Particle Physics*
- Physics and structure of particle accelerators
- Foundations and concepts in particle detectors
- Trace and vortex detectors, calorimetry, particle identification
- Special applications such as Cerenkov detectors, air showers, direct detection of dark matter, emulsions
- Simulations methods, selection electronics, trigger and data measurement
- Examples and key experiments

*PHY463 Research internship*
This internship lasts for 4 to 6 weeks, during which students construct, conduct and evaluate an experiment using a particle radiation at CERN or PSI or some other research lab. For instance, you might do an internship at PSI, where you work in a group for three weeks planning and constructing an experiment that uses the PSI's secondary laser and conducting it jointly during shifts. Then you must evaluate your data and complete a report.

*PHY513 Theoretical Cosmology*
(see in the section for the master's program in Astrophysics and Cosmology)

*PHY552 Quantum Field Theory II*

*Advanced topics such as:*
- Re-normalization groups
- Abel and non-Abel Eicht theories
- Standard model, Higgs mechanism
- Path integrals

PHY568 Flavour Physics
- B-Penomenology
- Neutrino masses and oscillations
- CP violations in $B^0_s$

*PHY497 Research seminar*
Students are required to regularly attend a research seminar in Particle Physics during their second and third semester ("Current work in astrophysics and particle physics" or "theoretical physics").

### 2.4.3. Astrophysics and cosmology

Coordinator: Professor B. Moore

This master's program offers an advanced education in astrophysics and cosmology. After introductory lectures, practice sessions and labs, students begin with their master's thesis that should take 9 months.

**Compulsory modules**

| Sem. | Nr. | Title | Class Time | | Performance assessment | Grading | CP |
|---|---|---|---|---|---|---|---|
| | | | Lectures | Practice sessions | | | |
| 1 | PHY511 | General Relativity | 4 | 2 | Module exam | Yes | 10 |
| 1 | AST512 | Theoretical Astrophysics | 4 | 2 | Module exam | Yes | 10 |
| 2 | AST513 | Theoretical Cosmology | 4 | 2 | Module exam | Yes | 8 |
| 2 and 3 | AST547 | Research seminar | 1 | | Participation | No | 2 |
| 2 and 3 | AST548 | Master's thesis | | | Grade from thesis (2/3) and module exam (1/3) | Yes | 50 |

**Elective modules**

The remaining credits needed to fulfil the requirement of 90 credit points must be earned in elective modules. For instance, we recommend: ESC411 Computational Science I, QTF1 (PHY551) or specialized astrophysics modules that take place every year (for instance, Stellar Structure and Evolution).

**Course contents in the compulsory modules**

*PHY511 General Relativity*

- repetition of special relativity
- principle of aequivalence
- motion in the gravitational field, gravitational red-shift
- tensors in Riemann-Space
- covariant derivative, parallel transport
- Riemann tensor, Bianchi-Identities
- Einstein's field equations
- Schwarzschild-solution
- precession of the perihelion, deflection of light
- geodesic precession
- gravitational waves
- black holes
- Friedman-Robertson-Walker universe

*AST513 Theoretical Cosmology*

- big bang and early universe
- nucleosynthesis
- inflation
- relativistic perturbation theory and growth of structure
- cosmic microwave background and large scale structure
- dark matter and dark energy

*AST512 Theoretical Astrophysics*
- radiative processes in the interstellar medium
- Star structure
- Star development
- Supernovae
- White dwarfs
- Neutron stars
- Black holes
- Planet formation

*Research seminar*
During their second and third semesters, students are required to attend at least one seminar per week http://www.ics.uzh.ch/en/seminars/

### 2.4.4. Bio- and medical Physics

Coordinator: Prof. J. Unkelbach

This master's program offers an advanced education in astrophysics and cosmology. After introductory lectures, practice sessions and labs, students begin with their master's thesis that should take 9 months.

**Compulsory modules**

| Sem. | Nr. | Title | Class Time | | Performance assessment | Grading | CP |
|---|---|---|---|---|---|---|---|
| | | | Lectures | Practice session | | | |
| 1 | 227-0385-10L (ETH) | Biomedical Imaging | 3 | 2 | Module exam | Yes | 6 |
| 2 and 3 | WBAT1377 | Research seminar | 1 | | Participation | No | 2 |
| 2 and 3 | PHY598 | Master's thesis | | | Grade from thesis (2/3) and module exam (1/3) | Yes | 50 |

**Compulsory elective modules**
The modules, worth 10 CP, are chosen from the list below depending on whether the focus is on biological or medical physics.

| Sem. | Nr. | Title | Class Time | | Performance assessment | Grading | CP |
|---|---|---|---|---|---|---|---|
| | | | Lectures | Practice session | | | |
| 1 | PHY471 | Physics and Mathematics of Radiotherapy Planning | 2 | 2 | Module exam | Yes | 6 |
| 1 | PHY401 | Condensed matter | 4 | 2 | Module exam | Yes | 10 |
| 2 | PHY361 | Physics against cancer: The Physics | 2 | 1 | Module exam | Yes | 6 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | of Imaging and Treating Cancer | | | | | |

**Elective modules**
The remaining credit points missing from the total of 90 must be earned through elective modules. Whether a module will be awarded credit is determined individually in consultation with the supervisor of the Master's thesis. For instance, we recommend: PHY461 Experimental Methods and Instruments, STA404 Clinical Biostatistics, ESC411 Computational Science I, PHY233 Numerical Methods I, PHY352 Continuum mechanics, BIO330 Modelling in Biology, BIO253 Experimental Techniques in Physical Biology, PHY431 Biology for Physicists

**Course contents in the compulsory modules**

*227-0385-10L Biomedical Imaging*
(is being offered by the Institute for Biomedical Engineering)
- Physikalische und technische Grundlagen der medizinischen Bildgebung
- Bildrekonstruktion
- Röntgenbildgebung
- Computertomographie (CT)
- Single Photon Emission Tomography (SPECT)
- Positron Emission Tomography (PET)
- Magnetresonanztomographie (MR)
- Ultraschall

*PHY471 Physics and Mathematics of Radiotherapy planning*
- Wechselwirkung von Strahlung im Gewebe
- Dosisberechnungsalgorithmen
- Bestrahlungsplanung
- Intensitätsmodulierte Strahlentherapie (IMRT)
- Mathematische Optimierungsmethoden in der IMRT Planung
- Bildregistrierung
- Grundlagen der klinischen Radioonkologie, Zielvolumendefinition, Fraktionierung

*PHY361 Physics against cancer: The physics of imaging and treating cancer*
- Radiation Physics
- Imaging for radiotherapy
- Imaging with protons and ions
- Radiotherapy with photons, electrons, protons and heavy ions
- Basics of radiobiology and bio-physical modeling for radiotherapy
- Organ motion management
- Special radiotherapy techniques

*PHY401 Condensed Matter*
Phenomenology of
- energy bands and fermi areas
- optical properties
- supra-conduction
- di-electrics and ferro-electrics
- magnetic properties
- surface effects
- electron optics and applications of focussed electron radiation
- production of structures at the micro- and nanometer scale

- lithographic structuring methods
- mesoscopic physics

*PHY461 Experimental Methods and Instruments in Particle Physics*
- Physics and structure of particle accelerators
- Foundations and concepts in particle detectors
- Trace and vortex detectors, calorimetry, particle identification
- Special applications such as Cerenkov detectors, air showers, direct detection of dark matter, emulsions
- Simulations methods, selection electronics, trigger and data measurement
- Examples and key experiments

*STA404 Clinical biostatistics*
- Confidence intervals for proportions,
- Analysis of diagnostic studies,
- Analysis of agreement,
- Randomized controlled trials,
- Hypothesis tests and sample size calculation,
- Randomization and blinding,
- Analysis of continuous and binary outcomes,
- Multiplicity,
- Subgroup analysis,
- Protocol deviations,
- Some special designs (crossover, equivalence, and clusters),
- Analysis of prognostic studies,
- Development and assessment of clinical prediction models.

*ESC411 Computational Science I*
- Ordinary differential equations
- Partial differential equations
- Monte-Carlo
- Inverse problems
- Signal-processing
- Optimization
- Visualization
- Combinatorial problems

*PHY233 Numerical Methods I*
- Floating point representation
- Solving systems of linear equations
- Matrix diagonalization algorithms
- Eigenvalue calculations
- Function interpolation and extrapolation
- Solving the differential equations with numerical methods

*BIO330 Modelling in Biology*
- Deterministic Reaction-Diffusion models
- Stochastic Reaction-Diffusion models
- Finite-element modeling
- Cell-based tissue models
- Image analysis

*BIO253 Experimental Techniques in Physical Biology*
- Biomechanics of tissue
- Force measurements
- Modern microscopy

- Scattering methods
- Nuclear magnetic resonance

*PHY431 Biology for Physicists*
- Constituents of Biomatter, DANN, RNA, Proteins
- Heredity and evolution
- Allometric scaling laws
- Morphogenesis
- Transcription of genes
- Neural Networks

*Research seminar*
Students are required to regularly attend a research seminar in bio- or medical physics during their second and third semester. (e.g. ath the department for radiooncology ath the University Hospital, at the Paul-Scherrer Institute or at the Institute for Biomedical Engineering).

### 2.5. Examinations and performance assessments

The procedure of **module examinations** is regulated in the General Regulations and the Study Program Regulations at the Faculty of Science. The most important regulations are also listed in section 5.6 of these Study Regulations. Oral exams usually take 20 minutes, while written exams take 2 hours. At the beginning of the semester, the responsible faculty member in each module states what kind of examination there will be. This faculty member is also responsible for the content and conducting of the module exam and should be available for questions regarding the exam.

In the module PHY131 Physics III and the modules in experimental physics (PHY210 ? (Festkörperphysik), PHY211 Nuclear and particle physics I, PHY212 Physics at the nanometer scale, PHY213 Nuclear and particle physics II), module grades are composed of 75% module exam grades and 25% lab grades. To pass these modules, both the grades in the exam and in lab must be passing.

In addition, students may be required to complete further **records of performance** (such as completing practice problems). The responsible faculty member will determine these at the beginning of the semester.

**In modules without a module exam**, records of performance may be conducted during lecture periods such as an ungraded attendance exercise or a quiz.

### 2.6 Minors for students with a major in physics

Depending on their major program (BSc180, BSc150, BSc120), students may need to select a minor program. For a BSc150 students must complete a 30 CP minor. For a BSc120 students must complete a minor for 60 CP (two minors for 30 CP each is also possible). They may select any minor offered at either UZH or ETH. Grades in a minor are determined by an average of the grades received in modules, which are weighted according to how many credit points the modules were worth. Every successfully completed minor along with the grade received will be shown in the bachelor or master’s diploma.

During their master’s studies with a 90 CP major, students may select a 30 CP minor. In this case, the master’s program involves a total of 120 CP and the standard duration increased by one semester.

We especially recommend the following minors for physics students:

### 2.6.1 Mathematics

A minor in mathematics requires 30 or 60 credit points. The only compulsory module is MAT112 Linear Algebra II.

**Compulsory modules**

| Nr. | Title | Class Time (SWH i.e. weeks) | | Exam period | Grading | CP |
|---|---|---|---|---|---|---|
| | | Lectures | Practice sessions | | | |
| MAT112 | Linear Algebra II | 4 | 2 | 27 | | 9 |

For physics students with a minor in mathematics, MAT111 Linear Algebra I and MAT112 Linear Algebra II may be taken instead of the compulsory module MAT141 Linear Algebra for the Natural Sciences. Any missing CP for their major must be earned in other Physics courses.

**Core elective modules**

Students completing the 30 CP minor must take at least one module from the core elective portion; students completing the 60 CP minor must take at least two.

| Nr. | Title | Class Time (SWH i.e. weeks) | | Exam period | Grading | CP |
|---|---|---|---|---|---|---|
| | | Lectures | Practice sessions | | | |
| MAT801 | Numerics I | 4 | 2 | 28 | Yes | 9 |
| MAT221 | Analysis III | 4 | 2 | 6 | Yes | 9 |
| MAT211 | Algebra I | 4 | 2 | 6 | Yes | 9 |
| MAT701 | Geometry/Topology | 4 | 2 | 6 | Yes | 9 |
| MAT901 | Stochastics | 4 | 2 | 28 | Yes | 9 |

**Elective modules**

Additional courses in Mathematics for a total of 30/60 CP (NF30:12 CP, NF60: 33CP). Students may select courses from the core elective portion that they did not complete as a core elective module.

### 2.6.2 Astrophysics

A minor in Astrophysics is offered at the Institute for Computational Sciences and is only open to students majoring in Physics. Students planning to concentrate in Astrophysics during their master's are advised to complete this minor during their bachelor. Physics I to II are prerequisites for coursework in this minor (PHY111, PHY121, PHY131) as well as mechanics (PHY311).

Students may choose a 30 or 60 CP minor.

**Minor for 30 CP:**
**Compulsory modules**

| Sem. | Nr. | Title | Class Time (SWH i.e. weeks) | | Exam period | Grading | CP |
|---|---|---|---|---|---|---|---|
| | | | Lectures | Practice sessions | | | |
| Autumn | AST241 | Introductory Astrophysics | 3 | 1 | * | * | 6 |
| Autumn | AST201 | Introduction to Astrobiology | 2 | 1 | * | * | 5 |
| Spring | PHY352 | Continuum Mechanics | 3 | 2 | 25 | Yes | 8 |
| Spring or Autumn | AST243 | Practical training in Comput. Astrophysics | | | Report | * | 9 |
| Autumn | AST291 | Proseminar Astrophysics | 2 | | Seminar | No | 2 |

* see course catalogue

**Minor for 60 CP:**
**Compulsory modules:**
The compulsory modules for a 60 CP minor are identical to those for a 30 CP minor (see paragraph above: minor for 30 CP, compulsory modules).

**Core elective modules for the 60 CP minor:**
The remaining 30 CP must be selected from the following core elective portion:
AST512 Theoretical Astrophysics (10 CP)
AST513 Theoretical Cosmology (10 CP)
PHY511 General Relativity (10 CP)
ETHZ Statistical Methods in Cosmology and Astrophysics (6 CP)
ETHZ Cosmological Probes (6 CP)
ETHZ Extrasolar Planets (6 CP)
ETHZ Observational Techniques in Astrophysics (6 CP)
ETHZ Physics of Star and Planet Formation (6 CP)
ETHZ Astrophysics II (10 CP)

### 2.6.3 Chemistry

**Chemistry for 30 CP:**

The compulsory portion of the 30 ECTS minor includes modules CHE170-173 for 16 CP. 9 CP worth of courses must be completed from the core elective portion (CHE201-207, CHE 154/155). 5 CP from the core elective portion must be earned in the practical courses (CHE 211/213/214). The successful completion of CHE171/173 or proof of equivalent lab experience is a prerequisite for these courses.

**Chemistry for 60 CP**
The compulsory portion of the 60 ECTS minor includes modules CHE 101/102/111/112 for 30 CP as well as the spectroscopy module (CHE207, 4 ECTS). 21 CP worth of courses must be completed from the core elective portion (CHE201-206, CHE 154/155, CHE 303-305). 5 CP from the core elective portion must be earned in the practical courses (CHE 211/213/214). The successful completion of CHE111/112 or proof of equivalent lab experience is a prerequisite for these courses.

### 2.6.4 Computational Sciences, 60 CP

The Computational Science is an interdisciplinary minor. In addition to learning the foundations of core subjects such as applied mathematics, statistics and informatics, students will also gain insight into various applications of computational sciences. Two fields of application will be selected from the following list:

1. Simulations in the Natural Sciences
2. Bioinformatics
1. Neuroinformatics

**Compulsory modules**
AINF1166 Informatics I (6 CP)
AINF1152 Informatics IIb (6 CP)
ESC391 Proseminar Computational Science (1 CP)

**Core elective modules**
At least one of the introductory lectures in statistics/stochastics from the list below, as well as 12 CP from the core elective portion in two or three of the subject areas neuroinformatics, bioinformatics or SPIN.

STA110 Introductory Probability (5 CP)
STA111 Stochastic Modelling (5 CP)
STA120 Introductory Statistics (5 CP)
STA121 Statistic Modelling (5 CP)

**Elective modules**
The remaining 18 CP should be selected from elective modules listed in the program regulations.

### 2.6.5 Neuroinformatics

In addition to select lectures and practical courses at the Institute for Neuroinformatics, a minor in Neuroinformatics provides the opportunity to attend related lectures, practical courses and semester projects at other institutes and faculties.

**Compulsory modules**
AINF1166 Informatics I (6 CP)
INI415 Systems Neuroscience (6 CP)
ESC391 Proseminar Computational Science (1 CP)

**Core elective modules**
Students must earn 6 CP in the core elective portion. The list of core elective modules is in the program regulations.

**Wahlmodule**
The remaining CP must be earned in elective modules. A list of elective modules can be found in the program regulations.

### 2.6.6 Minor in Simulations in the Natural Sciences, 30 CP

**Compulsory modules**
AINF1166 Informatics I (6 CP)
ESC125 Introduction to Computer Simulations 1a (3 CP)
ESC391 Proseminar Computational Science (1 CP)

**Core elective modules**
At least 9 CP must be earned from the list below:

ESC127 Applications of Computer Simulations 1b (2 CP)
ESC202 Applications of Computer Simulations II (5 CP)
AST243 Practical Course in Computational Astrophysics (9 CP)
ESC401HPC 1a (2 CP)
ESC402b HPC 1b (2 CP)
ESC403 HPC 1c (2 CP)
MAT820 Numeric Practical Course (3 CP)
MAT012 Introduction to scientific computing (4 CP)

## 2.7 Physics as a minor for students with another major

Following offerings are directed at students of different subjects that chose physics as a minor or for whom physics is a compulsory foundational subject. You may find further information in the Study Regulations of the respective major.
A minor in Physics can be taken for 30 or 60 CP. Additionally, there is a consecutive MSc minor for 30 CP. Depending on students' major and their prior experience in Physics and Mathematics, they will be required to complete different courses.

**Physik as a minor for 30 CP for students majoring at other faculties:**

- MAT182 Analysis for the natural sciences (6 CP)
- PHY116 Physics I and PHY126 Physics II for minoring students (8 CP each)
- PHY139 Physics III without lab (8 CP)

**Physics as a minor for 30 CP for students at MNF with a major other than Chemistry:**

- PHY116 Physics I and PHY126 Physics II for minoring students (8 CP each)
- PHY102 Practical course for minoring students (6 CP)
- PHY139 Physics III without lab (8 CP)

**Physics as a 30 CP minor for students majoring in Chemistry:**

- PHY119 and PHY129 Supplements for minoring studetns Physics I & II (3 CP each)
- PHY102 Practical course for minoring students (6 CP)

- PHY131 Physics II (12 CP)
- One of the following core elective modules: PHY280, PHY282 oder PHY281 (je 6 CP).

**Physics for 60 CP for students at other faculties:**

The curriculum contains the following compulsory courses:

- PHY116 Physics I for minoring students (8 CP)
- MAT182 Analysis for the Natural Sciences (6 CP)
- MAT141 Linear Algebra for the Natural Sciences (5 CP)
- PHY126 Physics II for minoring students (8 CP)
- PHY102 Practical course for minoring students (6 CP)
- PHY131 Physics III (12 CP)

The remaining CP must be selected from the following core elective modules:

- PHY114 Informatics for Physics students (1 CP)
- PHY125 Scientific Computing (3 CP)
- PHY231 Data analysis (3 CP)
- PHY280 Solid state physics without a practical course (6 CP)
- PHY212 Physics of soft matter
- PHY281 Nuclear and Particle Physics without a practical course (6 CP)
- PHY321 Electrodynamics (8 CP)
- PHY331 Quantum mechanics I (8 CP)
- PHY341 Thermodynamics (8 CP)
- PHY311 Mechanics (8 CP)

**Physics for 60 CP for students majoring in Mathematics:**

The curriculum contains the following compulsory courses:

- PHY111 Physics I (11 CP)
- PHY121 Physics II (11 CP)
- PHY102 Practical course for minoring students (6 CP)
- PHY131 Physics III (12 CP)

The remaining CP must be selected from the following core elective modules:

- PHY114 Informatics for Physics students(1 CP)
- PHY125 Scientific Computing (3 CP)
- PHY231 Data analysis (3 CP)
- PHY280 Solid State Physics without a practical course (6 CP)
- PHY281 Nuclear and Particle Physics without a practical course (6 CP)
- PHY321 Electrodynamics (8 CP)
- PHY331 Quantum mechanics I (8 CP)
- PHY341 Thermodynamics (8 CP)
- AST241 Introduction to Astrophysics (6 CP)
- PHY311 Mechanics (8 CP)

**Physics for 60 CP for students majoring in Biology or Geography:**

The curriculum contains the following compulsory courses:

- MAT141 Linear Algebra for the Natural Sciences (5 CP)
- PHY102 Physics I for minoring students (8 CP)

- PHY126 Physics II for minoring students (8 CP)
- PHY131 Physics III (12 CP)

The remaining CP must be selected from the following core elective modules:

- PHY114 Informatics for Physics students (1 CP)
- PHY125 Scientific Computing (3 CP)
- PHY231 Data analysis (3 CP)
- PHY280 Solid State Physics without a practical course (6 CP)
- PHY281 Nuclear and Particle Physics without a practical course (6 CP)
- AST241 Introduction to Astrophysics (6 CP)
- PHY321 Electrodynamics (8 CP)
- PHY331 Quantum mechanics I (8 CP)
- PHY341 Thermodynamics (8 CP)
- PHY311 Mechanics (8 CP)

**Physics for 60 CP for students majoring in Chemistry:**

The curriculum contains the following compulsory courses:

- PHY119 Supplements for Physics I for minoring students (3 CP)
- PHY102 Practical training for minoring students (6 CP)
- PHY129 Supplements for Physics II for minoring students (3 CP)
- PHY131 Physics III (12 CP)
- PHY280 Solid State Physics without a practical course (6 CP)
- PHY312 MMP I (6 CP)
- PHY322 MMP II (6 CP)

The remaining CP must be selected from the following core elective modules:

- PHY114 Informatics for Physics students (1 CP)
- PHY125 Scientific Computing (3 CP)
- PHY231 Data analysis (3 CP)
- PHY281 Nuclear and Particle Physics without a practical course (6 CP)
- PHY212 Physics of soft matter (6 CP)
- AST241 Introduction to Astrophysics (6 CP)
- PHY321 Electrodynamics (8 CP)
- PHY331 Quantum mechanics I (8 CP)
- PHY341 Thermodynamics (8 CP)
- PHY311 Mechanics (8 CP)

Instead of the modules PHY116/126/139 (Physics I/II/II for minoring students), students may choose to take PHY111/121/131 (Physics I/II/III for physics majors).

We strongly recommend all students to contact the departmental advisors before registering for a minor in physics.

**Minor in Physics in the master's program for 30 CP**

Students may complete a minor in Physics as part of their master's degree. The minor is worth 30 CP and the program is individually determined based on each students' prior experience.

This minor in the master's program is particularly recommended to students intending to teach Physics as their second teaching subject for their Teaching Diploma.

## 2.8 Teaching degree for Swiss “Maturität” schools (university-track secondary schools)

The Institute of Gymnasial and Professional Pedagogy offers the necessary training for a teaching degree for “Maturität” schools. As the program is constantly being remodelled, it is best to look up detailed information at www.ife.uzh.ch/llbm.html.

The program covers 60 cp. You may choose whether to complete the degree in one or two subjects (i.e. to primarily teach physics, but have mathematics as a secondary subject).

The requirement for admission to a teaching program at “Maturität” schools is a master’s degree in physics or an equivalent degree.

**Compulsory elective modules in the area of subject specific didatics**
A teaching degree in a high school subject requires the attendance of subject-specific courses that focus on teaching at “Maturität” schools. Up to 6 CP of the below modules count towards these courses upon request:

- AST241 Introduction to Astrophysics
- PHY250 Electronics
- PHY251 Electronics course
- PHY261 Tutorial
- PHY262 teaching assistantship for Physics I
- PHY263 teaching assistantship for Physics II
- PHY271 additional lab experiments
- PHY272 Semester project
- PHY291 Proseminar in experimental Physics
- PHY391 Proseminar in theoretical Physics

**Physics as a 2$^{nd}$ subject for a teaching degree at “Maturität” schools**
The coursework required for a degree in teaching physics as a 2$^{nd}$ subject involves 90 CP. This requirement can for instance be fulfilles with a 60 CP BSc minor and a 30 CP MSc minor.

**Mathematics as a 2$^{nd}$ subject for a teaching degree at “Maturität” school**
Physicists who want to teach mathematics as their second subject must complete 90 CP worth of coursework. This requirement is usually fulfilled with a 60 CP BSc minor and a 30 CP MSc minor.

# 3. How to organize your studies

### 3.1 Duration of Studies

The standard duration of studies as described in these Study Regulations is six semesters. If students only complete their bachelor’s thesis during the summer vacation, studies will take three full years. Obtaining a master’s degree should take another three semesters, if no additional minor is completed. With a minor, the master’s program lasts 4 semesters.

At most, students are allowed to take twice the amount of time as intended to complete the bachelor and master’s program, counting from the start of the respective direction of study. Students who failed to fulfil the program in the anointed time period may no longer obtain a degree at the Faculty of Science. The Faculty may grant an extended period for study upon a well-founded request.

Departmental advisors are happy too assist in a sensible spreading out of the required course load over an extended duration of studies.

### 3.2 Personal mentoring, Advising

When students begin a program at the institute, they are each assigned a professor as an advisor. Advisors will help students at their request in questions concerning physics, their studies, and personal goals up until they earn their bachelor's degree. Once you have been assigned an advisor, you are asked to contact him or her independently.

### 3.3 Time commitment for your studies and a part-time job

The standard duration of studies is based on a full-time course load. Thanks to the flexibility of the Study Program Regulations, students can potentially keep a part-time job. However, even with a comparatively small part-time job, students should expect a slightly longer duration of studies.

Most modules require students to complete exercises and lab reports independently. This work usually takes as much time as actual class time. To be able to follow lectures, students will discover how important it is to work over material after class for, on average, one hour for every lesson.

Breaks are another opportunity to have a part-time job, though you must keep the scheduling of exams and intensive courses in mind (see section 2.2.5). We recommend that students discuss details carefully with the departmental advisors.

### 3.4 Research internships

Opportunities often arise for students to work with research teams in their labs, where they can get to know the current topics of research and the researchers. Students who are interested should address the team leaders directly or else contact the departmental advisors. In addition, the research centres at the CERN (Geneva), DESY (Hamburg) and PSI (Villigen in Kanton AG) offer programs for students over the summer, which involve practical work as well as theoretical education.

### 3.5 Military

Lectures and labs during the semester, intensive courses in the lecture-free period as well as dates for module exams may overlap with recruit schooling and other military training events. Therefore, we recommend students to complete their service before beginning their studies. If students do have to attend training events during their studies, they should be in touch with the departmental advisors. However, absence due to military service will never lead to a reduction of demands in a module exam or other controls of performance.

### 3.6 Mobility

At the university level, national as well as international projects and scholarships strongly encourage student mobility. A certain degree of mobility is expected of future academics in light of the growing globalization in economics and technology. For instance, physicists should be well versed in English, since pretty much all primary literature and international conferences are in English.

We recommend for students to complete at least one semester of their studies at a university in a foreign country, so they can gain new experiences, widen their horizons and work together with people from different cultural backgrounds. Interested students must apply for admission to a foreign program independently. You can find further information on the university website or directly with the official mobility positions (www.uzh.ch/de/studies/mobility.html).

# 4 Addresses and Information Services

These guidelines: www.physiks.uzh.ch/de/studium.html

Information about the study of physics: www.physiks.uzh.ch

Homepages of the Physics Institute: www.physik.uzh.ch
Homepage of the Institute for Computational Science: http://www.ics.uzh.ch

Postal address: Physik-Institut der Universität, Winterthurerstr. 190, CH-8057 Zürich

Student Advisory Services:

Prof. C. Aegerter, Tel. 044 635 58 13, christof.aegerter@physik.uzh.ch, Büro 36 K 86

Dr. Katharina Müller, Tel. 044 635 57 72, studium@physik.uzh.ch, Büro 36 J 22

Dr. Matthias Hengsberger, Tel. 044 635 4013, matthias.hengsberger@physik.uzh.ch, Büro 11 G 06.

Course catalogue: www.studentservices.uzh.ch

Events at the UZH: www.agenda.uzh.ch

Regulations and information sheets for the Faculty of Science: www.mnf.ch/de/studium/reglemente.html

Office of Student Affairs, for requests and general questions: www.mnf.ch/de/studium/wie-studieren/beratung.html

# 5. Frequently asked questions and answers regarding a degree at the MNF

### 5.1 What documents contain the regulation of a degree at the MNF?

These Study Regulations are designed to be informative. However, we have included all information that is relevant to studying at the institute from the superordinate regulations, which have been listed bellow.

The binding superordinate regulations are (see www.mnf.uzh.ch/studium/reglemente-merkblaetter/bachelor-master.html ):

a) Framework Regulations for studying in the bachelor and master’s programs at the Faculty of Science at the University of Zurich.
b) Program Regulations for studying in the bachelor and master’s programs at the Faculty of Science at the University of Zurich.

c) Regulations for Obtaining a Doctoral Degree

The Framework Regulations contains the general ordinances for the bachelor and master's programs. The Study Program Regulations describe each program's contents. The Doctorate Regulations regulates the doctoral program, which is not included in these Study Regulations.

These guidelines and the regulations a), b) and c) will be in effect for the foreseeable future. The Course Catalogue (www.studentservices.uzh.ch), which is put out every semester, contains more current information, such a detailed description of course offerings.

### 5.2 How is a program constructed? What academic degrees can I attain?

The various programs of study at the MNF are structured in levels. The first level leads to a bachelor's degree, the next level to a master's degree. The bachelor's program provides students with solid foundational knowledge and trains them in structured scientific thinking. The master's program then provides an advanced scientific education and trains students to work in the sciences independently.

The bachelor's program serves as a foundation for further studies at the master's level, be it in the same subject at our or a different university, or be it in a different subject. The Study Program Regulations determine under which conditions changing subjects between the bachelor and master's program is possible.

At the third level following a master's degree, students may begin doctoral studies, as long as they have found an advisor willing to oversee their dissertation. During doctoral studies in physics, the university usually provides students with financial support.

A master's degree provides the necessary training in a subject necessary to obtain a teaching degree for "Maturität" schools.

### 5.3 What is a minor?

A minor is a different subject from a major, in which students must earn either 30 or 60 credit points (see the following section). It will be listed in the bachelor and master's diploma.

### 5.4 How does the credit point system work?

All programs of study are planned according to the principles of the credit point system. This means that all academic performances with be awarded with credit points (cp) in conjunction with a control of performance (i.e. an exam or a paper). The system follows these principles:

- No credit points will be awarded without a control of performance.
- One credit point approximately corresponds to 30 hours of work. This time period should include class time as well as time needed for independent work (going over lectures, solving problems, writing papers and reports, preparing for exams, etc.).
- One semester of full-time study (including the lecture-free period) corresponds to 30 cp.

#### 5.4.1 How many credit points do I need? How much time do I have?

180 CP are necessary for a bachelor's degree, an additional 90 CP (or 120 CP) are needed for a master's degree. This means that the bachelor's program will usually take six, the master's program three (potentially 4) additional semesters (the intended duration of study)

At most, students are allowed to take twice the intended duration of study to complete their degree, counting from the start of a specific direction of study. If a student fails to complete the requirements necessary for a bachelor's or master's degree in this time period, they will no longer be permitted to earn a degree at the Faculty of Science. The Faculty may permit an extended duration of study upon a well-founded request.

Therefore, part-time students in particular have the possibility of continuing their studies for, at most, twice the intended duration of study. On the other hand, with a bit of an extra effort, it may also be possible to earn the required credit points in less than the intended time period.

#### 5.4.2 Can I compile my credit points freely?

No. Students may not choose the courses through which they earn credit points freely. These Study Regulations and the Study Program Regulations describe which courses are compulsory as well as where there is room for choice. For further information see section 5.5.

#### 5.4.3 How can I find my credit point status?

Once per semester, students receive a transcript of the credit points they have thus far earned along with any grades received. Students are obliged to report any discrepancies to the dean's office within four weeks.

### 5.5 How is the degree structured? What are modules?

All program's of study are structured into modules. One module may consist of one or more courses. Credit points are only awarded for modules. At most, a module may extend over two semesters. Completion of a module may be dependent on the fulfilment of requirements; the Lecture Catalogue with Commentary provides further information on the matter (www.studentservices.uzh.ch/).

#### 5.5.1 What types of modules are there?

We differentiate between three types of modules:
- Compulsory module: a module that all students in a specific program must complete.
- Core elective module: a module that must be chosen from a predetermined list of options.
- Elective module: a module that may be chosen freely from all the course offerings of one subject or group of subjects.

The Study Program Regulations of the MNF specifies the compulsory, core elective and elective modules of each program of study, including the corresponding credit points. The determination of elective and core elective modules may also be put out in the Lecture Catalogue with Commentary.

#### 5.5.2 Who is responsible for modules (including examinations or other performance records)?

Each module has a responsible faculty member, who is listed in the Lecture Catalogue with Commentary.

### 5.5.3 How do I register for a module?

You may register for a module according to the general regulations of the UZH. You will find the current link for booking modules at www.students.uzh.ch/booking.html.

### 5.5.4 How do I earn my credit points?

Credit points are only awarded after controls of performance. Scheduling, form and breadth of these performance controls will be announced in the Lecture Catalogue with Commentary.

If students are discovered in an act of dishonesty at a performance control, the performance control will be recorded as having been failed.

## 5.6 What are module examinations? How are they conducted?

A module exam is a written or oral exam on the material covered in a module. The responsible faculty member decides whether the exam will be written or oral. Module exams are graded on the standard scale of 1 through 6 (half grades are possible). If the grade for the entire module is 4 or higher, students receive credit for the module. If the grade is lower than 4, students will not receive credit. The grade from a module exam is calculated into the final grade of your bachelor or master’s diploma in proportion to how many credit points it was worth.

### 5.6.1 Do I have to register for individual module exams? Can I cancel my registration?

Once you have registered for a module, you are automatically signed up for the respective module exam. However, you may drop the module, including the exam, without explanation up until the cancellation deadline. The exact cancellation deadline is provided in the Course Catalogue.

### 5.6.2 Will I receive an invitation for each of my module examinations?

Not necessarily. You will not receive an invitation to written exams. The responsible faculty member will provide the necessary information for written exams. The responsible faculty member must also announce the time and date of oral module examinations. In addition, the administration at the physics institutes will send you an invitation to oral module exams at the physics institute.

### 5.6.3 When are the module examinations held?

The first exams of the fall semester will be held in the calendar weeks (CW) 51 and 2 to 6.
The first exams of the spring semester will be held in the calendar weeks 22 to 28.
Repeat exams are not necessarily held during the exam periods. Usually they are scheduled during CW 35 to 37.
The calendar weeks for individual module exams are listed in the guidelines or the program regulations. The exact dates of module exams are coordinated by the Office of Student Affairs and their date, time and location will be published in the course catalogue.

### 5.6.4 How and when will I receive the results of my module examinations?

Following every exam period, a commission of faculty members validates results. Students can view their results on a personal account prior to this.

### 5.6.5 What are my possibilities for repetition?

A module exam that was not passed can be taken over once, but only once. If a student does not pass a module exam for a compulsory module on his or her second try, he or she will be barred from continuing studies in any program for which this module is compulsory. If a student does not receive a passing grade for an elective module on his or her second try, he or she may replace the course with a different module. Elective modules can always be replaced with a different module after repetition.

If you should not pass a module exam, you will receive a registration form for the repeat exam along with your results. The registration form will inform you of the date by when you must enter a binding registration for the exam. If you do not register in time, you will have to retake the whole module and may repeat the exam only once more. Upon request, you may be allowed to repeat the exam of a single compulsory module a second time. This does not apply to the bachelor's thesis.

### 5.6.6 What happens if I fail to attend an exam or a repetition exam? What should I do in this case?

Anyone who fails to attend a module exam will fail the module. The Faculty may allow for exceptions where there are good reasons or a doctor's attestation. If this is the case, you must hand in a written request including necessary papers or attestations with the dean's office at latest five days after the exam.

In general, you will need to retake you exam on the date for repetition exams of the respective module.

### 5.6.7 How are performance controls conducted in modules for which no exam is intended?

In this case, the responsible faculty member is in charge of the situation. Their choice will be recorded in the Lecture Catalogue with Commentary. Even without an exam performance may be graded.

If you are prevented from attending such a performance control because of your health or another important reason, you must contact the responsible faculty member without delay. The responsible faculty member should then determine a date for repetition.

If a performance control is not completed successfully, the regulations for the repetition of an exam apply.

If you do not fulfil the requirements of a performance control, you will be given the opportunity to do them over. Depending on the type of performance control, this may mean that you will have to retake the entire module.

## 5.7 What do we need to know about bachelor or master's thesis?

A bachelor's thesis in physics involves working within a research team. Students present their results in a written report and an oral presentation. The bachelor's thesis is graded.

A master's thesis is expected to take 9 months of work. The thesis consists of advanced research, of which the results must be presented in a written report. The results must also be presented during a presentation within a seminar. The master's thesis and the presentation will be graded.

You may make a second attempt at a thesis with a new topic, but only once. The report must be written in German or English, or with the permission of your advisor in French or Italian.

### 5.8 Will I receive a bachelor's or master's degree automatically if I fulfil the necessary requirements?

No. These degrees are not awarded automatically when the necessary credit points have been earned. First, you must submit a request for completion of the bachelor or master's program. You will find the necessary forms at www.physik.uzh.ch/en/study/studeinberatung/formulare. If you have fulfilled all requirements, the Faculty will award you your title at the next gathering of the Faculty, as long as you submitted the request three weeks beforehand. Otherwise, you will receive your title at the next gathering.

### 5.9 How will my diploma look?

The diploma is written out in both German and English. It will also contain a grade, which is calculated according to the Study Program Regulations from the grades you received over the course of your studies. Grades in your major and minor will be recorded separately. In addition to your diploma, you will receive an academic record of all completed modules with their respective credit point values, as well as a diploma supplement, which contains general information about program's of study in Switzerland, especially at the University of Zurich.

### 5.10 Can I switch university every semester?

Yes. In general, credit points will be counted at all universities as long as they also follow the ECTS credit point system. A new university is however allowed to determine certain requirements for a program of study if their program of study is significantly different from the one at the UZH. However, if you wish to receive a bachelor's degree from the MNF, you will have to earn at least 90 of the 180 necessary credit points at the University of Zurich, though the Faculty may make exceptions upon request.

## 6. Glossary and Abbreviations

| | |
|---|---|
| MNF | Faculty of Science: an organizational entity at the University of Zurich, which contains all natural sciences and mathematics. |
| CP | Credit points, ECTS points |
| ECTS | European Credit Transfer and Accumulation System |
| MSc | Master of Science |
| BSc | Bachelor of Science |
| SWH | Semester week hours (amount of hours per week per semester) |
| Dean | Head of the Faculty |
| Office of Student Affairs | Administrative office of the Faculty, at the Uni Irchel in Building Y-10 |
| FS | Fall semester |

| | |
|---|---|
| SS | Spring semester |
| Student Administration Office | Administrative office of the entire university, in the main building at the university center. |
| vfZ | Lecture-free period |
| MP | Mathematics for Physics students |
| KTI/II | Nuclear and Particle Physics I and II |
| QM | Quantum Mechanics |
| ED | Electrodynamics |
| NanoP | Physics at the Nanometer Scale |
| FK | Solid State Physics |