

# Studyguide: Physics at the University of Zurich

## Contents

<b>1. Introduction</b> .....	<b>3</b>
1.1 The University of Zurich and the department of physics .....	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 Equality in Physics .....	4
<b>2. Studying physics at the University of Zurich</b> .....	<b>5</b>
2.1 Overview .....	5
2.2 Bachelor's degree .....	5
2.2.1. Compulsory and core elective modules in the 3 <sup>rd</sup> to 6 <sup>th</sup> semester .....	9
Table: Compulsory and core elective modules in the 3 <sup>rd</sup> to 6 <sup>th</sup> semester .....	10
2.2.2. Elective modules in the BSc180 .....	11
2.3 Syllabus: Material covered in the modules of a bachelor's degree in physics .....	13
2.3.1 Compulsory modules in the 1 <sup>st</sup> to 2 <sup>nd</sup> semester .....	13
2.3.2 Compulsory and core elective modules in the 3 <sup>rd</sup> to 6 <sup>th</sup> semesters .....	14
2.3.3 Core elective courses in the 4 <sup>th</sup> - 6 <sup>th</sup> semester .....	17
2.4 Master's degree .....	18
2.4.1 Physics of Condensed Matter .....	20
2.4.2 Particle Physics .....	22
2.4.3. Astrophysics and cosmology .....	24
2.4.4. Bio- and medical Physics .....	26
2.5. Examinations and performance assessments .....	29
2.6 Minors for students with a major in physics .....	29
2.6.1 Mathematics .....	30
2.6.2 Astrophysics .....	30
2.6.3 Chemistry .....	31
2.6.4 Computational Sciences, 60 CP .....	31
2.6.5 Neuroinformatics .....	32
2.6.6 Minor in Simulations in the Natural Sciences, 30 CP .....	32
2.7 Physics as a minor .....	33
2.8 Teaching degree for Swiss "Maturität" schools (university-track secondary schools) .....	35
<b>3. How to organize your studies</b> .....	<b>36</b>
3.1 Duration of Studies .....	36
3.2 Personal mentoring, Advising .....	36
3.3 Time commitment for your studies and a part-time job .....	36
3.4 Research internships .....	36
3.5 Military .....	36
3.6 Mobility .....	36
<b>4 Addresses and Information Services</b> .....	<b>37</b>
<b>5. Frequently asked questions and answers regarding a degree at the MNF</b> ....	<b>37</b>
5.1 What documents contain the regulation of a degree at the MNF? .....	37
5.2 How is a program constructed? What academic degrees can I attain? .....	38
5.3 What is a minor? .....	38
5.4 How does the credit point system work? .....	38
5.4.1 How many credit points do I need? How much time do I have? .....	38
5.4.2 Can I compile my credit points freely? .....	39

5.4.3 How can I find my credit point status? .....	39
5.5 How is the degree structured? What are modules? .....	39
5.5.1 What types of modules are there? .....	39
5.5.2 Who is responsible for modules (including examinations or other performance records)? .....	39
5.5.3 How do I register for a module? .....	39
5.5.4 How do I earn my credit points? .....	39
5.6 What are module examinations? How are they conducted? .....	39
5.6.1 Do I have to register for individual module exams? Can I cancel my registration? .....	40
5.6.2 Will I receive an invitation for each of my module examinations? .....	40
5.6.3 When are the module examinations held? .....	40
5.6.4 How and when will I receive the results of my module examinations? .....	40
5.6.5 What are my possibilities for repetition? .....	40
5.6.6 What happens if I fail to attend an exam or a repetition exam? What should I do in this case? .....	40
5.6.7 How are performance controls conducted in modules for which no exam is intended? .....	40
5.7 What do we need to know about bachelor or master's thesis? .....	41
5.8 Will I receive a bachelor's or master's degree automatically if I fulfil the necessary requirements? .....	41
5.9 How will my diploma look? .....	41
5.10 Can I switch university every semester? .....	41
<b>6. Glossary and Abbreviations .....</b>	<b>41</b>

# 1. Introduction

## 1.1 The University of Zurich and the department of physics

The University of Zurich was founded in the year 1833. It is renowned worldwide as a centre 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/](http://www.physik.uzh.ch/) and the institute of computational science, [www.ics.uzh.ch/](http://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, 80 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 choose to complete their degree part-time.

The UZH values a broad education. 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](mailto:fpu@physik.uzh.ch)

Home page: [fpu.physik.uzh.ch](http://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 Equality in Physics

The Faculty of Mathematics and Natural Sciences (MNF) of the University of Zurich (UZH) considers gender equality and diversity among students, its academic and non-academic staff to be very valuable and is committed to implementing the [UZH's Code of Conduct Gender Policy](#).

It is a fact that fewer women than men study physics, chemistry or engineering in Switzerland, while in other countries, such as Italy or France, their proportion is significantly higher.

Before 2000, the proportion of women among physics students was 10% and has been rising steadily since then; today it is 33% among new students. The proportion of women among doctoral students, scientific staff and professors has also risen steadily over the last 20 years.

The Department of Physics strives counteract any form of prejudice (whether conscious or unconscious) and to create family-friendly working conditions. Suggestions on how to improve working conditions for students are always welcome so that a pleasant climate can be achieved for all students.

Links

Gender and Diversity UZH (<https://www.gleichstellung.uzh.ch/en.html>)

[Person of Trust](https://www.mnf.uzh.ch/en/fakultaet/vertrauenspersonen.html) (<https://www.mnf.uzh.ch/en/fakultaet/vertrauenspersonen.html>)

Psychological Counselling Services UZH (<https://www.pbs.uzh.ch/en.html>)

## 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](http://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 IV 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 (CP).

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:

**Table: Short Summary of BSc 180, 150 and 120**

	BSc180	BSc150	BSc120
Compulsory lectures Physics	161 CP (including 4 CP in proseminars)	139 CP	100 CP
Core elective lectures Physics	2 lectures from core elective block with min. 10 CP	2 lectures from core elective block with min. 9CP 2 CP from proseminar	Min 18 CP from three lectures in the core elective block 2 CP from proseminar
Remaining ECTS	Elective modules <sup>1</sup> offered in any subject at the University, with 9 CP	30 CP minor	60 CP minor

<sup>1</sup>Courses 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."

**Be aware that you need to be correctly inscribed in your study program in the semester you graduate.**

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 Bachelor-Studiengang: Mono- und Major- (150 ECTS) Studienprogramme

	AI111 Artificial Intelligence and Critical Thinking 1 ECTS						
1* HS (31)	Physik I PHY111 8 ECTS	Vertiefung zu Physik I PHY110 2 ECTS	Praktikum zu Physik I PHY112 3 ECTS		Lineare Algebra I MAT111 8 ECTS	Analysis I MAT121 8 ECTS	
vFZ	AI121PHY Artificial Intelligence and Critical Thinking Seminar 1 ECTS						
2 FS (29)	Physik II PHY121 8 ECTS	Vertiefung zu Physik II PHY120 2 ECTS	Praktikum zu Physik II PHY122 4 ECTS	Scientific Computing PHY124 4 ECTS	Lin. Algebra II für Physikstud. MAT142 3 ECTS	Analysis II für Physikstudierende MAT132 8 ECTS	
vFZ							
3 HS (28/27)	Physik III PHY131 8 ECTS	Datenanalyse I PHY231 3 ECTS		Mathematische Methoden der Physik I PHY312 8 ECTS	Mechanik PHY311 8 ECTS	Wahlmodule oder Nebenfach (30 ECTS)	
vFZ	Werkstatt I <sup>(1)</sup> PHY113 1 ECTS						
4 FS (27/17)	Physik IV PHY141 5 ECTS	Datenanalyse II <sup>(1)</sup> PHY241 2 ECTS	Elektronik <sup>(1)</sup> PHY250 3 ECTS	Mathematische Meth. der Physik II <sup>(1a)</sup> PHY322 5 ECTS	Elektrodynamik PHY321 8 ECTS		
vFZ	Praktikum III PHY132 4 ECTS						
5 HS (22/18)	Festkörperphysik PHY210 5 ECTS	PR FK PHY220 <sup>(1a)</sup> 2 ECTS	Kern- und Teilchenphysik I PHY211 5 ECTS	PR KT PHY221 <sup>(1a)</sup> 2 ECTS	Proseminar Theorie <sup>(2)</sup> PHY391 2 ECTS		Wahlpflichtmodul 5/8 ECTS
vFZ	Quantenmechanik I PHY331 8 ECTS						
6 FS (21/17)	Bachelorarbeit PHY399 12 ECTS			Proseminar Exp.physik <sup>(2)</sup> PHY291 2 ECTS	Wahlpflichtmodul 5/8 ECTS	Thermodynamik PHY341 5 ECTS	

(1) = Pflichtmodule nur für Monofach, Wahlmodule Major 150, (1a) = Wahlpflichtmodul Major 150

(2) = Wahlpflichtmodule Major 150 (Proseminare)

\* = Semester, HS/FS, (Monofach/Major) ECTS pro Semester aus Pflichtmodulen

## Übersicht über den Bachelor-Studiengang: Major-Studienprogramm (120 ECTS)

AI111 Artificial Intelligence and Critical Thinking 1 ECTS						
1* HS (31)	Physik I PHY111 8 ECTS	Vertiefung zu Physik I PHY110 2 ECTS	Praktikum zu Physik I PHY112 3 ECTS		Lineare Algebra I MAT111P 8 ECTS	Analysis I MAT121P 8 ECTS
AI121PHY Artificial Intelligence and Critical Thinking Seminar 1 ECTS						
2 FS (29)	Physik II PHY121 8 ECTS	Vertiefung zu Physik II PHY120 2 ECTS	Praktikum zu Physik II PHY122 4 ECTS	Scientific Computing PHY124 4 ECTS	Lin. Algebra II für Physikstud. MAT142 3 ECTS	Analysis II für Physikstudierende MAT132 8 ECTS
3 HS (27)	Physik III PHY131 8 ECTS	Datenanalyse I <sup>(3)</sup> PHY231 3 ECTS		Mathematische Methoden der Physik I PHY312 8 ECTS	Mechanik <sup>(3)</sup> PHY311 8 ECTS	Nebenfach (60 ECTS)
4 FS (5)	Physik IV PHY141 5 ECTS			Mathem.Methoden der Physik II (WP) <sup>(1)</sup> PHY322 5 ECTS	Elektrodynamik (WP) <sup>(1)</sup> PHY321 8 ECTS (WP)	
5 HS (0)	Festkörperphysik (WP) <sup>(1)</sup> PHY210 5 ECTS	Kern- und Teilchen- physik I (WP) <sup>(1)</sup> PHY211 5 ECTS	Proseminar Theoretische Physik <sup>(2)</sup> PHY391 2 ECTS (WP)	Quantenmechanik I (WP) <sup>(1)</sup> PHY331 8 ECTS		
6 FS (8)	Bachelorarbeit PHY398 8 ECTS		Proseminar Experimentalphysik <sup>(2)</sup> PHY291 2 ECTS (WP)	Thermodynamik (WP) <sup>(1)</sup> PHY341 5 ECTS		

- (1) = Wahlpflichtmodule (WP), Wahlpflichtblock 1.  
 (2) = Wahlpflichtmodule (WP), Wahlpflichtblock 2 (Proseminare).  
 (3) = Diese Module können optional im 5. Semester belegt werden.  
 \* = Semester, HS/FS, (ECTS) ECTS pro Semester aus Pflichtmodulen.

If you plan to start with your minor in the 3<sup>rd</sup> semester, we recommend to attend PHY 311 in the 5<sup>th</sup> semester or discuss your study plans with the student advisor.

## Compulsory modules in the 1<sup>st</sup> and 2<sup>nd</sup> 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: Compulsory modules in the 1<sup>st</sup> and 2<sup>nd</sup> semester**

Sem.	Modul	Class time (SWH or weeks)			CW* Exam	Grade	CP
		Lectures	Exercises	Lab course			
1	PHY111 Physics I	4	2		2	yes	8
1	PHY112 Lab Course I			3		no	3
1	MAT121P Analysis I	4	2		6	yes	8
1	MAT111P Linear Algebra	4	2		6	yes	8
1	PHY 110 Supplements to Physics I	2			+	yes	2
1	AI111 Artificial Intelligence and Critical Thinking			1		no	1
2	PHY121 Physics II	4	2		26	yes	8
2	PHY 120 Supplements to Physics II	2			+	yes	2
2	PHY122 Lab Course II			3		no	4
2	MAT132 Analysis II for Physics Students	4	2		27	yes	8
2	PHY124 Scientific Computing	2		2		yes	4
2	MAT 142 Linear Algebra II for Physics Students	2	1			yes	3
2	AI121PHY Artificial Intelligence and Critical Thinking Seminar		1			no	1

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

- The requirement of MAT 142 Linear Algebra for natural scientists II for physics students can also be fulfilled with 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.
- MAT 142 Linear Algebra II for physics students is only a compulsory module for students who started in autumn 18 or later.
- MAT 111 Linear Algebra I is only a compulsory module for students who started in autumn 18 or later, it replaces linear Algebra for natural scientists (MAT 141)

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

In the second year, students take Physics III and IV, which provide a phenomenological introduction to Quantum Mechanics and the theory of relativity. Students are also introduced to theoretical physics. In addition, students study more Mathematics and a few practical topics of their choice.

BSc120 includes two core elective blocks, in the table below, these will be referred to with the abbreviation CE1 and CE2. Students must complete three modules in CE1 and one in CE2.

BSc180 and BSc150 include only one core elective block (CE). Students completing BSc150 must complete one module in CE, students in BSc180 must get at least 10 CP from this block.

**Table: Compulsory and core elective modules in the 3<sup>rd</sup> to 6<sup>th</sup> semester**

Sem.	Module	Class time (SWH or weeks)				BSc 180	BSc 150	BSc 120	CW exams	Grade	CP
		Lecture	Exercise	Lab course	Block course						
3	PHY131 Physics III	4	2			CM	CM	CM	4	yes	8
3	PHY231 Data analysis	1	2			CM	CM	CM	51	yes	3
3	PHY311 Mechanics	4	2			CM	CM	CM	6	yes	8
3	PHY312 Mathematical Methods in Physics I	4	2			CM	CM	CM	2	yes	8
lfp	PHY 113 Workshop I				2	CM		--		no	1
4	PHY250 Electronics	2				CM		--	--	yes	3
4	PHY242 Data analysis II			2		CM				yes	2
4	PHY141 Physics IV	3	1			CM	CM	CM	23	yes	5
4	PHY322 Mathematical Methods in Physics II	4	2			CM	CB1	CB1	26	yes	8
4	PHY321 Electrodynamics	4	2			CM	CM	CB1	28-29	yes	8
lfp	PHY132 Lab course III				2	CM	CM	--	25/27	no	4
5	PHY210 Solid state physics	3	1			CM	CM	CB1	4	yes	5
5	PHY211 Nuclear and Particle Physics I	3	1			CM	CM	CB1	2	yes	5
5	PHY331 Quantum Mechanics I	4	2			CM	CM	CB1	6	yes	8
5	PHY220 Lab course Solid state physics			1.5 days		CM	CB1		report	yes	2
5	PHY221 Lab course Nuclear and Particle Physics I			1.5 days		CM	CB1		report	yes	2
5	AST241 Introduction to Astrophysics	3	1			CB	CB1	--	2-7	yes	5
5	PHY391 Proseminar Theoretical Physics		1			CM	CB2	CB2		yes	2
6	PHY341 Thermodynamics	3	1			CM	CM	CB1	24-28	yes	5
6	PHY291 Proseminar Experimental physics		1			CM	CB2	CB2	--	yes	2
6	PHY212 Physics of soft matter	3	1			CB	CB1	--	24-28	yes	5
6	PHY213 Nuclear and Particle Physics II	3	1			CB	CB1	--	24-28	yes	5
6	PHY351 Quantum Mechanics II	4	2			CB	CB1	--	24-28	yes	8
6	PHY361 Physics against cancer	3	1			CB		--	24-28	yes	5
6	PHY352 Continuum Mechanics	4	2			CB		--	ETH	yes	8
6	PHY399 Bachelor's thesis				9	CM	CM	--		yes	12
6	PHY398 Bachelor's thesis BSc120				6	--	--	CM		yes	8

lfp: lecture-free period

- 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 (PHY131, PHY213) (for dates, see section 2.2.5) or 1.5 days in the semester (PHY220, PHY221). 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 lab courses, 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](http://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 (8 for BSc 120) credit points (meaning approximately 9 (6) 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:

**Table: Elective modules in the BSc180**

Sem.	Nr.	Title	Class time (SWH or weeks)		Exam period	Grade	CP
			Exercises	Block course			
lecture free period	PHY123	Workshop course II		2		no	1
lecture free period	PHY224	Programming in C++		2		no	1
lecture free period	PHY225	Scientific programming in Python		1		no	1
lecture free period	PHY251	Electronics course		2		no	3
FS/SS	PHY261	Tutorial	6			no	5
	PHY271	Additional lab course				no	2

- PHY123, PHY224 and PHY225: half day
- PHY261: Leading practical trainings or Exercises. The minimum requirement is a full time work load (on average 5 SWH) 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](http://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](http://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.

**Table: Booking of the lecture-free period after the fall semester (Christmas until mid-February)**

Calendar week		2	3	4	5	6	7
1st Semester	Module exam	Physics I				Analysis I / Lin. Alg.	
	Block course						
3rd Semester	Module exam	MMP I		Physics III		Mechanics	
	Block course		Work shop I, course 1	Work shop I, course 2	Work shop I, course 1		Work shop I, course 2
5th Semester	Module exam	Nuclear and Particle I	CE	Solid State Physics	CE	QM I	CE:

**Table: Booking of the lecture-free period after the spring semester (Early June until mid-Sept.)**

Calendar week		23	24	25	26	27	28	29	...	34	35	36	37
2nd Sem.	Module exam				Physics II	Analysis II							
	Block course									Program. in C++	Program. in C++		
4th Sem.	Module exam			Physics IV	MMP II		Electrodyn.						
	Block course	Lab course III	Lab course III							Workshop II	Electronics/ Workshop II		
6th Sem.	Module exam			Thermodynamics CE									
	Block course				Scientific Programming Python								

- 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 Programming in C++ take place during two weeks for half the day.
- Block course Scientific Programming in Python takes place during one week the whole day.

## 2.3 Syllabus: 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 1<sup>st</sup> to 2<sup>nd</sup> semester

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

- Mathematical tools (vector fields, complex notation)

#### Mechanics:

- Kinematics and dynamics of mass points
- Dynamics of point systems and rigid bodies
- Rotating systems, angular momentum
- 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
- Magnetic 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)

#### *Supplements to Physics I (PHY110)*

- Taylor Expansion
- Differential equations
- Vector fields
- Differential operators, gradient, divergence, rotation
- Complex notation

- Matrix inversion, Eigenwerte
- Fourier Transformations

#### *Supplements to Physics II (PHY120)*

- Hydrodynamics, Navier-Stokes equations
- Gravity, Kepler's Law
- Atmospheric Physics
- Brownian motion and transport phenomena
- Fourier optics and wave theory
- Movement of charges in el-magn. fields

#### *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 (PHY124)*

- Linux
- Graphical Display
- 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  $\mathbb{Q}$  to  $\mathbb{R}$ ; complex numbers
- Sequences and series; Constancy of functions; Sequences and series of functions; Intermediate value theorems
- Differential calculus; local behaviour 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 derivatives, Taylor series; local behaviour of a graph; convexity
- Theorem of inverse functions; theorem of implicit functions; real manifold; local extrema with constraints
- Integral calculations in  $\mathbb{R}^n$ ; transformation equation; length and area content
- Vector analysis: vector fields, rotations, divergence, Stokes' theorem; divergence theorem; Green's theorem

#### *Linear Algebra (MAT111)*

- Basics and algebraic structures: sets, groups, bodies, rings, Euclidean rings, residue bodies and body extensions
- Matrices and linear systems of equations: vector spaces, matrices, Gaussian elimination method, linear dependence, generating system, basis, equivalence of

- matrices, similarity of matrices, linear algebra over rings
- Determinant: Symmetric group, Multilinear mappings, Determinant as normalized alternating mapping, Further properties of the determinant, Orientation
- Eigenvalues and eigenvectors: Definition and diagonalizability criterion, characteristic polynomial and trigonalizability, theorem of Cayley-Hamilton, fundamental theorems

#### *Lineare Algebra II für Physikstudierende (MAT142)*

- Tensors
- Infinitely dimensional vector spaces

### **2.3.2 Compulsory and core elective modules in the 3<sup>rd</sup> to 6<sup>th</sup> semesters**

#### *Physics III (PHY131)*

Theory of relativity

- Lorentztransformation
- Relativistic energy-momentum relation
- 4-vectors
- General relativity

Laws of thermal radiation:

- Radiation of black bodies
- Particle/wave dualism
- Photon-electrical effect
- Compton effect
- Bending of electrons
- Pair production, annihilation

Foundations in quantum mechanics:

- de Broglie waves, Heisenberg uncertainty principles, Schrödinger equations, expected values, Eigenvalues, Eigenfunctions
- Simple potential wells, tunnel effects

#### *Physics IV (PHY141)*

- Hydrogen atom
- Angular momentum and magnetic moments, fine structure, Zeeman effect
- Spin, fermions and bosons
- Multiparticle wave functions, Pauli principle
- Periodic system, covalent bonds
- Laser
- entanglement and Bell's inequality

#### *Lab Course Physics III/IV (PHY132)*

In this advanced lab, we will perform some key experiments that have contributed to the development of modern quantum mechanics and which were covered theoretically in the Physics III and IV lectures. Quantum mechanics is of central importance in a wide variety of fields of physics: from atomic physics to condensed matter physics to astrophysics. The course includes writing of a report and completion of an error calculation

#### *Data Analysis (PHY231)*

- Evaluation measurement results
- Statistical distributions (binomial, Poissonian, exponential, chi<sup>2</sup>, Lorentz, 2-dimensional Gaussian distributions), correlations, folding
- Monte-Carlo methods
- Polynomial adaptations and adaptations of non-linear functions to measurements
- Least-square methods and maximum-likelihood methods
- Exercises in Python

### *Data Analysis II (PHY241)*

- Monte Carlo methods
- Selected topics related to data analysis
- Project

### *Workshop (PHY113/PHY123)*

- Basic training in precision mechanics
- Boring, Milling, Turning, Grinding, Soldering, Welding

### *Physics of Condensed Matter (PHY210)*

- Structure of crystals: 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 solutions 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
- Optical properties: complex dielectric constants, plasma oscillations, inter-band transitions, optoelectronic building elements
- Magnetism: para- and diamagnetism, ferromagnetism, anti-ferromagnetism, spin-glass
- Superconductivity: Phenomenology, basics of the theories

### *Lab Course Condensed Matter (PHY 220)*

In this advanced practical course some key experiments are performed which have contributed to the development of solid state physics and which have been treated theoretically in the lecture Solid State Physics.

### *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
- Quark models of hadrons, Isospin
- Particle production in e+e collisions
- Quarkonia
- Dirac equations and Feynman laws
- Conservation laws
- Weak interactions
- Electro-weak interactions

### *Nuclear and Particle Physics Lab (PHY221)*

In this lab an experiment is set up carried out to measure the lifetime of Positronium. Students will learn about particle detectors and readout electronics, fit the data that are collected using tools from the data analysis course.

### *Electronics (PHY250)*

- 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

#### *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
- Elementary transport theory
- Irreversibility

### **2.3.3 Core elective courses in the 4<sup>th</sup> - 6<sup>th</sup> semester**

#### *Physics of soft matter (PHY212)*

- 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

*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
- Prandtl boundary layer
- Couette flow and Taylor instability
- Development of turbulence



## 2.4 Master's degree

The Master's degree program in Physics is offered as a mono or major program, each with 90 ECTS credits. In the second option, a minor of 30 ECTS credits must be completed in addition to the major in physics of 90 ECTS credits.

At the beginning of the Master's program, students discuss their individual curriculum with the director of the study program, which is then written down in a learning agreement.

Before beginning the Master's thesis, this learning agreement is finalized with the director of the study program and/or the supervisor of the Master's thesis. Subsequent changes to the agreement require the agreement of the director of the study program.

Master's theses are offered in two different lengths. Longer theses of 50 ECTS take about 10 months with full-time employment (including preparation for the examination, as well as the possibility of holidays in consultation with the supervisor). Independent research is strongly emphasized in such theses.

Shorter theses amounting to 30 ECTS take about 6 months with full-time employment (including preparation for the examination and the possibility of holidays in consultation with the supervisor). It is possible to attend a wider range of advanced lectures for such theses.

Work in the physics groups at UZH can be divided into the following overall research areas:

- Condensed matter: the study of materials whose properties are characterised by the interaction of many quantum states. The work is mainly experimental, in the groups Aegerter, Chang, Natterer, Nordlander, Janoschek, Lатыchevskaia and Schilling, as well as theoretical in the groups Neupert and Bzdušek.
- Elementary particle physics: the study of the fundamental building blocks of matter and their interactions. The work is carried out experimentally in the Baudis, Canelli, Kilminster, Serra, Steinkamp and Caminada groups, and theoretically in the Gehrmann, Grazzini, Isidori, Pozzorini, Signer, Stoffer, Zoller and Crivellin groups.
- Astro(particle) physics and cosmology: the study of the properties of galaxies and the universe as a whole. This includes in particular the search for dark matter. The work is carried out theoretically in the Helled, Jetzer, Mayer, Moore, Saha, Feldmann, Schneider and Yoo groups and experimentally in the Baudis, Kilminster, Penning and Soares-Santos groups.
- Biological and medical physics: The use of physical examination methods and imaging techniques to understand biological systems or for medical applications, e.g. in radiotherapy. The work takes place in the Aegerter, Kozerke, Lатыchevskaia, Schneider, Schuler and Unkelbach groups.

An overview of current research work can be found in the annual reports at <http://www.physik.uzh.ch/en/research/reports.html> and on the websites of the individual research groups: <http://www.physik.uzh.ch/en/research/research.html>

Master's theses can be carried out in the groups of the Institute of Physics and associated research groups. For research areas that are not covered by these groups, it is also possible to carry out a Master's thesis in an external research group. For this purpose, a written application with a work plan must be submitted to a UZH physics lecturer who must be prepared to take responsibility for co-supervision of the thesis. The choice of lectures to be attended will then be agreed on with this lecturer.

However, only topics relating to physics are generally considered for such thesis projects. A Master's thesis in an external research group is subject to the requirements of the Master's degree program in physics at UZH in terms of duration, quality, supervision and grading. The corresponding credit points therefore count as credit points earned at UZH.

Successful graduates are awarded the degree of 'Master of Science UZH in Physics'. To obtain the Master's degree, 90 ECTS credits are required.

The Master's program is taught in English.

### **Admission to the Master's degree program with a major in Physics**

A Bachelor of Science UZH in Physics or a Bachelor's degree in Physics from another Swiss university automatically entitles the holder to be admitted to the Master's degree program in Physics.

All compulsory and compulsory elective modules of the Bachelor's degree program (incl. Bachelor's thesis) must be completed when registering for the Master's degree program. A maximum of 30 ECTS credits acquired during the Bachelor's degree program can be credited towards the Master's degree program. The Master's thesis may only be started after completion of the Bachelor's degree program.

Bachelor's degrees from foreign universities are assessed individually by the faculty. The relevant documents must be submitted together with the application for enrolment to the Registrar's Office or to the Admissions Office for students with foreign qualifications. Depending on previous education, additional coursework may be required during the Master's program.

### **Admission to the consecutive Master's program from the BSc180/BSc150 mono or major study program in Physics**

With a BSc degree in the mono study program in Physics 180 or in the major study program in Physics 150 ECTS Credits, it is possible to transfer to the consecutive Master's program without any conditions.

### **Admission to the consecutive Master's program from the major study program Physics 120**

Students with BSC 120 must specify in the LA which modules from the bachelor's program may still need to be taken in the master's program. Common examples are:

- Solid State Physics (PHY210)
- Nuclear and Particle Physics I (PHY211)
- Quantum Mechanics I (PHY 331)
- Thermodynamics and Statistical Mechanics (PHY341)

It is possible to count it toward the elective portion of the master's program.

## Compulsory modules

### **Master's thesis and associated module examination PHY550/PHY530 (50 or 30 ECTS)**

The Master's thesis forms a central part of the Master's degree program, especially if the longer version of 50 ECTS is chosen. The Master's thesis consists of an independent research project within one of the physics research groups at our university or by arrangement in an external research group.

The Master's thesis is reported in a written report, which is graded.

If you work full-time, a 50 ECTS Master's thesis takes approximately 10 months, including preparation for the module examination and writing the report. Holidays of up to four weeks are also possible in consultation with the supervisor within this time frame. In the case of part-time employment and more or fewer holidays, the duration changes accordingly.

A Master's thesis worth 30 ECTS corresponds to a duration of approximately 6 months, whereby the same conditions apply. This duration includes holidays of up to two weeks.

The module examination for the Master's thesis consists of two parts, each lasting around 30 minutes, and is also graded. The Master's thesis is first presented in a public seminar. In a second, non-public part, at least two lecturers will conduct an oral examination on physical concepts related to the Master's thesis.

The overall grade for the Master's thesis is calculated from the weighted average of the grades for the written report (2/3) and the module examination (1/3). Both the Master's thesis and the module examination must be graded as sufficient, i.e. at least 4.0.

The dates for the Master's thesis and the associated module examination are set directly with the supervisor. Registration takes place using the forms on the website

<https://www.physik.uzh.ch/en/study/Counselling-and-forms/formulare.html>

### **Research seminar PHY555**

Research seminars must be attended as part of the Master's degree program. These can be chosen from all the research seminars on offer, as well as the joint colloquium in physics with ETH. A total of 20 seminar lectures must be attended during 2 semesters, whereby attendance must be confirmed by the organiser of the seminar or a participating lecturer.

Forms can be found on the website

<https://www.physik.uzh.ch/en/study/Counselling-and-forms/formulare.html>

### **Minor subject**

90 ECTS Credits are required to obtain the Master's degree in Physics. A minor subject can be taken voluntarily for an additional 30 ECTS Credits.

### **Master's grade**

The Master's grade is calculated from the credit-weighted average of all graded modules in the Master's degree program.

### **Selection of further lecture modules**

In addition to the research seminar and the Master's thesis, a total of 16 ECTS must be selected from a block of core elective modules, listed below. Depending on the area of the Master's thesis, various combinations of core electives are recommended to ensure optimal preparation for the thesis. However, especially with a shorter Master's thesis totalling 30 ECTS credits, it is possible to attend a broader range of advanced lectures.

The elective area remaining after the core elective lectures can also be filled with other core elective modules. The module PHY 403 (Master Thesis Proposal) is particularly recommended if you are considering a research career.

Master's modules in physics from all areas of physics offered by ETH and UZH are also permitted.

## Core elective modules

Module	ECTS
PHY 352 Continuum Mechanics	8
PHY 361 Physics against cancer	6
PHY 401 Condensed Matter	10
PHY 411 Solid state theory	10
PHY 425 Modern Optics and Microscopy	4
PHY 431 Biological Physics	4
PHY 451 Elementary Particle Physics	8
PHY 452 Elementary Particle Theory	10
PHY 471 Physics and Mathematics of Radiotherapy planning	6
PHY 473 Introduction to Astroparticle Physics and Cosmology	6
PHY 475 Computational problems in medical physics and radiation oncology	6
AST511 General Relativity	10
AST512 Theoretical Astrophysics	10
AST513 Physical Cosmology	10
AST 514 Planetary Formation	10

The core electives and the elective modules are discussed in the learning agreement with the director of the study program (Prof. Christof Aegerter) at the beginning of the study program and fixed with the supervisor of the Master's thesis or the director of the Master's study program before the start of the Master's thesis. Suitable combinations for the different areas (and sub-areas thereof) as well as possible elective modules are listed below.

### Condensed matter:

For a Master's thesis in the area of condensed matter, the core elective modules PHY401 and PHY411 are recommended.

Elective modules focusing on condensed matter (offered by UZH):

- PHY 212 Festkörperphysik II
- PHY 420 Electronspectroscopy
- PHY 425 Modern Optics and Microscopy
- PHY 426 Laser Matter Interaction
- PHY 427 Electron microscopy lectures
- PHY 432 Physics with Muons: From Atomic Physics to Solid State Physics
- PHY 434 Nanomagnetism and Spintronics
- PHY 435 Introducing Photons, Neutrons and Muons for Materials Characterisation
- PHY 522 Computational Quantum Physics
- PHY 523 Unconventional Superconductivity
- PHY 541 Introduction to Disordered and Random Systems
- PHY 542 Geometry and Topology in Condensed Matter Physics
- PHY 585 Principles of X-ray and Neutron Scattering
- PHY 576 Topological condensed matter physics
- CHE 437 Surface and Interface Science

### **Elementary Particle Physics:**

For a Master's thesis in the area of particle physics, the core elective modules PHY451 and PHY452 are recommended.

- Elective modules focusing on particle physics (offered by UZH):
- PHY 213 Kern- und Teilchenphysik II
- PHY 432 Physics with Muons: From Atomic Physics to Solid State Physics
- PHY 461 Experimentelle Methoden und Instrumente der Teilchenphysik
- PHY 462 Particle physics experiment at PSI
- PHY 551 Quantenfeldtheorie I
- PHY 552 Quantum Field Theory II
- PHY 563 The Standard Model and Beyond
- PHY 564 QCD and Scattering Amplitudes
- PHY 578 Effective Field Theories for Particle Physics
- PHY 579 Special Topics in Particle Theory
- PHY 585 Principles of X-ray and Neutron Scattering

### **Astrophysics**

For a Master's thesis in the area of astrophysics, the core elective modules AST512 and AST514 are recommended.

Elective modules focusing on astrophysics (offered by UZH):

- PHY 473 Introduction to Astroparticle Physics and Cosmology
- PHY 519 Applications of General Relativity in Astrophysics and Cosmology
- PHY 551 Quantum Field Theory I
- AST 511 General Relativity
- AST 513 Physical Cosmology
- ESC 204 Computational Methods for Radiative Transfer
- ESC 411 Computational Science I

### **Cosmology**

For a Master's thesis in the area of cosmology, the core elective modules AST511 and AST513 are recommended.

Elective modules focusing on cosmology (offered by UZH):

- PHY 473 Introduction to Astroparticle Physics and Cosmology
- PHY 519 Applications of General Relativity in Astrophysics and Cosmology
- PHY 551 Quantum Field Theory I
- AST 512 Theoretical Astrophysics
- AST 514 Planetary Formation
- ESC 204 Computational Methods for Radiative Transfer
- ESC 411 Computational Science I

### **Astroparticle Physics**

For a Master's thesis in the area of experimental astroparticle physics, the core elective modules PHY451 und PHY473 are recommended.

Elective modules focusing on astroparticle physics (offered by UZH):

- PHY 461 Experimentelle Methoden und Instrumente der Teilchenphysik
- PHY 519 Applications of General Relativity in Astrophysics and Cosmology
- PHY 563 The Standard Model and Beyond
- PHY 585 Principles of X-ray and Neutron Scattering
- AST 511 General Relativity
- AST 512 Theoretical Astrophysics
- AST 513 Physical Cosmology

### **Biological Physics**

For a Master's thesis in the area of biological physics, the core elective modules PHY352, PHY425 und PHY431 are recommended.

Elective modules focusing on biological physics (offered by UZH):

- PHY 252 Computergestütztes Experimentieren
- PHY 253 Computergestütztes Experimentieren II
- PHY 426 Laser Matter Interaction
- PHY 427 Electron microscopy lectures
- PHY 474 Advanced Topics in Medical Imaging
- BIO 330 Modelling in Biology
- ESC 204 Computational Methods for Radiative Transfer

### **Medical Physics**

For a Master's thesis in the area of medical physics, the core elective modules PHY361, PHY471 und PHY475 are recommended.

Elective modules focusing on medical physics (offered by UZH):

- PHY 425 Modern Optics and Microscopy
- PHY 426 Laser Matter Interaction
- PHY 427 Electron microscopy lectures
- PHY 474 Advanced Topics in Medical Imaging
- ESC 204 Computational Methods for Radiative Transfer

### **Theoretical Physics**

For a Master's thesis in the area of theoretical physics, the core elective modules PHY411, PHY452 und AST511 are recommended.

Elective modules focusing on theoretical physics (offered by UZH):

- PHY 351 Quantenmechanik II
- PHY 519 Applications of General Relativity in Astrophysics and Cosmology
- PHY 522 Computational Quantum Physics
- PHY 523 Unconventional Superconductivity
- PHY 541 Introduction to Disordered and Random Systems
- PHY 542 Geometry and Topology in Condensed Matter Physics
- PHY 551 Quantum Field Theory I
- PHY 552 Quantum Field Theory II
- PHY 563 The Standard Model and Beyond
- PHY 564 QCD and Scattering Amplitudes
- PHY 576 Topological condensed matter physics
- PHY 578 Effective Field Theories for Particle Physics
- PHY 579 Special Topics in Particle Theory
- AST 512 Theoretical Astrophysics
- AST 513 Physical Cosmology

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

#### *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

*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 modelling 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

*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

*PHY431 Biology for Physicists*

- Constituents of Biomatter, DANN, RNA, Proteins
- Heredity and evolution
- Allometric scaling laws
- Morphogenesis
- Transcription of genes
- Neural Networks

*PHY451 Elementary particle physics*

- Beginning of particle physics
- Detectors Accelerators
- QCD physics
- Electroweak physics
- Flavor and neutrino physics
- Dark matter
- Beyond-Standard Model physics
- Future facilities

### *PHY452 Elementary Particle Theory*

- Elements of Quantum Field Theory
- Quantum Electrodynamics
- Nonabelian Gauge Theories
- Quantum Chromodynamics (Strong Interactions)
- Electroweak Standard Model and Higgs Mechanism
- Quark Masses and Mixing
- Neutrinos

### *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.

### *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

### *PHY551 Quantum Field Theory*

- Relativistic wave functions
- Quantification of free fields
- Re-normalization
- Perturbation theory

### *PHY552 Quantum Field Theory II*

*Advanced topics such as:*

- Re-normalization groups
- Abel and non-Abel Eich theories
- Standard model, Higgs mechanism
- Path integrals
- PHY568 Flavour Physics
- B-Phenomenology
- Neutrino masses and oscillations
- CP violations in  $B_s^0$

### *PHY568 Flavour Physics*

- B-Phänomenologie
- Neutrino-Massen und -Oszillationen
- CP-Verletzung im  $B_s^0$

### *AST511 General Relativity*

- repetition of special relativity
- principle of equivalence
- 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

### *AST512 Theoretical Astrophysics*

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

### *AST513 Physical 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

### *BIO253 Experimental Techniques in Physical Biology*

- Biomechanics of tissue
- Force measurements
- Modern microscopy
- Scattering methods
- Nuclear magnetic resonance

### *BIO330 Modelling in Biology*

- Deterministic Reaction-Diffusion models
- Stochastic Reaction-Diffusion models
- Finite-element modelling
- Cell-based tissue models
- Image analysis

### *ESC411 Computational Science I*

- Ordinary differential equations
- Partial differential equations
- Monte-Carlo
- Inverse problems
- Signal-processing
- Optimization
- Visualization
- Combinatorial problems

### *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.

### *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

## 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 case of failure the exam can be **repeated once**. Instead of taking the repetition examination, the entire module can also be repeated. In the case of modules whose performance assessment includes solving exercises, the exercises must also be repeated.

In addition to the exam, 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.

### Postponement of exams

Since HS21, it is possible to move the examination date for some modules to the repetition period. You must postpone an exam to the repetition period online on the MNF homepage in the Studies section. You have until the end of the cancellation period to do this. For fall semester modules, that is the end of November, and for spring semester modules the 1st week of May. Exact deadlines are listed in the lecture calendar for each module under "Organization". These deadlines are binding. Any prerequisites for admission to the module examination (exercises etc.) must be fulfilled independently of the examination date.

In physics this concerns the modules

MAT 111 Linear Algebra I

MAT 121 Analysis I

PHY 311 Mechanics

PHY 312 Mathematical Methods in Physics I

PHY 331 Quantum Mechanics I

PHY 321 Electrodynamics

PHY 322 Mathematical Methods of Physics II

## 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. 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

**Table: Compulsory modules for minor in mathematics**

Nr.	Title	Class Time (SWH)		Exam period	Grading	CP
		Lectures	Exercises			
MAT112	Linear Algebra II	4	2	27		9

For physics students with a minor in mathematics, MAT112 Linear Algebra II may be taken instead of the compulsory module MAT142 Linear Algebra II 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.

**Table: Core Elective modules for minor in mathematics**

Nr.	Title	Class Time (SWH)		Exam period	Grading	CP
		Lectures	Exercises			
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 (Minor30:12 CP, Minor60: 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**

**Table: Compulsory modules for minor in Astrophysics**

Sem.	Nr.	Title	Class Time (SWH)		Exam period	Grading	CP
			Lectures	Exercises			
Autumn	AST241	Introductory Astrophysics	3	1	*	*	6

\* 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 30 or 60 CP minor:**  
see course catalogue

**2.6.3 Chemistry**

**Chemistry for 30 CP:**

The compulsory portion of the 30 ECTS minor includes modules CHE170-173 for 16 CP. Modules worth 9 CP must be completed from the core elective modules (CHE201-207, CHE 154/155). 5 CP from the core elective modules 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). Modules worth 21 CP must be completed from the core elective modules (CHE201-206, CHE 154/155, CHE 303-305). 5 CP from the core elective modules 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
3. 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.

### **Elective modules**

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

1 Fall	PHY111 (General) Physics I 8 ECTS		PHY110 Physics I Addendum 2 ECTS			
Semester Break						
2 Spring	PHY121 (General) Physics II 8 ECTS	PHY102 Physics Laboratory for Minors 6 ECTS	PHY120 Physics II Addendum 2 ECTS	PHY124 Scientific Computing 5 ECTS	MAT142 * Lin. Alg. II 2 ECTS	MAT132 * Analysis II for Physics 8 ECTS
3 Fall	PHY131 Physics III (Modern Physics I) 8 ECTS		PHY231 Data Analysis I 3 ECTS		PHY311 Mechanics 8 ECTS	PHY312 Math. Methods in Physics I 8 ECTS
4 Spring	PHY141 Physics IV (Modern Physics II) 5 ECTS		PHY211 Soft Matter Physics 5 ECTS		PHY321 Electrodynamics 8 ECTS	PHY322 Math. Methods in Physics II 8 ECTS
	PHY132 Lab. Course III 4 ECTS					
5 Fall	PHY211 Nuclear and Particle Phys. I 5 ECTS	PHY210 Solid State Physics 5 ECTS	PHY220/221 Lab NP/SSP 2 ECTS	AST241 Introduction to Astrophysics 5 ECTS	PHY331 Quantum Mechanics I 8 ECTS	PHY341 Thermodynamics 5 ECTS
	Compulsory Modules Minor 30 ECTS	Add. Compulsory Modules Minor 60 ECTS	Core Elective Modules Minor 60 ECTS			

\* = only modules specifically for physics majors

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.

### Physics as a minor for 30 CP:

- PHY111 Physics I and PHY121 Physics II (8 CP each)
- PHY131 Physics III (8 CP)
- PHY102 Lab course for minors (6 CP)

### Physics for 60 CP :

- PHY111 Physics I (8 CP)
- PHY121 Physics II (8 CP)
- PHY110 Supplements to Physics I (2 CP)
- PHY120 Supplements to Physics II (2 CP)
- PHY131 Physics III (8 CP)

- PHY141 Physics IV (5 CP)
- PHY102 Lab course for minors (6 CP)

The remaining CP are to be collected from the following core elective modules:

- MAT142 Linear Algebra for physics students (2 CP)\*
- MAT132 Analysis II for physics students (8 CP)\*
- PHY124 Scientific Computing\*
- PHY132 Lab course III (4 CP)
- PHY210 Solid State Physics (7 CP)
- PHY211 Nuclear and Particle Physics (7 CP)
- PHY212 Physics of soft matter (5 CP)
- PHY220 Lab course solid State Physics (2CP)
- PHY221 Lab course nuclear and Particle (2CP)
- PHY312 MMP I (8 CP)
- PHY322 MMP II (8 CP)
- PHY124 Scientific Computing (5 CP)
- PHY231 Data analysis (3 CP)
- PHY241 Data analysis II (3 CP)
- AST241 Introduction to Astrophysics (5 CP)
- PHY321 Electrodynamics (8 CP)
- PHY331 Quantum mechanics I (8 CP)
- PHY341 Thermodynamics (5 CP)
- PHY311 Mechanics (8 CP)

\* = only modules specifically for physics majors

In consultation with the student advisor, other physics modules can also be chosen in the core elective area.

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/lbpm.html](http://www.ife.uzh.ch/lbpm.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 didactic**

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 assistant for Physics I
- PHY263 teaching assistant for Physics II
- PHY271 additional lab experiments
- PHY272 Semester project
- PHY291 Proseminar in experimental Physics
- PHY391 Proseminar in theoretical Physics

### **Physics as a 2<sup>nd</sup> subject for a teaching degree at “Maturität” schools**

The coursework required for a degree in teaching physics as a 2<sup>nd</sup> subject involves 90 CP. This requirement can for instance be fulfilled with a 60 CP BSc minor and a 30 CP MSc minor.

### **Mathematics as a 2<sup>nd</sup> 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](http://www.uzh.ch/de/studies/mobility.html)).

## 4 Addresses and Information Services

These guidelines: [www.physiks.uzh.ch/de/studium.html](http://www.physiks.uzh.ch/de/studium.html)

Information about the study of physics: [www.physiks.uzh.ch](http://www.physiks.uzh.ch)

Homepages of the Physics Institute: [www.physik.uzh.ch](http://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](mailto:christof.aegerter@physik.uzh.ch), Büro 36 K 86

Dr. Katharina Müller, Tel. 044 635 57 72, [studium@physik.uzh.ch](mailto:studium@physik.uzh.ch), Büro 36 J 22

Dr. Matthias Hengsberger, Tel. 044 635 4013, [matthias.hengsberger@physik.uzh.ch](mailto:matthias.hengsberger@physik.uzh.ch), Büro 11 G 06.

Course catalogue: [www.studentservices.uzh.ch](http://www.studentservices.uzh.ch)

Events at the UZH: [www.agenda.uzh.ch](http://www.agenda.uzh.ch)

Regulations and information sheets for the Faculty of Science:  
<https://www.mnf.uzh.ch/en/studium/reglemente.html>

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

The binding superordinate regulations are (see <https://www.mnf.uzh.ch/en/studium/reglemente.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](http://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 will 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 programs 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/](http://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](http://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 the 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 the second try, the course may be replaced once 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](http://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.
lfp	Lecture-free period
MP	Mathematics for Physics students
KTI/II	Nuclear and Particle Physics I and II
QM	Quantum Mechanics
ED	Electrodynamics
FK	Solid State Physics