

UNIVERSITÉ DE FRIBOURG SUISSE
FACULTÉ DES SCIENCES

UNIVERSITÄT FREIBURG SCHWEIZ
MATHEMATISCH-NATURWISSENSCHAFTLICHE FAKULTÄT

Curriculum for the obtention of the Degree of

Master of Science in Physics

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1 General Remarks

This curriculum describes all regulations concerning the study of physics at the University of Fribourg. It is based on the regulations of the Faculty of Science as defined in the *Règlement pour l'obtention des Bachelor of Science et des Master of Science de la Faculté des sciences*, which entered into force on February 2nd, 2004, hereafter called the *Regulation* for short). In case of discrepancies of translation, the French version will be considered authoritative.

1.1 Academic Titles and Study Programs

The Science Faculty of the University of Fribourg awards the following official academic titles to students who have successfully completed their respective course of studies:

- **Bachelor of Science in Physics**, subsequently called **BSc**.
- **Master of Science in Physics**, subsequently called **MSc**.

The **BSc study program** in Physics at the university level provides a basic scientific education in physics including both theoretical and experimental aspects. Its completion opens possibilities in many professional domains and provides a solid basis for life-long learning, an indispensable requirement for professional success. In addition, the BSc in Physics is the basis for advanced studies leading to the MSc in Physics. Anyone in possession of a federal general qualification for university entrance (*maturité fédérale / eidgenössisches Maturitätszeugnis*) or a document deemed equivalent (cf. Art. 6 of the Regulation) can be admitted to the BSc Physics degree programme.

The **MSc study program** in Physics provides the student with more advanced courses, and begins the process of specialization. Completion of the degree allows access to various professional activities in research, education, industry, commerce, and administration. Furthermore, the MSc is the entry requirement for doctoral studies. When accompanied by an additional subject like mathematics, the MSc allows one to enter a complementary education program leading to a qualification as a high-school teacher (*Fähigkeitszeugnis für das Höhere Lehramt II*).

Persons in possession of a Physics BSc from the University of Fribourg, or from any other university, are admitted to the Physics MSc as outlined in Art. 7 of the Regulation. Persons in possession of a BSc degree in a different subject, or degrees judged to be equivalent (e.g., a degree from an engineering school) can also be accepted into the MSc study program based on a decision of the Faculty of Science. The admission decision is made individually for each case. Provisional admission can be granted and depends on the fulfilment of additional requirements set by the Faculty (cf. Section 3.5 of this document).

1.2 Course Structure

The course work leading to both the BSc and MSc degrees is subdivided into formal lectures, exercise classes, laboratory activities, seminars, specialized projects, and so on. These courses are measured in units of “UE” (from “unité d'enseignement” or “Unterrichtseinheit”). To each UE, a number of **ECTS¹ points** is assigned, which, following successful completion of the course (e.g., exams) are converted into ECTS credits (see Section 1.3). The BSc degree course

¹ ECTS stands for *European Credit Transfer System*. One ECTS point corresponds to approximately 30 hours of work. See http://ec.europa.eu/education/programmes/socrates/ects/index_en.html for more information.

requires 180 ECTS credits (corresponding to six semesters of study), and the MSc degree requires an additional 90 ECTS credits (three semesters).

The purpose of the different UE types is as follows:

- **Lectures** give a formal introduction to the scientific methods in physics and advance thinking in a scientific way. They help in acquiring the basic knowledge and understanding the fundamental physics concepts.
- **Exercise classes** complement the lectures and provide essential help for the understanding and practical application of a lecture's content. Through them, the student will practice and apply the acquired principles and mathematical techniques.
- **Laboratory work**, be it experimental or theoretical, is the basis of scientific research. It provides a controlled environment for the hands-on realization of physical measurements. It is during this work that the student will encounter many of the instruments used in research, how such devices assist in making measurements, and the systematic and statistical limits of precision on the measurements made.
- **Seminar presentations** are used to expand the student's knowledge in specialized domains often neglected in the formal courses as well as to begin the development of oral presentation skills for scientific results.
- **Student projects** are a first step towards applying the skills learned in the lectures and exercise classes to real research problems.
- The preparation of the **Master thesis**, under the supervision of an experienced researcher, is the actual starting point of scientific research.

The BSc degree course is composed of a **major branch** made up of 150 ECTS, and a selectable **minor branch** counting for 30 ECTS. The major branch consists of the compulsory UEs in physics and mathematics, and a supplementary science chosen from chemistry, biology, or computer science (locally known as the “propaedeutic branch”). The UEs of the minor branch may not overlap with those of the major. Outside of that restriction, all other subjects taught at the University of Fribourg can potentially be selected as minors. Among the selective minors, mathematics is the obvious choice for physicists, although interdisciplinary study with another science is often attractive. If a student wishes to choose a different minor, she or he must consult with the student advisor in physics to establish a suitable curriculum.

The MSc degree program consists of a one full year of formal lectures, exercise classes, projects, seminars, and an MSc project lasting six months and terminating with the MSc thesis. Although examinations of the UEs of the BSc can be deferred for several semesters after the course, note carefully that the examinations of the MSc UEs are only possible after all requirements for the BSc have been completed (cf. 1.3). Frequently, lectures for both the masters and third year of bachelors programs are given in common, with differences made in the associated exercises to reflect the different levels. Advanced classes for both MSc and PhD students are also sometimes offered.

1.3 Acquired skills

The aim of the studies leading to the award of an MSc in Physics is to deepen knowledge and perfect competence in the chosen field and at the same time develop skills in scientific English. Thus, at the end of the course, a student will have shown that he/she can apply their knowledge to accomplish a research project and will have learned how to work independently or how to integrate into an interdisciplinary research team. The award of the degree requires creative and self-critical talents as well as the ability to communicate ideas and work both in English and their native language.

1.4 Course Assessment (UE) and Accreditation of ECTS Credits

Acquisition of ECTS credits occurs via three steps: assessment of individual UEs, grouping of UEs into a validation package, and awarding the respective ECTS credits for the completed package.

Exercises are assessed following written criteria given at the beginning of the course (e.g., number of submitted exercise papers, number of correctly solved exercises, etc.). Permission to sit the exam associated with a formal lecture can be subject to the successful completion of the lecture's corresponding exercise class.

Assessment of lectures is made by an oral and/or written exam, whose type and duration are specified in this curriculum. Exams occur during the official exam sessions in spring, summer, or autumn, and are subject to a fee. Students register for each exam via the GESTENS web interface (<http://www.unifr.ch/science/gestens>) within the stipulated delays according to the on-line procedure and using their university provided account and password. The marks range from 6 (highest mark) to 1 (lowest mark). An exam marked below 4 can be repeated, but only once, and at earliest during the next exam session.

A **Validation package** comprises multiple, separately assessed, UEs. Art. 18 of the Regulation determines the number of these packages whereas this curriculum determines their content.

ECTS points are credited according to Art. 19 of the Regulation if:

- the weighted average of the exam marks of a validation package is at least 4. The weighting is given by the number of ECTS points assigned to a UE, and
- the assessment criteria for UE not subject to formal examinations (practical work exercises seminars, etc.) are met.

After satisfying those conditions, a package is considered validated and the corresponding ECTS points are converted into ECTS credits and attributed to the student. Upon request, the Dean's office will issue confirmations in which exam results and awarded credits are acknowledged (Art. 22 of the Regulation), provided the exam fee has been paid.

1.5 Teaching Languages

Each course of the BSc is taught in either German or French depending on the choice of the instructor. Students are free to decide in which of the two languages they wish to express themselves. Courses for third year taught in common with MSc students are in English.

MSc courses are taught in English. For exams and written work (project reports, MSc thesis etc.) students can choose between German, French, or English.

1.6 Ethics and Science

Ethical principles are an integral part of a scientific education. Accepted international conventions must be respected during research and while documenting all scientific work whether it be a project, a lecture, a thesis, or a report. In particular, every external source of information (articles, lectures, web pages, etc.) must be correctly cited.

1.7 Regulations and additional Information

Detailed information about studying physics at the University of Fribourg can be found in the following documents either by direct download from the University websites, or in writing from Office of the Physics Department, Chemin du Musée 3, CH-1700 Fribourg:

- Regulation concerning the admission to the University of Fribourg [Règlement d'admission de l'Université de Fribourg / Zulassungsreglement der Universität Freiburg; (www.unifr.ch/rectorat/reglements)]
- Regulation of 2 February 2004 governing the granting of the titles of Bachelor of Science and Master of Science (www.unifr.ch/science)
- Curriculum for major and minor branches in the Faculty of Science of the University of Fribourg (www.unifr.ch/science)
- Study guide of the University of Fribourg (www.unifr.ch/guide)
- Course Program of the University of Fribourg (www.unifr.ch/main/programmecours)
- UE database (www.unifr.ch/science)
- The current examination session calendar of the University of Fribourg

Finally, each student obtains a personal and secure space that can be reached using an individual university e-mail password. This space can be reached by the link "Connexion" on web page www.unifr.ch/science/gestens and allows inscription to courses and exams, access to exam results, the initiation of the process of attestation, etc..

2 Bachelor of Science (BSc)

See the French or the German versions of the curriculum for the BSc degree requirements.

3 Master of Science (MSc)

[Version 2006, validation packages: MSc1-PH.0014, MSc2-PH.0015]

The MSc program in Physics requires 90 ECTS to complete, and is expected to take 18 months. The first year (60 ECTS) consists primarily of courses, exercises, the weekly seminar, and the first part of the master's work, designed to strengthen and complete the student's existing physics knowledge. The lectures can be taken at Fribourg, or may be partially composed of courses offered under the BeNeFri agreement, or from the "Troisième Cycle Romand" courses of the Swiss-French universities. The MSc degree course is completed by a research project of 36 ECTS in total, which includes the writing of a master's thesis.

UEs (Course Units) of the MSc can only be assessed and accredited after successful completion of the BSc.

3.1 MSc Course Units

The first year of MSc study has two semesters of compulsory courses counting for 21 ECTS. The compulsory courses vary between even and odd years as noted below.

3.1.1 Program for odd-numbered years

Semester 1 (autumn)

Code	Title of UE	hours	ECTS
Compulsory Courses			
PH.4101	Electrons and photons	2	2
PH.4111	Exercises (Electrons and photons)	1	1.5
PH.4301	Magnetism and quantum fluids	2	2
PH.4311	Exercises (Magnetism and quantum fluids)	1	1.5
PH.4501	Classical statistical mechanics	2	2
PH.4511	Exercises (Classical statistical mechanics)	1	1.5
			10.5

Semester 2 (spring)

Code	Title of UE	hours	ECTS
Compulsory Courses			
PH.4201	Atomic spectroscopy	2	2
PH.4211	Exercises (Atomic spectroscopy)	1	1.5
PH.4401	Structure and dynamics of matter	2	2
PH.4411	Exercises (Structure and dynamics of matter)	1	1.5
PH.4605	Introduction to the Many-Body Problem	2	2
PH.4615	Exercises (Relativistic quantum mechanics and manybody theory)	1	1.5
			10.5

3.1.1.1 Course Units distributed over three semesters:

Code	Title of UE	hours	ECTS
Compulsory Courses			
PH.4003	Project		5
PH.4004	Colloquia		0.5
PH.4005	Proseminars and Colloquia	1	2.5
PH.5001	Colloquia / Research seminar		1

Elective Courses

PH.xxxx	Specialized courses in Physics	15
	Other (Scientific English recommended)	9
		33

The adviser will inform you about the choice and distribution of the UE.

3.1.2 Program for even-numbered years**Semester 1 (autumn)**

Code	Title of UE	hours	ECTS
Compulsory Courses			
PH.4102	Atomic physics	2	2
PH.4112	Exercises (Atomic physics)	1	1.5
PH.4302	Electrons in solids	2	2
PH.4312	Exercises (Electrons in solids)	1	1.5
PH.4502	Quantum statistical mechanics	2	2
PH.4512	Exercises (Quantum statistical mechanics)	1	1.5
			10.5

Semester 2 (spring)

Code	Title of UE	hours	ECTS
Compulsory Courses			
PH.4202	Modern optics	2	2
PH.4212	Exercises (Modern optics)	1	1.5
PH.4402	Soft condensed matter	2	2
PH.4412	Exercises (Soft condensed matter)	1	1.5
PH.4602	Introduction to field theory	2	2
PH.4612	Exercises (Introduction to field theory)	1	1.5
			10.5

3.1.2.1 Course Units distributed over three semesters:

Code	Title of UE	hours	ECTS
Compulsory Courses			
PH.4003	Project		5
PH.4004	Colloquia		0.5
PH.4005	Proseminars and Colloquia	1	2.5
PH.5001	Colloquia / Research seminar		1
Elective Courses			
PH.xxxx	Specialized courses in Physics		15
	Other (Scientific English recommended)		9
			33

The adviser will inform you about the choice and distribution of the UE.

3.2 Content of the MSc UE**3.2.1 Lectures**

The obligatory courses are given in common with courses for students in the third year of the BSc, with additional content and exercises adapted to the higher level demanded of MSc students. The exams will also reflect the more stringent requirements.

In addition to the required lectures, the student will require at least 15 ECTS from lectures specializing in either experimental or theoretical physics. The choice of available lectures varies from year to year; at Fribourg we have offered the following topics:

- Selected chapters in Atomic Physics and Optics (e.g., Precision physics with spin polarized atoms)
- Selected chapters in Solid State Physics (e.g., Magnetism, Solid State Spectroscopy, and Superconductivity)
- Selected chapters in Soft Condensed Matter Physics (e.g., Light, X-ray, and neutron scattering in soft matter)
- Advanced Statistical Mechanics
- Many-body theory
- Critical Phenomena
- Electronics
- Computational Physics
- General Relativity
- Biological Physics
- Symmetries in Physics
- Optics of strongly scattering media

The specialized lectures may also be taken at other universities; for example, the BeNeFri Advanced Materials course (12 ECTS). The *Troisième Cycle courses* of the Swiss-French universities are also eligible. It is recommended that the student follows specialization courses in the same domain as the intended thesis work.

Other lectures are necessary to complete the ECTS requirements; these elective courses are at the discretion of the student.

3.2.2 Seminars and Colloquia

Each student will present a seminar based on recent research papers (cf. 2.2.3); attendance is expected for all other seminar presentations, as well as for the weekly department colloquia presented by visiting researchers.

3.2.3 Advanced Project

The advanced project, be it experimental or theoretical, consists of work performed within one of the research groups present at Fribourg. During the work, the student will become intimately familiar with the experimental techniques and/or theoretical methods applicable to the physical problems on which the master's thesis will eventually be based. The results will be written in an extended, detailed report.

3.3 MSc Exams and Assessment

The UEs of the first year of study are collectively assessed under the name of validation package MSc1, and gives the student 54 ECTS, if successful. The evaluation of the weekly seminar and the project is made based on criteria announced at the beginning of the year. The course evaluations are made by the following exams:

1. Twenty-minute oral exam for each of the following:
 - *Electrons and Photons* (PH.4101) or *Atomic Physics* (PH.4102)
 - *Atomic Spectroscopy* (PH.4201) or *Modern Optics* (PH.4102)
 - *Magnetism and Quantum Fluids* (PH.4301) or *Electrons in Solids* (PH.4302)
 - *Structure and Dynamics of Matter* (PH.4401) or *Soft Condensed Matter* (PH.4402)
 - *Classical Statistical Mechanics* (PH.4501) or *Quantum Statistical Mechanics* (PH.4502)

- *Introduction to the Many-Body Problem* (PH.4605) or *Introduction to Field Theory* (PH.4602)
- 2. Evaluation criteria (written/oral exam, homework evaluation, etc) fixed in writing at the beginning of the course for:
 - Specialized courses in Physics;
 - Scientific English;
 - Elective courses.

3.4 Master's thesis and exam

The second validation package of the Master's program (MSc2, 36 ECTS) consists entirely of the UE dedicated to the *Master's thesis* itself (PH.5000). This work is foreseen to last between six (6) to twelve (12) months. It will start during the 2nd semester of MSc studies and will extend over the entire 3rd semester. It is real research work which the student will do under the supervision of an active researcher in the field, and during which the student's aptitude for fundamental research will begin to develop. The work will be presented both as a formal written document, and as a 30 minutes oral presentation. The work will be judged on the same 1 (totally unacceptable) to 6 (excellent) scale as the exams are. MSc2 will be validated only for marks of 4 and above. If a work is judged insufficient, a second MSc2 project may be offered to the student.

Successful completion of the MSc1 and MSc2 course work results in the right to the title **Master of Science in Physics, University of Fribourg (MSc)**.

3.5 Admission Regulations for the Master Programme

3.5.1 Admission procedure

Admission to the Masters program may be granted provided the following two conditions have been met by the applicant:

- Satisfying the University admission requirements as defined in the *Règlement concernant l'admission à l'Université de Fribourg*,
- The student possesses a Bachelor in Physics from the University of Fribourg or a degree judged equivalent by the Faculty of Science.

The Faculty of Science establishes and maintains the list of equivalent degrees. Candidates holding a degree quoted in that list can be automatically accepted for a Master's program (provided the other requirement, i.e. (1), is satisfied). Candidates with degrees not on the list will be required to submit an application, in writing, to the Committee of Student Requests ("Commission des requêtes des étudiant-es", care of: Office of the Dean, Faculty of Science, Musée 6a, CH-1700 Fribourg, Switzerland), which will decide on eligibility. In some cases, acceptance may be conditionally based on additional coursework requirements: these may be satisfied in parallel with the regular master's work, or the student may be required to enter as a qualifying student. Final acceptance in the Master's program for a qualifying student is contingent on the successful completion of the additional requirements.

3.5.2 Standard Transfers

Under certain conditions, access to the Master's program may be granted directly. This is of particular applicability for candidates holding a title of Bachelor HES. A detailed description of these conditions is available from the Décanat of the Science Faculty, or from the Studies Adviser in the Physics department.