UNIVERSITY OF RIJEKA – DEPARTMENT OF PHYSICS

GRADUATE STUDY PROGRAMME PHYSICS

MAY, 2020.

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I. DESCRIPTION OF STUDY PROGRAMME FORM

BASIC INFORMATION	
Title of study programme	**Graduate study programme PHYSICS**
study programme coordinator	**University of Rijeka - Department of Physics**
Study programme implementor	**University of Rijeka - Department of Physics**
Type of study programme	university
Level of study programme	graduate
Academic/professional degree awarded upon completion of study	**Master of physics**

1. INTRODUCTION

1.1 Reasons for launching the study programme

When the Department of Physics at the University of Rijeka was founded, one of the principal strategic goals was to initiate and organize graduate study in research physics. After employing outstanding scientists from the country and abroad, the Department of Physics has developed significantly its scientific and research capacities and increased its output in the past few years. A Center for micro- and nano-science and technologies (CMNZT) was founded at the University of Rijeka. Due to the common researchers, it cooperates tightly with the Department of Physics. At the Center, the students have a great opportunity to work with the cutting-edge modern equipment and take part directly in experimental research. When the Department moved to the new building at the University Campus in Rijeka in September 2012, the last necessary condition to finally launch and organize the new graduate study of research physics was fulfilled.

This kind of study is of greatest and utmost importance, primarily to satisfy requirements of local and national economy, but also to satisfy the needs for physics specialists in the local community of the city of Rijeka and at the University of Rijeka.

The development of high-tech industries is of greatest and primary importance for countries like Croatia, which lacks the natural resources (such as minerals, oil or gas), but still aims to achieve the substantial living standard for their citizens. In order to meet this goal, the country must follow the recent scientific progress and must have a substantial number of highly educated and skilled citizens as a labour force, which will be able to introduce new technologies and scientific achievements in our economy. According to some estimates, 60% of the world industry is based or tightly connected with technologies coming from application of quantum physics, so a sufficient number of trained and highly-educated physicists is of key importance for the Croatian economy. The proposed graduate study programme is intended to educate and provide skills and qualifications needed to meet such demands. Few technologies and know-how's can be mentioned for which well-educated physicists are essential: micro- and nano-technologies, environment protection, appliances for diagnostics and therapy in medicine, research, development and application in chemical industries, research and application in the fields of biomedicine, biotechnology, genetics, etc.

Beside the mentioned arguments, there are other specific reasons for the initiation of the proposed study programme. The city of Rijeka and the Primorsko-goranska county plan to launch and invest in large economic projects where environment protection plays an important role. Thus the particular curriculum *Physics and environmental science* in the proposed study programme is the direct response to such needs. It is very important to educate students in this field in order to enable them to actively participate in development, research and application of new technologies in environment protection from the standpoint of natural sciences. Climate changes, drinking water and air susceptibility and exposure to industrial pollutants, construction of new roads and development of transport infrastructure, are just a few of the reasons why environmental protection has become one of the leading world problems and subject to scientific research and debates.

It should be emphasized that Croatia, aware that conservation of natural and especially water resources is one of the most important conditions for our survival, is one of the countries which has declared environment protection as its top scientific

priority.

A large part of the Primorsko-goranska county is geologically a karst region which is highly susceptible and exposed to pollution. Besides, the climate changes represent a major problem which can and will affect the future development of tourism as leading economy in our region. Particular curriculum *Physics and environmental science* as a part of the proposed graduate study will enable students to take part in solving the exposed problems. The strategic plan for development of Primorsko-goranska county defines environment protection as one of its four top priorities, so highly-educated environmental physicists will be needed to meet the EU environmental protection standards in the county. Note that a new Center for medical physics and radiation protection was founded this year at the Clinical hospital center Rijeka, which will also require qualified physicists. A strong research group of experimental astroparticle physicists at the Department of Physics is linked to the medical application of physics. Namely, this group takes part in the development and application of gamma detectors and cameras, all of them being the key elements of sophisticated devices for medical diagnostics (i.e. PET-scanners).

Through this graduate study programme, University of Rijeka will receive a vigorous impetus in development and growth of scientific research in natural sciences. It would also enable our researchers to become more competitive on the national and international level. Foundation of such a graduate study logically leads to introduction of doctoral postgraduate studies, which would significantly boost the scientific and research potentials at the Department of Physics. This study programme also requires and simultaneously enables strong synergy and integration with other university departments (Mathematics, Informatics, Biotechnology) and with the Faculty of Medicine. It will educate research physicists for multi- and inter-disciplinary research conducted at the mentioned institutions. Besides, some of the study programme lecturers belong to the staff of the mentioned institutions.

One of the important problems in Croatia is a persistent brain drain of the most perspective students, whose only possibility is to search for university education in physics in other cities or abroad, as this kind of graduate study (or a similar one) does not exist neither in Rijeka nor in larger region. Despite the progress in mobility, most of them do not return back to Rijeka, especially the most successful ones. As physicists are at present among the most needed employees in all developed countries with a highly developed educational system, it is almost impossible to compensate brain drain with 'brain gain'. We expect to reduce brain drain by initiating this study programme.

1.2.Evaluation of purposefulness in respect to the market needs in public and private sector

The labour market will strongly benefit from launching of the proposed graduate study programme. According to data from the National employment office, there is a persistent and continuous lack of physicists on the labour market, not only in Croatia but also in the European union. On the other hand, according to the document entitled „*Network of high-education institutions and study programmes in Republic of Croatia*“ (AZVO, September 2011), under the section „*Recommendations for educational enrolment politics and scholarship politics*“, at least 10 regional administrative units have declared a need for the increase of the number of students attending the university programmes in physics. In the same document, environment protection is declared as one of the four top priorities. The particular curriculum *Physics and environmental science* is designed for education of highly skilled specialists needed to meet these demands.

The importance of graduated physicists educated in the proposed study programme, goes much further than the above stated needs. In fact, such studies provide a number of different competences and skills, mainly focused on analytical reasoning and problem-solving approach for which advanced skills in mathematics and/or computing are needed. As a consequence, the physicists are highly demanded in developed economies in fields which are not originally directly linked to physics, but its methods and analytical thinking are used, for example in finances and financial markets. Condition for the development of economies based on high technologies is the availability of highly educated and trained specialists on the labour market. Note that education of at least 5 years is necessary to produce such profiles. It should be also emphasized that many top students who finish such studies, due to their ability of analytical and problem-solving approach, launch their own successful start-up companies, which adds a new value to the private economic sector and opens new working places.

1.2.1.Connection with the local community (economy, entrepreneurship, civil society)

The need for physicists has been declared by the local region, the University of Rijeka being its scientific and education center. A strong support is expected for the proposed study programme by the fact that the Primorsko-goranska county has expressed a strong interest for the founding of Analytical center for environment research at the University of Rijeka. This center is meant to provide a precise detection and analysis of all important parameters needed for the decision on strategy of environmental management in the county and farther. In cooperation with the Department of Physics, the Department laboratories (*Laboratory for elemental microanalysis* and *Laboratory for environmental physics* which will become part of the Department in 2013) will be in charge of a detailed sample analysis in order to detect the sources of possible pollution. Another contribution will be provided by the Center for micro- and nano-science and technologies already in function, with more equipment planned to be acquired from EU structural funds through the project for laboratory equipment on university campus. This project, declared as top priority of the University of Rijeka, stands as well on the priority list of the Ministry of science, education and sport.

The Clinical hospital center Rijeka has recently founded the Center for medical physics and radiation protection. The Department is establishing cooperation with this Center. The Center is expected to be highly interested in the proposed study programme which would provide highly-educated physicists working for the Center.

1.2.2.Compliance with professional association's requirements (recommendations)

The proposed programme of the graduate study in Physics is fully compatible and compliant with the requirements, recommendations and strategy of the *Croatian physical society* and of *European physical society*.

1.2.3. Name possible partners outside higher education system that showed interest in the study programme

Primorsko-goranska county, City of Rijeka, Clinical hospital center Rijeka.

1.3 Comparability of the study programme with similar programmes of accredited higher education institutions in the Republic of Croatia and the EU (name and explain comparability of the proposed programme with two programmes, whereas at least one of which should be from the EU (provide their web sites))

During the creation of the proposed study programme, special care was taken to assure its equivalence and compliance with similar study programmes in the leading European universities. The following study programmes were consulted and followed:

1. Master in Physics, Faculty of Physics (Ludvig-Maximilians-Universitity, Munich, Germany);
   http://www.en.physik.lmu.de/programs/degrees/msc_physics/index.html
2. Master of Physics and Applications, UPMC (Sorbonne Universites, Paris, France); **http://www.upmc.fr/en/education/diplomas/sciences_and_technologies/masters/master_of_physics_and_applications.html**

It can be seen that the basic structure and contents of the quoted study programmes are very similar and compliant with the structure of the proposed study programme: the first year of the study consists of courses in theoretical physics and experimental methods and of the laboratory exercises, which will provide the basis for elective more specialized courses in the second semester. The second year of study consists almost entirely of the specialized courses which lead to research activities and diploma thesis. The differences that arise between the study programmes are mainly influenced by differences in the national higher education systems and presence of particular fields of physics on institutions.

1.4. Openness of the study programme towards horizontal and vertical mobility of students within national and international higher education area

The proposed study programme is fully compatible and compliant with main ideas and baseline of the Bologna treaty and Bologna reforms, which includes a high level of students' mobility. Bachelor of a university of adequate quality level can enrol in this graduate study. It is expected that the graduates in this study programme will gain a sufficient knowledge to be able to apply to appropriate postgraduate study/doctoral school in any country. The ECTS system enhances students' mobility

between different universities in Croatia and abroad. Transfers between study programmes inside and between universities are also possible.

1.5. Alignment with the Mission and the Strategy of the University of Rijeka

This study is in complete agreement with the University of Rijeka Mission and Strategy. One of the main goals is formation of flexible academic profiles in all three university levels (undergraduate, graduate and postgraduate), in accordance with the needs of the community, economy and development of the society. With its interdisciplinary and multidisciplinary character, the proposed study fulfils the requirements of the University strategy. This study is a follow up of the Undergraduate study Physics (accredited in 2011) and fills, up to now empty, second academic level necessary to start the postgraduate doctoral study in physics as a third academic level. Besides, it represents the necessary basis needed to achieve the scientific mission of the University, all this in order to help further development of natural sciences at the University. It is expected that it will help integration of University in the local economy and social development.

1.6 .Institutional strategy for study programmes development

Introduction of a new graduate study in research physics will significantly enhance the quality of scientific and research activities and outputs in the Department, which is one of its primary goals.

1.7. Other important data – according to the coordinator's opinion

The compulsory literature for some courses which is not present in the University library in the required number, will be acquired before the beginning of the academic year when the particular course enters into realization for the first time.

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2. GENERAL PART

2.1. Title of study programme

Graduate study programme PHYSICS

2.1.1. Type of study programme

university

2.1.2. Level of study programme

graduate

2.1.3. Area of study programme (scientific/artistic) – indicate the title

Area-Natural sciences, Fields- Physics

2.2. Study programme coordinator

University of Rijeka - Department of Physics

2.3. Implementor/s of study programme

University of Rijeka - Department of Physics

2.4. Duration of study programme (indicate possibilities of part-time study, long distance study)

Two academic years, i.e. four semesters.

2.4.1. ECTS credits – minimal number of credits required for completion of study programme

120 ECTS credits

2.5. Enrolment requirements and selection procedure

The candidates should obtain adequate undergraduate university degree (B.Sc.) in natural or technical sciences. Applicants who do not have an adequate undergraduate university degree in physics (B.Sc. in physics) have to pass an obligatory qualifying exam in which the knowledge and skills needed to follow the 1st year courses will be tested.

2.6. Study programme learning outcomes

2.6.1. Competences which student gains upon completion of study (according to CROQF (HKO): knowledge, skills and competences in a restricted sense –independence and responsibility)

The general competences which student gains upon completion of the study programme include:

- advanced knowledge of physics adequate to join scientific research groups,
- capability of analytical reasoning and autonomous problem solving, regardless of their nature and field, which includes application of advanced mathematical, statistical and/or computational methods,
- developed scientific reasoning and approach by active participation in scientific research during the study,
- practical skills (methodology, preparation and execution of an experiment) acquired by work with modern equipment during exercises and laboratory courses,

By concluding one of the following four particular curricula in the graduate study, the student gains specific knowledge, skills and competences:

(A) Solid state physics
The solid state physics investigates and analyses structures built from bonding of atoms or molecules in stable configurations. It involves research of matter properties from nano and micro structures including specific phenomena connected with material surfaces, up to specific properties typical for the behaviour of infinite crystals. In this particular curriculum, students gain fundamental knowledge on solid state physics from both theoretical and experimental standpoint. They are expected to understand and predict the behaviour of materials in more complex structures. Students gain skills and competences needed to solve more complex experimental and theoretical problems. They are able to actively answer the challenges of the fast technological development in the modern society.

(B) Astrophysics and physics of elementary particles
Accelerated growth of astrophysics and particle physics in the last two decades has resulted in their strong mutual interweaving, though, traditionally, these two fields of physics were well separated, the former dealing mainly with the largest, and the latter with the smallest scale in nature. The interconnection of these two fields has led to astroparticle physics as a new field. Consequently, the proposed particular curriculum is based on modern approach which enables students to understand the two fields through their mutual interconnection. The curriculum remains flexible to leave the student the choice to specialize in different combinations of fields (such as astrophysics + atomic and molecular physics, astrophysics + nuclear physics, elementary particle physics + nuclear physics). Students gain basic and advanced knowledge and skills on the recent understanding of the fundamental forces in the universe and on the structure of the universe from the smallest to the largest scales. By attending laboratory and experimental courses, the students also gain important experimental and practical skills and competences that can be used even outside the fundamental scientific research. This enables students to get acquainted with experimental equipment, devices and methods based on the most advanced technologies which have wide application in industry and medicine.

(C) Atomic and molecular physics
Atomic and molecular physics deals with the research of matter properties from the smallest atoms to the extremely complex molecules, their mutual interaction as well as interaction between matter and radiation. Student gain knowledge and understanding in atomic and molecular physics which are essential in chemical, biological, and biotechnological laboratories in the public and private sectors. They gain advanced knowledge and skills in atomic and molecular physics, including theory and application of absorption and emission, scattering of electromagnetic radiation on excited atoms and molecules, spectroscopic methods, lasers and optical properties of matter. After the graduation in this particular curriculum, students are expected to have developed skills and competences needed in further education in the frame of postgraduate/doctoral studies in this or related fields. The students are prepared to work in health institutions as well as in private enterprises in which lasers and laser or other type of spectroscopy are applied.

(D) Physics and environmental science
Students gain knowledge and skills needed to understand relevant concepts in theoretical physics which are essential in solving environment-related problems. They are expected to:
- be able to interconnect and apply skills and knowledge from different fields of physics in order to solve environmental problems
- become acquainted with experimental methods in physics with special emphasis on their application in environmental science
- gain knowledge and understanding of physical processes and phenomena in the water, atmosphere and soil and their influence on specific ecosystems
- gain understanding of the recent global environmental problems,
- gain understanding and knowledge of the concepts of the biochemical circulation of elements in the nature,
- gain knowledge of statistical and computing methods and their application in environmental monitoring and modelling,
- gain knowledge of different anthropogenic and natural factors contributing to environmental pollution and be able to assess their environmental impact.

2.6.2. Employment possibility (list of possible employers and compliance with professional association's requirements)

There are vast employment possibilities for students graduating in this study programme. For example, research and

development departments, sections and laboratories in high-tech and/or advanced technology companies (such as Ericsson-Nikola Tesla), companies in chemical (INA) or IT sector, laboratories for monitoring and analyses of environmental samples (public health department, private enterprises), private and public research institutions, various government agencies at all levels (mostly in the field of environmental protection). Furthermore, employment could be found in the financial sector (banks, insurance and investment funds), as well as in hospitals and other related institutions that use advanced diagnostic and therapeutic equipment. Other possible jobs are the ones where radioactive substances are handled or radiation protection is needed. The proposed study develops broader competences including advanced knowledge and skills in mathematics, statistics and computing, as well as analytical reasoning and problem-solving approach. The latter ensures the variety of employing possibilities in a developed economy.

2.6.3. Possibility of continuation of study on higher level

After the graduation, students will be able to enrol to all postgraduate studies of physics in Croatia (e.g. Faculty of Science at the University of Zagreb) and abroad. According to the ideas of Bologna treaty and Bologna reforms, the student is expected to be allowed to apply for postgraduate studies in other fields of natural and other sciences.

2.7. Upon applying for graduate studies list proposer's or other Croatian institution's undergraduate study programmes which enable enrolment to the proposed study programme

Undergraduate study Physics (University of Rijeka – Department of Physics),
Undergraduate study Physics (Faculty of mathematics and natural sciences at University of Split),
Undergraduate study Physics (J.J. Strossmayer University of Osijek – Department of Physics).

The bachelors from other study programmes related to natural or technical sciences can apply for this graduate study assuming that they have passes the qualifying exam.

2.8. Upon application of integrated studies - name reasons for integration of undergraduate and graduate level of study programme

The proposed study is not integrated.

3. PROGRAMME DESCRIPTION

3.1. List of compulsory and elective subjects and/or modules (if existing) with the number of active teaching hours required for their implementation and number of ECTS-credits (Table 1)

Table 1: 3.1. List of compulsory and elective courses and/or modules with teaching hours required and ECTS credits allocated (pages 10-25)

3.2. Description of each subject (*Appendix 1)*

Appendix 1: Course description (page 26, all courses in alphabetical order)

3.3. Structure of study programme, dynamic of study and students' obligations

The dynamics of the study and students' obligations are regulated by the Rules of studies issued by the University of Rijeka and by the programme of each study course. The whole study programme is divided into four semesters, while each study course is a one-semester course. At the beginning of the graduate study (1st year), students can choose on of the four particular curricula:
(A) Solid state physics
(B) Astrophysics and physics of elementary particles
(C) Atomic and molecular physics
(D) Physics and environmental science

Student's Supervisor from the faculty staff is assigned to each student at the beginning of the study. The Supervisor helps the student during his progress through the study, helps him to decide for the elective courses in the frame of enrolled particular curriculum, guides the student in accordance to his potential and abilities, and takes care of the timing regarding the introduction of the student to the scientific research and selection of thesis supervisor. The student's Supervisor guides and helps the student in agreement with the Head of the graduate study. In order to increase flexibility and mobility of the students, in agreement with the student's Supervisor and Head of the graduate study, they are allowed to attend courses from different particular curricula.

3.3.1. Enrolment requirements for the next semester or trimester (course title)

The enrolment requirements are aligned with the Rules of studies issued by the University of Rijeka. The rules related to the enrolment of a specific course, if existing, are given in the description of that particular course.

3.4. List of courses and/or modules student can choose from other study programmes

The following courses are available on other graduate study programmes at the Department of Physics:
- Semiconductors and applications (graduate study *Engineering and material physics*)
- Micro and nano sciences and technologies (graduate study *Engineering and material physics*)
- Electrodynamics (graduate study *Physics and mathematics*)

3.5. List of courses and/or modules that can be implemented in a foreign language (specify the language)

All the courses offered by the faculty of the Department of Physics of the University of Rijeka can be delivered and implemented in English language.

3.6. Allocated ECTS credits that enable national and international mobility

ECTS credits achieved during the study programme (30 ECTS per semester, 120 in total) allow students to transfer to other (equivalent) study programmes at universities in Croatia or abroad.

3.7. Multidisciplinarity/interdisciplinarity of study programme

Multidisciplinarity of the proposed study programme is achieved through the wide choice of courses and lecturers who are researchers coming from various fields of different scientific areas (natural, technical, biomedical and biotechnological sciences). The particular curriculum *Physics and environmental science* has pronounced interdisciplinarity.

3.8. Mode of study programme completion

The graduate study programme is completed by a final exam consisting of a public defence of the Master Thesis, previously written on the basis of the performed scientific research.

3.8.1. Conditions of approval of final work /thesis and/or final/thesis exam application

The topic of the Master Thesis can be approved only to students who have accomplished all 1st year courses of the study programme (i.e. 60 ECTS credits are a required minimum). Student must have completed all courses of the graduate study in order to submit the written form of the Master Thesis for review and evaluation.

3.8.2. Composing and furnishing of final work/thesis

The written form of the Master Thesis is regulated by the Set of Rules for writing the Master Thesis, issued by the Department of Physics.

3.8.3. Final work/thesis assessment procedure and evaluation and defense of final work/thesis

The Master Thesis is reviewed and evaluated by a three-member committee consisting of supervisor and two others lecturers in the graduate study programme. In the case of negative evaluation, the student must choose a new supervisor and topic of the thesis, and pass the whole procedure from the start. Positive evaluation of the written Master Thesis allows the student to apply for the public defence. The whole procedure for the public defence of the Master Thesis is regulated by the Set of Rules for Master Thesis, issued by the Department of Physics.

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(A) GRADUATE STUDY PROGRAMME PHYSICS
MODULE: Solid State Physics

LIST OF MODULES/COURSES							
Year: 1.							
Semester: 1.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**[1]	
Solid State Physics	Statistical Mechanics	45	15	15	8	C	
	Module FČS-I						
	Advanced Electrodynamics	45	15	15	8	C	
	Advanced Quantum Physics	45	30	15	8	C	
	Physics of Materials	30	30	0	6	C	

LIST OF MODULES/COURSES							
Year: 1.							
Semester: 2.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Solid State Physics	Seminar in Physics on English	0	0	15	2	C	
	Module FČS-II						
	Solid State Physics I	45	30	15	8	C	
	Atomic and Molecular Physics	45	15	15	8	C	
	Experimental Methods in Physics I	30	15	15	6	C	
	Elective courses II				6	E	
ELECTIVE COURSES II							
Students are required to take 1 course with a total of 6 ECTS credits.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Solid State Physics	Electronics	30	15	15	6	E	
	Quantum Field Theory	30	15	15	6	E	
	Advanced Computational Physics	30	15	15	6	E	

[1] IMPORTANT: Insert C for compulsory course or E for elective course.

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LIST OF MODULES/COURSES							
Year: 2.							
Semester: 3.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Solid State Physics	*Module FČS III*						
	Solid State Physics II	30	15	15	6	C	
	Semiconductors: Principles and Applications	30	15	15	6	C	
	Experimental Methods in Physics II	30	15	15	6	C	
	Structure of Matter Lab	0	0	60	6	C	
	Elective courses III				6	E	
ELECTIVE COURSES III							
Students are required to take 1 course with a total of 6 ECTS credits.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Solid State Physics	Magnetic Materials and Applications	30	15	15	6	E	
	Selected topics of Atomic and Molecular Spectroscopy	30	15	15	6	E	
	Electronics Laboratory	0	0	60	6	E	
	Precision Engineering and Microsystems Technologies	45	30	0	6	E	

LIST OF MODULES/COURSES							
Year: 2.							
Semester: 4.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Solid State Physics	Master Thesis Seminar	0	0	15	6	C	
	Master Thesis	0	180	0	18	C	
	Elective courses IV				6	E	
ELECTIVE COURSES IV							
Students are required to take 1 course with a total of 6 ECTS credits.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Solid State Physics	Quantum Field Theory	30	15	15	6	E	
	Advanced Computational Physics	30	15	15	6	E	
	Advanced Experimental Laboratory	0	0	60	6	E	
	Spintronics	30	15	15	6	E	
	Practical Work	0	0	150	6	E	

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(B) GRADUATE STUDY PROGRAMME PHYSICS
MODULE: Astrophysics and elementary particle physics

LIST OF MODULES/COURSES							
Year: 1.							
Semester: 1.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Astrophysics and elementary particle physics	Statistical Mechanics	45	15	15	8	C	
	Module AFEČ-I						
	Advanced Electrodynamics	45	15	15	8	C	
	Advanced Quantum Physics	45	30	15	8	C	
	General Relativity	30	15	15	6	C	

LIST OF MODULES/COURSES							
Year: 1.							
Semester: 2.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Astrophysics and elementary particle physics	Seminar in Physics on English	0	0	15	2	C	
	Elective courses II				28	E	
ELECTIVE COURSES II							
Students are required to take courses with a total of 28 ECTS credits. At least one of following courses is required: " Astronomy and Astrophysics I ", " Elementary Particle Physics I "							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Astrophysics and elementary particle physics	Astronomy and Astrophysics I	45	30	15	8	E	
	Atomic and Molecular Physics	45	15	15	8	E	
	Elementary Particle Physics I	45	30	15	8	E	
	Nuclear Physics	30	15	15	6	E	
	Experimental Methods in Physics I	30	15	15	6	E	
	Electronics	30	15	15	6	E	
	Quantum Field Theory	30	15	15	6	E	
	Advanced Computational Physics	30	15	15	6	E	

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LIST OF MODULES/COURSES							
Year: 1.							
Semester: 3.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Astrophysics and elementary particle physics	*Elective courses III*				30	E	
ELECTIVE COURSES III							
Students are required to take courses with a total of 30 ECTS credits.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Astrophysics and elementary particle physics	Astronomy and Astrophysics II	30	15	15	6	E	
	Astroparticle Physics	30	15	15	6	E	
	Experimental Methods in Physics II	30	15	15	6	E	
	Elementary Particle Physics II	30	15	15	6	E	
	Electronics Laboratory	0	0	60	6	E	
	Structure of Matter Lab	0	0	60	6	E	
	Observational Astrophysics	30	15	15	6	E	

LIST OF MODULES/COURSES							
Year: 1.							
Semester: 4.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Astrophysics and elementary particle physics	Master Thesis Seminar	0	0	15	6	C	
	Master Thesis	0	180	0	18	C	
	Elective courses IV				6	E	
ELECTIVE COURSES IV							
Students are required to take 1 course with a total of 6 ECTS credits.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Astrophysics and elementary particle physics	Astrophysics Lab	0	0	60	6	E	
	Physical Cosmology	30	15	15	6	E	
	Advanced Computational Physics	30	15	15	6	E	
	Selected Topics in High Energy Physics	30	15	15	6	E	
	Practical Work	0	0	150	6	E	

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(C) GRADUATE STUDY PROGRAMME PHYSICS
MODULE: Atomic and Molecular Physics

LIST OF MODULES/COURSES							
Year: 1.							
Semester: 1.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Atomic and Molecular Physics	Statistical Mechanics	45	15	15	8	C	
	Module AMoF-I						
	Advanced Electrodynamics	45	15	15	8	C	
	Advanced Quantum Physics	45	30	15	8	C	
	Quantum theory of Atoms and Molecules	30	15	15	6	C	

LIST OF MODULES/COURSES							
Year: 1.							
Semester: 2.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Atomic and Molecular Physics	Seminar in Physics on English	0	0	15	2	C	
	Module AMoF-II						
	Atomic and Molecular Physics	45	15	15	8	C	
	Experimental Methods in Physics I	30	15	15	6	C	
	Elective courses II				14	E	
ELECTIVE COURSES II							
Students are required to take 1 course with a total of 6 ECTS credits.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Atomic and Molecular Physics	Electronics	30	15	15	6	E	
	Solid State Physics I	45	30	15	8	E	
	Advanced Computational Physics	30	15	15	6	E	
	Nuclear Physics	30	15	15	6	E	

LIST OF MODULES/COURSES							
Year: 1.							
Semester: 3.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Atomic and Molecular Physics	*Module AMoF-III*						
	Experimental Methods in Physics II	30	15	15	6	C	
	Structure of Matter Lab	0	0	60	6	C	
	Selected topics of Atomic and Molecular Spectroscopy	30	15	15	6	C	
	Elective courses III				12	E	
ELECTIVE COURSES III							
Students are required to take 2 courses with a total of 12 ECTS credits.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Atomic and Molecular Physics	Solid State Physics II	30	15	15	6	E	
	Physical Chemistry	30	30	0	6	E	
	Semiconductors: Principles and Applications	30	15	15	6	E	
	Electronics Laboratory	0	0	60	6	E	
	Precision Engineering and Microsystems Technologies	45	30	0	6	E	

LIST OF MODULES/COURSES							
Year: 1.							
Semester: 4.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Atomic and Molecular Physics	Master Thesis Seminar	0	0	15	6	C	
	Master Thesis	0	180	0	18	C	
	Elective courses IV				6	E	
ELECTIVE COURSES IV							
Students are required to take 1 course with a total of 6 ECTS credits.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Atomic and Molecular Physics	Quantum Field Theory	30	15	15	6	E	
	Advanced Computational Physics	30	15	15	6	E	
	Advanced Experimental Laboratory	0	0	60	6	E	
	Nuclear Physics	30	15	15	6	E	
	Practical Work	0	0	150	6	E	

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(D) GRADUATE STUDY PROGRAMME PHYSICS
MODULE: Physics and Environmental science

LIST OF MODULES/COURSES							
Year: 1.							
Semester: 1.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Physics and Environmental science	Statistical Mechanics	45	15	15	15	C	
	Module FiZO-I						
	Electrodynamics	45	45	0	7	C	
	Atmospheric Physics	30	15	15	7	C	
	Instrumental Methods in Environmental Phyiscs	30	30	0	7	C	

LIST OF MODULES/COURSES							
Year: 1.							
Semester: 2.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Physics and Environmental science	Seminar in Physics on English	0	0	15	2	C	
	Module FiZO-II						
	Experimental Methods in Physics I	30	15	15	6	C	
	Soil Physics	30	15	15	7	C	
	Elective courses II-IV				16	E	

LIST OF MODULES/COURSES							
Year: 1.							
Semester: 3.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Physics and Environmental science	*Module FiZO-III*						
	Experimental Methods in Physics II	30	15	15	6	C	
	Structure of Matter Lab	0	0	60	6	C	
	Physical oceanography	30	30	0	7	C	
	Elective courses III				11	E	

LIST OF MODULES/COURSES							
Year: 1.							
Semester: 4.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Physics and Environmental science	Master Thesis Seminar	0	0	15	6	C	
	Master Thesis	0	180	0	18	C	
	Elective courses II-IV				6	E	

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ELECTIVE COURSES II-IV							
2nd semester: Students are required to take courses with a total of 16 ECTS credits. 4th semester: Students are required to take courses with a total of 6 ECTS credits. At least one of the chosen courses has to be in the field of physics.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Physics and Environmental science	Atomic and Molecular Physics	45	15	15	8	E	
	Nuclear Physics	30	15	15	6	E	
	Terrestrial Ecology	30	30	0	6	E	
	Atmospheric chemistry	30	0	30	6	E	
	Physical modeling of the environment	30	30	0	6	E	
	Advanced Experimental Laboratory	0	0	60	6	E	
	Advanced Computational Physics	30	15	15	6	E	
	Environmental impact assessment	30	30	0	6	E	
	Practical Work (only 4th semester)	0	0	150	6	E	
	Fundamentals of Polymer Physics	30	15	15	6	E	
	Spatial planning	40	10	10	5	E	
	Hydrogeology	30	15	0	5	E	
	Waste Management	30	10	5	4	E	
	Water management	30	0	30	4	E	
	Waste management	20	0	10	3	E	

ELECTIVE COURSES III							
Students are required to take courses with a total of 11 ECTS credits.							
MODULE	**COURSE**	**L**	**E**	**S**	**ECTS**	**STATUS**	
Physics and Environmental science	Interaction of the atmosphere and the sea and influence on oceanographic properties	30	0	30	6	E	
	Environmental Microbiology	30	20	10	6	E	
	Selected topics of Atomic and Molecular Spectroscopy	30	15	15	6	E	
	Aquatic Ecology	15	15	15	5	E	
	Biological oceanography	15	15	0	3	E	
	Geohazards	20	10	15	3	E	
	Environmental impact assessment	20	0	10	3	E	
	Environmental protection	15	0	15	2	E	