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**CODEX**

**Doctoral  
programme in**

**MATHEMATICS AND PHYSICS**

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## 1. INTRODUCTION

The study of mathematics and physics at the University of Ljubljana has been in progress since the University was established in 1919. Initially the programmes were intended for future teachers and were the first such studies on Slovene territory. Later they were expanded to the of physics, astronomy, meteorology and pedagogical physics, and the study of mathematics and pedagogical mathematics. The studies were reorganized several times, together with reorganizations of the University. The study of theoretical mathematics and physics at first took place at the Faculty of Philosophy, while the study of experimental physics was carried out at the Technical Faculty and the incomplete Medical Faculty. Later all mathematics and physics programmes were conducted at the Faculty of Natural Sciences and Mathematics, and from 1960 to 1995 at the Faculty of Natural Sciences and Technology. In 1995, the current Faculty of Mathematics and Physics (FMF) was founded. It is made up of two departments: Department of Mathematics, and Department of Physics. The Dean of FMF is Prof. Franc Forstnerič. The Vice-Dean for the study programme and Head of Department of Mathematics is Prof. Petar Pavešič. The Vice-Dean for research and Head of Department of Physics is Prof. Janez Bonča. The address of the Faculty is: Jadranska 19, 1111 Ljubljana (phone + 386 1 4766500).

The second half of the 20th century was a period of very rapid development of mathematics and physics. New fields were introduced while older ones underwent intense specialization. All this is reflected in research activities of Slovene physicists and mathematicians as well as in the new doctoral programme Mathematics and physics, redesigned according to their guidelines of the Bologna Declaration.

The Department of Physics and the Department of Mathematics are the two largest Slovene schools for their respective fields. They have well developed scientific cooperation with physicists and mathematicians all over the world and many FMF members have spent considerable time abroad. The results of the research of FMF members are published in top international mathematics and physics journals. The basis for the doctoral programme Mathematics and physics is research in the fields of mathematics and physics with the collaboration of internationally recognized Slovene and foreign experts, who can serve as advisers for the students. According to recommendations of the European University Association (EUA), the programme includes international exchange of students and publication of at least one scientific paper as a result of the research.

## **2. DESCRIPTION OF THE PROGRAMME**

The doctoral study programme Mathematics and physics lasts 3 years and comprises 180 credit points. It is a third level programme according to the Bologna scheme. The programme is composed of organized teaching which accounts for 60 credit points; the remaining 120 credit points are devoted to individual research for the doctoral dissertation. The programme is made up of two subprogrammes: Mathematics and physics. The subprogramme Physics has four modules: Physics, Physics Education, Meteorology, and Nuclear Physics. The subprogramme Mathematics has two modules: Mathematics and Mathematical Education.

The study requirements of the programme are in compliance with the Higher Education Act and with the Criteria for Accreditation of Institutions and Study Programmes of Higher Education, adopted by the Higher Education Council of the Republic of Slovenia. They are evaluated according to the European Credit Transfer System (ECTS), which makes it possible for parts of the programme to be included directly into international exchange with universities using ECTS.

The candidate is awarded the title Doctor of Science. In accordance with the selected subprogramme or module of study the field of the doctorate is a) physics, b) physics education, c) meteorology, d) nuclear technology, e) mathematics, or f) mathematical education.

## **3. FUNDAMENTAL OBJECTIVES OF THE DOCTORAL STUDY PROGRAMME MATHEMATICS AND PHYSICS AND GENERAL COMPETENCIES**

The main objective of the study programme Mathematics and physics is to train highly qualified researchers and experts for independent research and development in the fields of physics, astrophysics, nuclear physics, meteorology, mathematics, physics education and mathematical education at a level that is comparable and competitive with current top-quality research in the selected fields pursued in the most advanced parts of the world. Independent research for the doctoral thesis, representing the major part of the study programme, provides in-depth knowledge in the area of the narrow specialization, while the structure of the organized part of the study programme guarantees also sufficient broader knowledge which is today indispensable for a young expert to be able to respond readily to the rapid development and changes in modern science and to become an active member of larger interdisciplinary research teams.

The organized part of study in the subprogramme Physics is designed so that the student must select one subject from the group of subjects (A) which are bound to the selected

module and cover the broader field of the doctoral thesis, offering a deeper insight into the general principles of physics. This should provide a sound basis for independent research as well as appropriate breadth of knowledge. The remaining subjects are completely optional (group B) and are intended for narrower specialization in the candidate's field.

The subprogramme Mathematics is intended mainly for mathematicians with a Master's degree, who wish to pursue industrial development work or independent research in the field of mathematics or mathematical education. The fundamental objective of the subprogramme Mathematics is the training of highly qualified experts in the field of mathematics and mathematical education. The students will deepen their knowledge of mathematics and mathematical education – mainly in their narrow field of research, they will develop the capacity for independent and critical scientific thinking and will be capable of carrying out independent research and creating new knowledge.

The subprogramme is conceived so that on completion of the study, the doctoral student will possess a broad general knowledge of mathematics and will at the same time be able to carry out independently the most demanding research in the field of mathematics and mathematical education.

These characteristics guarantee students who complete the proposed study programme employment and successful work in a wide range of research and applied disciplines in the field of mathematics and in natural and engineering sciences, medicine, economics, computer science, in educational institutions, institutes etc.

**General competencies acquired with the programme:**

- Capacity for abstraction and problem analysis
- Gathering, critical evaluation and synthesis of data, measurements and solutions
- Identification of data needed for obtaining new knowledge
- Forming new knowledge on the basis of existing theories and available data
- Use of knowledge in practice (especially in modern technologies)
- Capacity for interdisciplinary integration of scientific knowledge
- Capacity for both autonomous research and development, and for working in a (international) group
- Communicating scientific knowledge to the general public
- Ability to use modern research methods and procedures
- Ability to critically evaluate and present own results
- Capacity for further independent education, research and following of the literature

**Subject-specific competencies:**

- In-depth understanding of the physical laws of nature
- Combining the basic laws of nature and observable properties of the world
- Ability to creatively identify physical problems and analyze them
- Capacity for mathematical formulation of physical problems
- Deduction of the physical basis of practical problems
- Ability to model problems
- Advanced physical experimental skills
- Critical evaluation of the results of measurements and their use in construction of models
- Understanding the principles of operation of technical devices on the basis of fundamental laws
- Presentation of physical methods and results adapted to the target public (in Slovene and in foreign languages)
- Ability to convey physics knowledge
- Thorough understanding of the results of research in the field of interest
- Ability to understand the most advanced mathematical problems and proofs
- Independence in research
- Capacity for abstraction of practical problems
- Ability to follow and use scientific mathematical literature
- Ability to use various modern mathematical methods for problem solving
- Capacity for critical and independent work and consulting in the field of physics and mathematical education

**4. ENROLMENT REQUIREMENTS AND SELECTION CRITERIA IN CASE OF RESTRICTED ENROLMENT**

**4.1 Enrolment requirements**

Thirty enrolment places will be advertised for first year students. Each year the requirements are presented in detail in the call for enrolment published by the appropriate Ministry of the Republic of Slovenia.

The following candidates can enrol in the doctoral study programme Mathematics and physics:

1. Candidates who have completed a second-level Bologna study programme in natural sciences or engineering
2. Candidates who have completed a previous 4 year university programme in natural sciences or engineering
3. Candidates who have completed a Higher education professional programme and a Specialist training study programme in natural sciences or engineering  
The Faculty of Mathematics and Physics may impose additional requirements amounting to 10 to 60 ECTS points before enrollment
4. Candidates who have completed a study programme that is regulated by directives of the European Union and carries at least 300 ECTS points.
5. Existing study programmes leading to a master of science or to specialisation after completing a university study programme in natural science or engineering. Candidates shall have 60 credits of study obligations recognised

Enrolment in the doctoral study programme Mathematics and physics is open also to graduates of other Slovene and foreign universities in accordance with the prescribed conditions valid for students from the Republic of Slovenia. The equivalence of previous education acquired abroad is established in the process of recognition of foreign education for continuation of education.

#### **4.2 Criteria for selection in case of limited enrolment**

In case of limited enrolment, candidates will be selected according to:

- grade average from a second-level or university study programme - 85% of points,
- quality of the diploma work in a university study programme or Master thesis in a second-level study programme, the rest of bibliography and awards - 15% of points.

## **5. CRITERIA FOR RECOGNITION OF KNOWLEDGE AND SKILLS ACQUIRED PRIOR TO ENROLMENT IN THE PROGRAMME**

A student can be awarded credit for knowledge acquired in different forms of previous education which corresponds in content to courses in the study programmes of FMF. Decisions concerning recognition of such knowledge as completed study requirement are made by the FMF Study Board on the basis of the student's written application with attached testimonials and other documents confirming successful acquisition of such knowledge and its content.

In awarding credit for an individual course, the Study Board will use the following criteria:

- comparability of the scope of previous education with the scope of the course for which credit is awarded,
- correspondence of the content of previous education to the content of the course for which credit is awarded.

If the Study Board determines that credit can be awarded for previously acquired knowledge, it shall allocate for such knowledge the same number of ECTS points as are carried by the corresponding course at the FMF Department of Physics.

## **6. REQUIREMENTS FOR ADVANCEMENT WITHIN THE PROGRAMME**

### **6.1 Requirements for advancing to the next year of study**

During their studies, students receive guidance and counselling from their mentors who are appointed at the beginning of study. In accordance with the Statute of the University of Ljubljana, the mentor is confirmed by the Senate of UL at the time of the acceptance of the theme of the doctoral work.

#### **Subprogramme Physics:**

For enrolment in the second year of study, students must complete a course from group A for the selected module, and at least one of the two elective courses from group B. They must also make a successful presentation of the theme of doctoral dissertation and collect a total of at least 45 ECTS points. For enrolment in the third year of study, students must complete all requirements from organized forms of study (60 ECTS points).

#### **Subprogramme Mathematics:**

For enrolment in the second year of study, students must collect at least 45 ECTS points. Of these, at least 20 ECTS points must be from organized forms of study (courses, seminars, and disposition). For enrolment in the third year, students must collect at least 90 ECTS points, of these 40 ECTS points from exams and seminars for the first and second years and/or disposition. The student must also prepare and get approved the theme of the doctoral thesis.

## **7. REQUIREMENTS FOR COMPLETION OF STUDY**

The requirement for completion of study and acquisition of the title Doctor of Science is that the candidate successfully meets all study requirements laid down in the programme and successfully defends the doctoral dissertation, amounting to a total of 180 credit points, 60 from the organized forms of study and 120 from research work. The candidate must also publish or have accepted for publication at least one scientific article from the field of the dissertation in one of the journals from group I or II, as defined in the FMF Interpretation of the *Criteria for Election of University Teachers, Researchers and Research Associates*. The research article must be published or accepted for publication before the defense of the thesis. The student completes the study with a positively evaluated dissertation and its defense.

## **8. TRANSFERS BETWEEN STUDY PROGRAMMES**

Transfers between study programmes are regulated by the Statute of UL and Criteria for Transfers between Study Programmes of UL. A transfer between programmes is defined as withdrawal from the programme in which the student initially enrolled and continuation of study in the doctoral programme Mathematics and physics.

Transfer to the doctoral (third-level) programme Mathematics and physics is possible:

- from other doctoral (third-level) programmes of UL; the candidate must fulfil the requirements for enrolment in the doctoral (third-level) programme Mathematics and physics; on the basis of credit points award for exams taken in the previous study programme, the FMF Study Board may require a candidate to take bridge exams (amounting to up to 60 ECTS points) and decide in which year of study he/she may enrol;
- under the same conditions as in the previous paragraph, transfer is possible from comparable programmes at other universities if a candidate meets the

requirements for enrolment in the doctoral (third-level) programme Mathematics and physics.

## 9. GRADING

Grading is governed by the Examination Rules of FMF. In accordance with the Statute of UL, grades 1 to 10 are used, with grades 6 to 10 being positive and 1 to 5 negative. The examinations can be written and/or oral. The preparation and presentation of seminars and theses are also graded. Grading procedures for individual courses are presented in Course Descriptions (Appendix 9).

## 10. EMPLOYMENT POSSIBILITIES

As shown by the positions held by our alumni, graduates of the doctoral programme Mathematics and physics can find employment in the following areas:

1. **Research** (Josef Stefan Institute; Institute of Chemistry; Institute of Mathematics, Physics and Mechanics; Institute of Metals and Technology, National Institute of Biology; Scientific-Research Centre of the Slovene Academy of Science and Arts).
2. **Higher education** (University of Ljubljana - FMF, FF, FGG, FKKT, FS, NTF, MF, FPP, FRI, FE, FK, PeF, VSZ, EF, FŠ, CTK; University of Maribor - FERI, FS, PeF; University of Primorska; University of Nova Gorica).
3. **Computer industry** (Halcom, Hermes Softlab, Cosylab, IBM, Oracle Software, Adacta, SRC, ITS Intertrade, Ultra).
4. **Electrical and electronic industry** (Iskra Avtoelektrika, Iskra Stikala, Iskra Emeco, Gorenje Velenje, Instrumentation Technologies, Siemens).
5. **Telecommunications** (Telekom Siol, Iskratel).
6. **Optical industry** (Fotona, Iskra Vega, Balder, Optotek, LPFK).
7. **Machining industry** (Turboinštitut, Sistemska tehnika, Acroni, Metal)
8. **Construction industry** (Institute of Construction, Institute of Material Research and Constructions)
9. **Energetics** (Nuclear Power Plant Krško, Petrol, JP Energetika Ljubljana)
10. **Chemical industry** (Sava Tech, Petrol, Johnson & Johnson)
11. **Pharmaceutical industry** (Krka, Lek)
12. **Healthcare** (Institute of Oncology, University Medical Centre Ljubljana)
13. **Certification institutions** (Slovene Institute of Quality and Metrology)

14. **Finance** (Wiener Staedtische Insurance Company, Triglav Insurance Company, Activa, Vzajemna, Medvešek Pušnik, Kapitalska družba)
15. **Government** (Ministry of Economy, Ministry of Education and Sports, Ministry of Higher Education, Science and Technology, Foreign Ministry, Ministry of Environment and Spatial Planning, Ministry of the Interior, Agency for Environment, Nuclear Safety Administration, Agency for Radioactive Wastes, Radiation Protection Administration, Institute of Occupational Safety, Intellectual Property Office, Institute of Education, Institute of Standardization, Institute of Quality, Tax Administration, Office of Standards and Metrology)
16. **Education** (educational institutions and centres (Institute of Education, Educational Research Institute), primary and secondary schools, publishing companies, media etc.

The modules of the study programme satisfy the interests of the students and enable them to acquire broad knowledge and insight into the current state of research in the field of mathematics and physics. The large number of elective courses allows them to acquire appropriate education in the selected specialty of the doctoral dissertation. Employment opportunities are primarily determined by a graduate's ability to pursue independent research or development work rather than by the specific field of study.

## 11. CURRICULUM

The doctoral programme Mathematics and physics lasts three years and carries 180 ECTS points. The study requirements comply with the Higher Education Act and with the Criteria for Accreditation of Higher Education Institutions and Study Programmes, adopted by the Council for Higher Education of RS, and are evaluated according to the European Credit Transfer System (ECTS). This allows the programme to participate directly in the international exchange of students in countries using ECTS.

The study programme is composed of an organized part which accounts for 60 credit points. The remaining 120 credit points are allocated to individual research for the doctoral dissertation.

### 11.1 Structure of curriculum

#### Subprogramme Physics:

The organized part of the programme includes 32 courses, of which 13 belong to group A and 19 to group B. Each course is equivalent to 10 ECTS points. The courses in group A

belong to specific modules, and students must select one course from this group that belongs to the module of their doctoral field. The courses in group B are elective; the student must select 2 courses from group B or an equivalent number of courses from the subprogramme Mathematics. The above three courses must be taken in the first year of study.

In the first year of study, candidates acquire 15 ECTS points with a specialty seminar, in which they must present the theme of their doctoral dissertation. The presentation is evaluated as successful/unsuccessful by the committee for the approval of the doctoral thesis, appointed by the Senate of FMF in accordance with the Statute of UL.

The candidate acquires additional 5 points with other seminar activities (Physics colloquia, internal seminars at various research institutions etc.). Weekly Physics colloquia of the Department of physics are mandatory and carry 3 ECTS points. The suitability and credit value of other seminar activities are determined by the Study Board of the Department of Physics.

Ten credit points are acquired in other study programmes at UL, other universities and summer schools. The credit ratings of these activities are determined by the rules of the respective programmes. The candidate must present a certificate confirming the acquisition of these credit points. In case that the completed course does not carry an ECTS rating, the number of credit points to be awarded is determined by the Study Board of the Department of Physics.

Individual research leading to the doctoral thesis is carried out in the second and third years of study under the guidance of a mentor appointed by the Senate of FMF at the time of approval of the theme of the thesis. The mentor must have an appropriate academic title (Assistant Professor, Associate Professor, Professor) or research title (Research Associate, Senior Research Associate, or Research Counselor) and must have published papers in the field of the doctoral dissertation.

The doctoral study is completed with the preparation of the doctoral dissertation. The candidate submits the dissertation for evaluation to a committee, appointed by the Senate of FMF in accordance with the Statute of UL. After obtaining a positive opinion of the committee, the candidate defends the thesis in public. Before submitting the thesis, the candidate must have authored at least one paper that has been published, or accepted for publication, in an SCI journal.

### **Subprogramme Mathematics**

A student enrolled in the subprogramme Mathematics accrues the required 180 ECTS points by passing examinations, by actively participating in seminars, by a teaching

presentation in the module Mathematical Education, by passing the doctoral examination, and by preparing the doctoral dissertation. The coursework of a student in the subprogramme Mathematics consists of the following requirements:

### 1. Organized forms of study

#### a) *Theoretical, scientific and methodological part*

- Courses (40 ECTS points)
- Active participation in research seminars and/or a teaching presentation in the module Mathematical Education (10 ECTS points)

#### b) *Doctoral work*

The doctoral work consists of research and of preparation of the doctoral dissertation.

The organized part is

- Doctoral examination (5 ECTS points)
- Preparation of the doctoral dissertation and public defence (5 ECTS)

The curriculum of the subprogramme Mathematics contains 68 courses in the module Mathematics and 72 courses in the module Mathematical Education. The doctoral student, with the help of the mentor, can also select courses from other comparable programmes offered by Slovene and foreign universities that comply with the ECTS or an equivalent system.

The student must collect at least **40 ECTS points** by passing examinations in the offered courses, **10 ECTS points** by actively participating in seminars, **5 ECTS points** by passing the doctoral examination, and **5 ECTS points** by preparation and public defence of the dissertation. A student of the module Mathematical Education must select as part of the **40 ECTS points** at least **15 ECTS points** in mathematics subjects, at least **5 ECTS points** in subjects related to the use of modern technology in mathematical education, and at least **10 ECTS points** in general educational courses (possibly at other Faculties of UL). In the educational courses, candidates become acquainted with all levels of mathematical education, from primary school to university.

Candidates in the module Mathematical Education must make a *disposition*. In the first year, the student prepares a project on a mathematical topic and presents it several times to the targeted school population. With the presentation, the student shows both mathematical understanding and practical teaching skills. The presentation is evaluated by two university teachers and a practicing school teacher (5 ECTS points). During the first and second years, the student participates in an open discussion held within the framework of seminar

meetings, where the content and teaching ideas of the projects and presentations of students are argued. In the presentations and discussions, students test their mastery of primary, secondary and university teaching practice. Students attend the project presentations of other students (5 ECTS).

## **2) Research for doctoral dissertation (120 ECTS points):**

Research work must be concluded with at least one scientific article published or accepted for publication in a journal from group I or II of the FMF Interpretation of the Criteria for Election of University Teachers, Researchers and Associates.

### **First year**

In the first year, the doctoral student gets 20 ECTS points from the offered courses and 5 ECTS points from seminars or the teaching presentation in the module Mathematical Education. Students select the courses and seminars with the help of the mentor and in consideration of their field of research. The remaining 35 points, of the total of 60 points, are allocated for individual research.

### **Second year**

In the second year, the doctoral student gets 20 ECTS points from the offered courses and 5 ECTS points from seminars or the teaching presentation in the module Mathematical Education. Students select the courses and seminars with the help of the mentor and in consideration of their field of research. At the end of the second year, students are expected to pass the doctoral examination (5 ECTS points). The remaining 30 points, of the total of 60 points, are allocated for individual research.

### **Third year**

The third year is devoted to research work and to the preparation and defence of the doctoral dissertation. Fifty-five of the total of 60 points are allocated for research and 5 points for the preparation, presentation and public defence of the dissertation.

Before submitting the theme of the doctoral dissertation, students must pass the doctoral examination. For the examination, they select two mathematical fields, A and B. The list of mathematical fields includes: **algebra, complex analysis, functional analysis, numerical analysis, geometry, topology, probability, discrete mathematics, and computer mathematics.**

Students of the module Mathematics select as field A the field of their doctoral dissertation, while field B can be any of the other fields. The committee for the doctoral examination consists of three teachers, with each posing one question. Two questions must be from field A and one from field B.

For the doctoral examination in the module Mathematical Education, students select a broader mathematical field A corresponding to their thesis in mathematical education. Field B of the doctoral examination is from the area of general education (didactics, developmental psychology, adult education, etc.) selected in agreement with the mentor. Each candidate is co-mentored by a teacher of mathematics and a teacher in the field of education. The committee for the doctoral examination consists of teachers of mathematics and education. Students get three questions, one from field A, one from field B, and one that connects mathematical understanding and teaching methods.

### **11.2 Mobility**

Students select, in agreement with the mentor, courses from comparable programmes of UL or other universities, amounting to 10 credit points.

Students who in the framework of exchange programmes (e.g., Socrates, Erasmus) spend one or two semesters at some other university get 30 or 60 credit points, respectively, for the requirements completed there.

### **11.3 Forms of study by proportions**

The doctoral programme Mathematics and physics comprises 5400 work hours or 180 ECTS points. The organized forms of study take up 1800 work hours, i.e. 60 ECTS points, and individual research 3600 work hours, i.e. 120 ECTS points. Organized forms of study represent 33.3% and research 66.7% of the study requirements. The organized forms of study depend on the selection of courses. The proportion of lectures as a rule does not exceed 22.2% of the programme, while seminars and other forms of organized study account for 11.1% of the programme.

From the first year on, students work on their doctoral dissertation while acquiring the necessary knowledge by attending lectures and taking part in seminars. Practical work is carried out in the framework of doctoral research and also in the form of courses and research seminars. Practical training accounts for at least 72% of the programme.

## 12. LINKS TO OTHER PROGRAMMES

The comparability of the doctoral programme Mathematics and physics at the Faculty of Mathematics and Physics of UL with programmes of foreign universities allows for good cooperation and mobility between partner universities. International exchange is possible at all levels of implementation of the programme, from exchange of research to exchange of courses on the basis of international contracts and bilateral agreements. International cooperation is possible also through the participation of visiting professors and participation of students in mobility programmes (Erasmus, Socrates etc.). The programme is also open to foreign students. Cooperation with other higher education and research institutions is implemented in the form of research projects, and with the participation of foreign professors in individual courses, (co)mentorships and evaluation and defence of doctoral dissertations.

## 13. LIST OF COURSES

### Subprogramme Physics

#### Group A

	<b>Module</b>	<b>Course</b>	<b>Coordinator</b>	<b>ECTS</b>
1.	Physics	Modern astrophysics	Andrej Čadež	10
2.	Physics	Classical and quantum dynamic systems	Tomaž Prosen	10
3.	Physics	Experimental methods in particle and nuclear physics	Peter Križan	10
4.	Physics	Optical processes in matter	Irena Drevenšek-Olenik	10
5.	Physics	Soft matter theory	Rudi Podgornik	10
6.	Physics	Elementary particle theory	Svjetlana Fajfer	10
7.	Physics	Theory of solid states and nanostructures	Janez Bonča	10
8.	Meteorology	Selected chapters in numerical modelling of atmosphere	Mark Žagar	10
9.	Meteorology	Dynamics of weather and climate: atmosphere variability	Nedeljka Žagar	10
10	Reactor technology	Selected chapters of reactor technology	Borut Mavko	10
11	Reactor technology	Selected chapters of nuclear and reactor physics	Matjaž Ravnik	10
12	Physics education	Didactics of physics and projects	Gorazd Planinšič	10
13	Physics education	Selected chapters of classical physics	Andrej Čadež	10

**Group B**

	<b>Course</b>	<b>Coordinator</b>	<b>ECTS</b>
1.	Remote sensing in meteorology	Jože Rakovec	10
2.	Experimental astrophysics	Tomaž Zwitter	10
3.	Physics of modern materials	Janez Dolinšek	10
4.	Physics of nanosystems	Anton Ramšak	10
5.	Cosmology	Anže Slosar	10
6.	Quantum optics	Martin Čopič	10
7.	Quantum field theory	Svjetlana Fajfer	10
8.	Theory of lasers	Martin Čopič	10
9.	Methods of experimental physics of matter	Janez Dolinšek	10
10.	Symmetry in physics	Primož Zihel	10
11.	Advanced quantum physics	Peter Prelovšek	10
12.	Advanced statistical physics	Anton Ramšak	10
13.	Mechanics of nuclear constructions and materials	Leon Cizelj	10
14.	Modelling in nuclear thermohydraulics	Iztok Tiselj	10
15.	Radiation and environment	Andrej Likar	10
16.	Optical methods in physics for teachers	Igor Poberaj	10
17.	Physics of atmosphere: radiation	Jože Rakovec	10
18.	Open problems in physics	Nnorma Mankoč-Borštnik	10
19.	Experimental surface physics	Igor Muševič	10

**Mandatory seminar:**

	<b>Course</b>	<b>Coordinator</b>	<b>ECTS</b>
1.	Physics Colloquia	S. Žumer	10

**Subprogramme Mathematics:**

The list of courses of the subprogramme Mathematics contains 68 courses.

	<b>Course</b>	<b>Coordinator</b>	<b>ECTS</b>
1.	Complex analysis in $C^n$	Prof. dr. Miran Černe	5
2.	Topics in complex analysis	Prof. dr. Franc Forstnerič	5
3.	Fourier analysis	Prof. dr. Franc Forstnerič	5
4.	Special topics in harmonic analysis	Prof. dr. Franc Forstnerič	5
5.	Partial differential equations	Assoc. Prof. dr. Pavle Saksida	5
6.	Chapters in global analysis	Assoc. Prof. dr. Pavle Saksida	5
7.	Topics in operator theory	Prof. dr. Roman Drnovšek	5

8.	Topics in linear topological spaces	Prof. dr. Peter Šemrl	5
9.	Topics in Banach algebras	Prof. dr. Matej Brešar	5
10.	Topics in operator algebras	Prof. dr. Bojan Magajna	5
11.	Topics in Algebra	Prof. dr. Matej Brešar	5
12.	Associative Algebra 2	Prof. dr. Matjaž Omladič	5
13.	Algebraic groups	Assist. Prof. dr. Janez Bernik	5
14.	Nonassociative Algebra 2	Assist. Prof. dr. Igor Klep	5
15.	Commutative Algebra 2	Prof. dr. Tomaž Košir	5
16.	Topics in Linear Algebra	Prof. dr. Peter Šemrl	5
17.	Semigroup Theory	Assist. Prof. dr. Karin Cvetko Vah	5
18.	Group Theory	Assoc. Prof. dr. Primož Potočnik	5
19.	Real Algebra	Assoc. Prof. dr. Jaka Cimprič	5
20.	Computational Algebra	Assist. Prof. dr. Primož Moravec	5
21.	Algebraic geometry	Prof. dr. Tomaž Košir	5
22.	Geometry and topology of smooth manifolds	Assist. Prof. dr. Sašo Strle	5
23.	Symplectic geometry	Assoc. Prof. dr. Pavle Saksida	5
24.	Real algebraic geometry	Assoc. Prof. dr. Jaka Cimprič	5
25.	Foliations and Lie groupoids	Assoc. Prof. dr. Janez Mrčun	5
26.	Topics in geometry and topology	Assoc. Prof. dr. Janez Mrčun	5
27.	Homotopy theory	Assoc. Prof. dr. Petar Pavešić	5
28.	Fibrations and bundles	Assoc. Prof. dr. Petar Pavešić	5
29.	Spectral sequences and homological algebra	Assoc. Prof. dr. Petar Pavešić	5
30.	Geometric approximation	Prof. dr. Jernej Kozak	5
31.	Multivariate interpolation	Prof. dr. Jernej Kozak	5

32.	Curves and surfaces in CAGD	Prof. dr. Jernej Kozak	5
33.	Wavelets	Prof. dr. Jernej Kozak	5
34.	Theory of Splines	Prof. dr. Jernej Kozak	5
35.	Subdivision schemes	Prof. dr. Jernej Kozak	5
36.	Selected topics in Numerical linear algebra	Assoc. Prof. dr. Bor Plestenjak	5
37.	Nonlinear eigenvalue problems	Assoc. Prof. dr. Bor Plestenjak	5
38.	Multigrid methods	Assoc. Prof. dr. Bor Plestenjak	5
39.	Inverse eigenvalue problems	Assoc. Prof. dr. Bor Plestenjak	5
40.	Subspace iterative methods	Assoc. Prof. dr. Bor Plestenjak	5
41.	Financial mathematics in continuous time	Prof. dr. Matjaž Omladič	5
42.	Numerical methods in finance and economy	Prof. dr. Tomaž Košir	5
43.	Mathematical methods in risk theory	Prof. dr. Tomaž Košir	5
44.	Advanced topics in financial mathematics	Prof. dr. Tomaž Košir	5
45.	Bayesian methods in statistics	Prof. dr. Matjaž Omladič	5
46.	Mathematical methods in econometrics	Prof. dr. Matjaž Omladič	5
47.	Stochastic processes	Prof. dr. Matjaž Omladič	5
48.	Metric graph theory	Prof. dr. Sandi Klavžar	5
49.	Permutation groups	Assoc. Prof. dr. Primož Potočnik	5
50.	Combinatorial enumeration	Prof. dr. Marko Petkovšek	5
51.	Graph symmetries	Assoc. Prof. dr. Primož Potočnik	5
52.	Selected topics in discrete and computational geometry	Assist. Prof. dr. Sergio Cabello Justo	5
53.	Selected topics in algorithms	Assist. Prof. dr. Sergio Cabello Justo	5
54.	Selected topics in cryptography and coding theory	Prof. dr. Bojan Mohar	5
55.	Algebraic combinatorics	Prof. dr. Marko Petkovšek	5
56.	Selected topics in optimization	Assoc. Prof. dr. Martin Juvan	5

57.	Topics in discrete mathematics and its application	Assist. Prof. dr. Riste Škrekovski	5
58.	Colorings, flows and covers of graphs	Assist. Prof. dr. Riste Škrekovski	5
59.	Configurations	Prof. dr. Tomaž Pisanski	5
60.	Selected topics in theory of computing	Assist. Prof. dr. Andrej Bauer	5
61.	Selected topics in logic	Assist. Prof. dr. Andrej Bauer	5
62.	Selected topics in computability and computational complexity	Prof. dr. Marko Petkovšek	5
63.	Selected topics in combinatorics	Prof. dr. Sandi Klavžar	5
64.	Selected topics in graph theory	Prof. dr. Bojan Mohar	5
65.	Data analysis and visualization	Prof. dr. Vladimir Batagelj	5
66.	Large networks	Prof. dr. Vladimir Batagelj	5
67.	Selected topics in graph theory with applications (in science and technology)	Prof. dr. Tomaž Pisanski	5
68.	Algebraic and topological graph theory (regular maps)	Prof. dr. Tomaž Pisanski	5

Students of the module *Mathematical education* can additionally choose from the following list of courses.

	Course	Coordinator	ECTS
1.	Chapters in analysis	Prof. dr. Miran Černe	5
2.	Chapters in algebra and number theory	Prof. dr. Tomaž Košir	5
3.	Chapters in discrete mathematics	Assoc. Prof. dr. Martin Juvan	5
4.	Chapters in didactics of mathematics	Assist. Prof. dr. Damjan Kobal	5

### The list of the research seminars on the subprogramme Mathematics:

A part of a student's requirements in the subprogramme Mathematics is twice active participation at the research seminars of the Department of Mathematics, FMF, University of Ljubljana. These active participations at the research seminars are together valid 10 ECTS.

A student can choose among 14 research seminars.

	Seminars	Coordinators	ECTS
1.	Numerical analysis seminar	Prof.dr.Jernej Kozak	5

2.	Graph theory and algorithms seminar	Assist. Prof. dr. Sergio Cabello Justo Assist. Prof. dr. Riste Škrekovski	5
3.	Complex analysis seminar	Prof. dr. Franc Forstnerič Prof. dr. Josip Globevnik	5
4.	Algebra seminar	Prof. dr. Matjaž Omladič	5
5.	Functional analysis and algebra seminar	Prof. dr. Peter Šemrl	5
6.	Discrete mathematics seminar	Prof. dr. Tomaž Pisanski	5
7.	Topology seminar	Assoc. Prof. dr. Petar Pavešić	5
8.	Theory of operators seminar	Prof. dr. Matjaž Omladič	5
9.	Group theory and combinatorics seminar	Prof. dr. Dragan Marušič	5
10.	Probability and statistics seminar	Assoc. Prof. dr. Mihael Perman	5
11.	Geometric topology seminar	Prof. dr. Dušan Repovš Assist. Prof. dr. Sašo Strle	5
12.	Cryptography and code theory seminar	Assoc. Prof. dr. Aleksandar Jurišić	5
13.	Geometry seminar	Prof. dr. Franc Forstnerič Prof. dr. Tomaž Košir Assoc. Prof. dr. Janez Mrčun Assoc. Prof. dr. Pavle Šaksida	5
14.	Financial mathematics seminar	Prof. dr. Matjaž Omladič	5