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I. DESCRIPTION OF STUDY PROGRAMME FORM

BASIC INFORMATION	
Title of study programme	**Discrete mathematics and its applications**
study programme coordinator	**University of Rijeka**
Study programme implementor	**Department of mathematics – University of Rijeka**
Type of study programme	**University**
Level of study programme	**Graduate**
Academic/professional degree awarded upon completion of study	**Master of Science in Mathematics - course: discrete mathematics and its applications**

1. INTRODUCTION

1.1. Reasons for initiating the study

Reasons for initiating the study are: economy needs, improvement of scientific research at the University of Rijeka (by introducing contemporary methods of planning and analysis of experiments), shown interest of potential students and personnel potential of the Department of mathematics.
Discrete mathematics is a branch of mathematics that has many applications in other fields of science and economy. In this study program students will, among other things, acquire knowledge from graph theory, optimization, cryptography, coding theory and design of experiments.
Based on surveys of students on undergraduate course of mathematics at the University of Rijeka, we realized that there is great interest in this graduate program. We also believe that mentioned study program will attract students who live outside our district, since it will be the only study of this direction in the Republic of Croatia.
Department of mathematics, University of Rijeka, has personnel capabilities for performing this study, since the scientific work of thirteen employees of the Department is closely associated with the fundamental topics that will be processed in the framework of this study.

1.2. Estimation of purpose with respect to labor market needs in public and private sector

Acquired knowledge in this study is very applicable in the economy; graph theory has broad applications, from telecommunications to the design of road networks, coding theory and cryptography is used in everyday communication. Since there will be more jobs related to ICT technologies and data protection, needs for this profile will be larger. Optimization is very purposeful in various business processes, while the design and analysis of experiments is necessary in conducting of any experiment, from the manufactoring new drugs and testing machines and their parts. Also, knowledge of design of experiments is also very applicable in analyzing characteristics of the finished products, so we expect that the labor market will identify and show need for this profile.

1.2.1. Relationship with the Local Community (economy, business, civil society)

Acquired knowledge in this study is applicable in various sectors of the economy. Because of acquired knowledge in coding theory, cryptography, graph theory, and subjects in computer science, graduates can be employed in the economic subjects dealing with telecommunications and information technology. Acquired knowledge from the optimization and design of experiments provides employment in several branches of economy, for example, in companies that need to test finished products or prototypes.

1.2.2. Compatibility with the requirements of professional associations (recommendation)

While creating a study program, the following resource was especially considered:

Tuning Educational Structures in Europe
(http://tuning.unideusto.org/tuningeu/), especially the part that refers to the study of mathematics.
(http://tuning.unideusto.org/tuningeu/index.php?option=content&task=view&id=27&Itemid=50).

1.2.3. List of the possible partners outside the higher education system who expressed interest for study program

For now, the greatest interest in this study showed companies dealing with information technology, since these companies are often employing former students of the Department of mathematics, who graduated on our educational courses: Mathematics and Mathematics and Computer Science.

1.3. Comparability of study program with similar programs of accredited institutions of higher education in Croatia and the EU (specify and explain the comparability of the two programs, of which at least one of the EU, with a program that is proposed, and state network sites)

Study program of Discrete mathematics and implementation is comparable with the study program Mathematics (MSci) at the Queen Mary University of London (http://www.qmul.ac.uk/courses/courses.php?course_id=127&dept_id=16&ugcourses=1&course_level=2) and the study program at the University of Essex, modules MSc Discrete mathematics and its applications and MSc Statistics and Computer Science (http://www.essex.ac.uk/coursefinder/pdfs/pg/MATH.pdf).

Comparability with the study of Mathematics (MSCI) at the Queen Mary University of London is reflected in the subjects: combinatorics and graph theory (Combinatorics, Enumerative and Asymptotic Combinatorics, Extremal Combinatorics, Algorithmic Graph Theory), probability theory (Probability I, Probability II, Probability III), statistics (Introduction to Statistics, Statistical Modelling I, Statistical Modelling II, Advanced Statistical Modelling, Statistical Theory, Computational Statistics, Bayesian Statistics), coding theory and cryptography (Coding Theory, Cryptography), algebra and group theory (Algebraic Structures I, Algebraic Structures II, Fields and Galois Theory, Group Theory) and design of experiments (Design of Experiments). Courses of London's studies are numerous because it is four-year study.
Comparability with studies at the University of Essex is evident over the subjects of Graph Theory, Cryptography and Codes, Stochastic Processes and Experimental Design, which are part of the module MSc Discrete Mathematics and its Applications and MSc Statistics and Computer Science.
Performers of mentiones programs emphasize that finishing this study represents a good basis for the possible development of scientific career in the field of natural sciences and engineering, but also allows employment in various areas where is required algorithmic way of thinking and the ability to analyse data.

1.4. Openness to the horizontal and vertical student mobility in national and international higher education

This graduate program can enroll bachelors who have completed undergraduate course in mathematics in any Croatian or foreign university. After finishing this study, masters of mathematics will be able to enroll the Common doctoral program in mathematics at the University J.J. Strossmayer in Osijek, University of Rijeka, University of Split and the University of Zagreb, as well as appropriate doctoral studies abroad.

1.5. Compatibility with mission and strategy of the University of Rijeka

According to the Strategy of University of Rijeka for 2007-2013, university will devote special attention to the development of natural science. Since this is the first noneducational graduate course in mathematics at our university, implementation of this study certainly contributes in achieving the strategic aim of development of the natural sciences. We also expect that this study will contribute to the development of other natural sciences at the University by creating personnel who can apply appropriate mathematical methods for improving the process of planning and implementing experiments. One of the strategic aims of the University is development of research in the field of information and communication technologies. Since coding theory and cryptography are one of the main content of this program, study also contributes in achieving goal of development of ICT research.
The programme is also adjusted with the Strategy of University of Rijeka 2014.-2020.

- **Increase the number of students in engineering, biomedicine, biotechnology and natural sciences, in information and communication technology and in interdisciplinary studies related to these fields**

There is not many candidates with this profile in the labor market. According to the Strategy of University of Rijeka (2014.-2020.), strategic goal of University is to increase entry quotas and the number

of graduates on study programmes related to natural sciences.

- **Achieve favorable ratio of students per lecturer**

Entry quota of 15 enables a favorable ratio of students per lecturer on the Department studies.

- **Increase eligibility in the regime of internal mobility**

The programme ensures eligibility in the regime of internal mobility with the large number of elective courses in this study programme being compulsory on other study programmes (studies on Department of Mathematics, Department of Informatics or Department of Physics).

- **Increase the portion of e-learning in study programmes**

Almost all courses use advanced tools for e-learning, which causes quality changes in education. For the majority of courses, there is a version of a course on MudRi, e-learning system of University of Rijeka, at the same time keeping high standards of education quality, especially communication between professors and students. The needed ICT infrastructure is secured, ie. computer and software support for educational activities and e-learning.

- **Ensure regular monitoring of students' satisfaction**

Study programme predicts efficient administration of measures for monitoring and improvement of students' success which is conducted by the department's Board for quality assurance.

- **Determine the list of practical competencies which are guaranteed after finishing the studies and adjust the study programmes in the (re)accreditational procedure.**

1.6. Institutional development strategy of study programs (compatibility with the mission and strategic aims of the institution)

This study, as first noneducational course in mathematics at the University of Rijeka, is extremely important for implementing the strategy of development programs at the Department of mathematics. We also expect connecting with other programs of components of the University (mainly university departments) that should recognize the programs' potential in the development of competencies for future researchers.

On the 65. meeting, on October 20th, 2014., The Council of the Department of Mathematics has accepted the Strategy of University of Rijeka 2014.-2020. as a strategic document of the Department of Mathematics, University of Rijeka, and defined prioritized strategic goals of the Department. Some of the strategic goals related to education are:

- **Increase the number of students who enrolled in graduate studies**
- **Increase the number of students who graduated**
- **Determine the list of practical competencies which are guaranteed after finishing the studies and adjust the study programmes in the (re)accreditational procedure**
- **Increase the portion of e-learning in study programmes**

The implementation of Graduate university studies Discrete Mathematics and Applications is in accordance with the afore-mentioned mission and it contributes to realisation of strategic goals of Department of Mathematics, University of Rijeka.

1.7. Other important information - in the opinion of the proposer

Although the proposed study is first noneducational graduate course study implemented by the Department of mathematics, University of Rijeka, and different by its content and learning outcomes from existing courses of mathematics in Republic of Croatia, we want to emphasize that he will not represent a significant additional burden in terms of teacher load. In fact, some compulsory and all of elective courses are already implemented (as compulsory or elective) within the framework of existing studies performed by the Department of mathematics, Department of physics and Department of informatics, University of Rijeka (see section 3.4). Also, 6 new courses (36 ECTS) will be offered as an elective courses to students of existing programs in the Department of mathematics, as well as other components of the University of Rijeka.

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2. GENERAL PART

2.1. Title of study programme

Discrete mathematics and its applications

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

Mathematics

2.2. Study programme coordinator

University of Rijeka

2.3. Implementor/s of study programme

Department of mathematics – University of Rijeka

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

Study lasts 4 semesters, there is no possibility of attending classes in working time, neither through distance learning.

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

120 ECTS

2.5. Enrolment requirements and selection procedure

Candidates who achieved mathematical competencies described by the following learning outcomes can enroll the study programme:

1. **axiomatically and inductively construct the fields of real and complex numbers**
2. **describe an algebraic, metrical and topological structure of Euclidean space Rn**
3. **determine limits of a function, continuity and uniform continuity, and other properties of a function from Rn to Rm**
4. **analyse algebraic structures and differentiate basic properties of groups, rings, fields and vector spaces**
5. **differentiate properties of a linear operator**
6. **axiomatically construct Euclidean geometry with the overview of its historical development**
7. **formulate properties and existence conditions of regular polygons and polyhedra**
8. **formulate and analyse graph properties**
9. **formulate basic notions of descriptive statistics**
10. **use basic notions related to binary quadratic forms**
11. **describe set operations on finite and infinite sets**
12. **apply and understand properties of real elementary functions and fundamental complex functions of a complex variable**
13. **apply and understand use of differential calculus in geometry and in the analysis of properties of functions that are given in an explicit, implicit and parametric form**
14. **apply and understand use of integral calculus in geometry**
15. **apply and understand vector operations in problem solving**
16. **apply and understand properties of cyclic and permutation groups in problem solving**
17. **apply and understand the algorithm for finding the shortest path and the optimal tree in a graph**

18. **apply and understand properties of probability**
19. **apply and understand division algorithms**
20. **apply and understand numerical methods for solving nonlinear equations, definite integrals and ordinary differential equations, while analysing the obtained results**
21. **apply and understand simple and compound interest formulas in financial mathematics**
22. **solve indefinite and definite integral, Riemann integral of a function of several variables, and line and surface integral**
23. **expand functions into Taylor and Laurent series**
24. **determine the Jordan form of a matrix**
25. **choose an appropriate geometric construction for solving constructive problems using geometry equipment**
26. **choose an appropriate counting principle and/or a form of Dirichlet's principle for solving problems**
27. **solve combinatorial problems using recurrence relations**
28. **solve problems using properties of random variables**
29. **conduct statistical data analysis and testing hypothesis using computers**
30. **count using modular arithmetic, solve congruence equations and different types of congruence systems**
31. **apply methods for solving interpolation problems and function approximations**
32. **determine present value of money flow, financial rent, installments loan and compound interests in applications**
33. **solve problems using Lagrange's theorem, Sylow's theorems and Chinese remainder theorem**
34. **analyse convergence of sequences and series in Rn**
35. **construct orthonormal basis for an inner product space**
36. **differentiate vector and matrix norms, differentiate inner product spaces, normed spaces and metric spaces**
37. **differentiate and apply methods for solving systems of linear equations and geometrically interpret solvability of the systems in the plane and in the space**
38. **analyse mappings of algebraic structures with the emphasis on the isomorphism theorems**
39. **relate types of walks in a graph and their properties with applications in problem solving**
40. **compare plane geometries (Euclidean and non-Euclidean) and their models according to their characteristics**
41. **analyse mappings of n-dimensional Euclidean space and corresponding methods in solving problems using a constructive and an analytical approach**
42. **analyse basic probability models and distributions**
43. **explain a role of mathematical logic in mathematics as a science, the historical and intuitive importance of the logic of statements, and reasons for occurrence of the stronger logical theories, especially first-order logic**

This graduate courses at the Department of Mathematics can be enrolled by the bachelors who finished the graduate course if one or the following conditions is satisfied:

1. **The applicants who have finished the university graduate course and have acquired minimally 135 ECTS from mathematical courses, which is determined on the submitted documentation,**
2. **the applicants have who finished the university graduate course and have acquired minimally 120 ECTS from mathematical courses and have passed the examination organized by the Department of Mathematics.**

Applications for the examination are accepted every year until 15th May, while the time period for the examination lasts from 1st June until 15th July.

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)

Through the study programme, students will acquire theoretical and practical knowledge which helps them find a job in economy, and moreover, acquisition of learning new skills. Furthermore, students will

be able to

- **apply and understand the aspects of real, complex, harmonic analysis and measure theory in solving problems**
- **apply and understand the aspects of linear algebra, algebra and group theory in solving problems**
- **apply and understand the aspects of models of geometry with the emphasis on Euclidean geometry in problem solving, while using a constructive and an analytical approach**
- **apply and understand the aspects of discrete and combinatorial mathematics, probability and statistics in solving problems**
- **apply and understand the aspects of number theory, set theory and mathematical logic in solving problems**
- **apply and understand the aspects of applied mathematics in solving problems**
- **differentiate and analyse cryptographic systems**
- **differentiate and analyse different types of codes**
- **differentiate methods for detecting errors in data transmission and analyse conditions in under which it is possible to correct the error**
- **apply and understand use of the simplex algorithm and other linear programming methods**
- **have knowledge of matrix games**
- **successfully solve integer programming problems**
- **conduct a procedure for testing statistical hypothesis and apply methods for of statistical data analysis with or without using appropriate computer programs**
- **design and analyse experiments and solve a problem while using appropriate computer programs**
- **solve problems using graph theory, design theory and coding theory, writing advanced algorithms and implementing them in appropriate computer programs if needed**
- **mathematically prove validity of procedures and formulasthat are used within the courses of the study programme**
- **use acquired knowledge of theorems, procedures and formulas in solving problems**

Described learning outcomes for the proposed program, or competences that students acquire, in accordance with the Croatian Qualifications Framework qualify this program as a program of "Level 7", where labels A-G and associated levels are introduced as follows:

A – factual knowledge
B – theoretical knowledge
C – cognitive skills
D – practical skills
E – social skills
F – autonomy
G – responsibility

Through this course students will develop independence and responsibility, in particular through the seminars, projects, and solving individual assignments.

LEVELS	**KNOWLEDGE**	
	A **Factual knowledge**	**B** **Theoretical knowledge**
1	**A1** **Memorizing general** facts	**B1** **Memorizing general** theoretical knowledge
2	**A2** **Understanding basic** facts in performing **simple** tasks	**B2** **Understanding** basic theoretical knowledge in performing **simple** tasks within a field of work or study
3	**A3** **Applying basic** facts in solving problems	**B3** **Applying basic** theoretical knowledge in

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	within a field of work or study	solving problems within a field of work or study
4	**A4** **Analyzing** facts within a field of work or study	**B4** **Analyzing** theoretical knowledge within a field of work or study
5	**A5** **Analyzing** and **synthesizing** facts that create **awareness** of the **known boundaries** of the knowledge within a field of work or study, and their evaluation	**B5** **Analyzing** and **synthesizing** theoretical knowledge that creates **awareness** of the **known boundaries** of the knowledge within a field of work or study, and their evaluation
6	**A6** **Evaluation** of the facts within the field of work or study, a **part** of which is at the **forefront of knowledge** in a field of work or study	**B6** **Evaluation** of theoretical knowledge within the field of work or study, a **part** of which is at the **forefront of knowledge** in a field of work or study
7	**A7** **Evaluation** of the facts at the most **advanced frontier** of a field (of work or research) and at the **interface between different fields** that could be the **basis of scientific research** in a part of this field	**B7** **Evaluation** of theoretical knowledge at the most **advanced frontier** of a field (of work or research) and at the **interface between different fields** that could be the **basis of scientific research** in a part of this field
8	**A8** **Creating** and **evaluating** facts in part of the field of scientific research, which **leads to shifting boundaries of knowledge**	**B8** **Creating** and **evaluating** theoretical knowledge in part of the field of scientific research, which **leads to shifting boundaries of knowledge**

LEVELS	**SKILLS**		
	C **Cognitive skills**	**D** **Practical skills**	**E** **Social skills**
1	**C1** **Basic concrete logical** thinking (required for execution of simple concrete tasks) in familiar conditions	**D1** **Performing simple routine movements** in familiar conditions	**E1** **Realization of general rules of behavior** in familiar conditions
2	**C2** **Concrete logical** thinking (required for application of relevant information in the execution of a set of simple tasks) in familiar conditions	**D2** **Simple use of methods, instruments, tools and materials** in familiar conditions	**E2** **Realization of simple communication and cooperation with certain individuals** in familiar conditions
3	**C3** **Basic concrete creative** thinking (required for selection and application of relevant information in the execution of a set of complex routine tasks) in familiar conditions	**D3** **Complex** use of methods, instruments, tools and materials in familiar conditions	**E3** Realization of **complex** communication and cooperation **within a group** in familiar conditions

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4	**C4** **Basic abstract logical** thinking (required for selection and application of relevant information in the execution of a set of complex specific tasks) in changing conditions	**D4** Performing **complex** movements and complex use of methods, instruments, tools and materials (in the execution of a set of complex specific tasks) in changing conditions	**E4** Realization of **complex** communication and cooperation within a group in **changing** conditions
5	**C5** **Basic abstract creative** thinking (required for developing solutions of abstract problems) in partially unpredictable conditions	**D5** Performing complex movements and complex use of methods, instruments, tools and materials in **partially unpredictable conditions**, as well as **developing simple methods, instruments, tools and materials**	**E5** Realization of **management** and complex communication and cooperation within a group in **partially unpredictable** conditions
6	**C6** **Abstract logical** thinking (required for developing solutions of abstract problems) in unpredictable conditions	**D6** Performing complex movements and complex use of methods, instruments, tools and materials in **unpredictable conditions**, as well as developing **complex** methods, instruments, tools and materials	**E6** Realization of management and complex communication and cooperation **in different social groups** in unpredictable conditions
7	**C7** **Abstract creative** thinking (required in research for development of new skills and procedures and for integration of different areas)	**D7** Performing complex movements and complex use of methods, instruments, tools and materials, as well as developing **complex** methods, instruments, tools and materials required for research and innovative process	**E7** Realization of management and complex communication and cooperation **in different social groups and nations** in unpredictable conditions
8		**D8** **Creating, analyzing and evaluating new** proposed specialized movements and new methods, instruments, tools and materials	**E8** **Creating new social and civilizationally accepted communication and cooperation** with groups of different orientations and nations

LEVELS	COMPETENCES	
	F **Autonomy**	**G** **Responsibility**
1	**F1** Execution of **simple tasks under constant direct and professional guidance in familiar conditions**	**G1** Taking responsibility for **execution of simple tasks in familiar conditions**
2	**F2** Execution of simple tasks under **occasional direct and professional guidance** in familiar conditions	**G2** Taking responsibility for **execution of simple tasks and relationships with others in familiar conditions**
3	**F3** Execution of **complex** tasks and **adjustment of your own behavior within the given guidelines** in familiar conditions	**G3** Taking responsibility for **execution of complex tasks** in familiar conditions
4	**F4** Execution of complex tasks and adjustment of your own behavior within the given guidelines in **changing conditions**	**G4** Taking **partial** responsibility for **assessment and improvement of activities** in **changing** conditions
5	**F5** **Participation in managing activities** in partially unpredictable conditions	**G5** Taking **full** responsibility for **management** and **limited** responsibility for **evaluation** of improvement of activities in **partially unpredictable** conditions
6	**F6** Managing **professional projects** in unpredictable conditions	**G6** Taking **ethical and social responsibility** for **management** and **evaluation** of professional development of individuals and groups in unpredictable conditions
7	**F7** Managing **complex and changing** surrounding conditions and **deciding about changing them**	**G7** Taking **personal and team responsibility** for **strategic decision-making** and successful implementation and execution of tasks in **unpredictable conditions**, and social and ethical responsibility during the execution of tasks and consequences of the results of those tasks
8	**F8** **Expressing personal professional and ethical authority** and **permanent commitment** to researching and developing new processes	**G8** Taking **ethical and social responsibility for the success of the research**, for the **social utility of research results** and for **possible social consequences**

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

Acquired knowledge in this study is very applicable in the economy; graph theory has broad applications, from telecommunications to the design of road networks, coding theory and cryptography is used in

everyday communication. Acquired knowledge from the optimization and design of experiments provides employment in several branches of economy, for example, in companies that need to test finished products or prototypes.
2.6.3. Possibility of continuation of study on higher level
After finishing this study, masters of mathematics will be able to enroll the Common doctoral program in mathematics at the University J.J. Strossmayer in Osijek, University of Rijeka, University of Split and the University of Zagreb, as well as appropriate doctoral studies abroad.
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
Enroll to this graduate program is possible with finished undergraduate course Mathematics completed at the Department of mathematics, University of Rijeka, and finished undergraduate studies of mathematics in any of the Croatian and foreign universities.
2.8. Upon application of integrated studies - name reasons for integration of undergraduate and graduate level of study programme

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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 (appendix: Table 1)

3.2. Description of each subject (appendix: Table 2)

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

The study consists of a major number of compulsory subjects (92 ECTS) and a minor number of elective courses (28 ECTS, or 23.33% of the total number of ECTS for the study).
Basic subjects differ among the compulsory subjects, and they should be common to all (future) noneducational mathematics graduate programs at the Department of mathematics, University of Rijeka (56 ECTS), with whose adoption students acquire the necessary knowledge, skills and competences for further development in the field of mathematics, and set the basis for adoption subjects in area of discrete mathematics and applications.
The rest of the compulsory courses (36 ECTS) is closely associated with the name of study, respectively with learning outcomes from section 2.6.1..
By choosing elective courses student is developing himself, so he can acquire knowledge, on his own choice, that will introduce him with related fields of physics, computer science or education of mathematics. In cooperation with the Department of physics, Department of mathematics and the Faculty of Philosophy interdisciplinary nature of this study is increasing.
Rhythm of study is defined by Study regulations at the University of Rijeka, as well as general obligation, whereas the specific responsibilities of students are determined by description of each course and associated executive program, which is published every year before the related semester.

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

Admission requirements are determined by the Study regulations at the University of Rijeka.

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

Course title (course status within the proposed program)	***The existing program in which the course is taught (course status within the other program)***	***Note***
Vector Spaces 1 (compulsory)	*Graduate course in Mathematics – Math. Education Specialization (compulsory)*	*DM*
Measure and Integral (compulsory)	*Graduate course in Mathematics – Math. Education Specialization (elective)*	*DM*
Algebra 1 (compulsory)	*Graduate course in Mathematics – Math. Education Specialization (elective)*	*DM*
Linear Programming (compulsory)	*Graduate course in Mathematics – Math. Education Specialization (compulsory)* *Graduate course in Mathematics and Computer science – Education Specialization (compulsory)*	*DM*
Graph Theory (compulsory)	*Graduate course in Mathematics – Math. Education Specialization (elective)*	*DM*
Algebra 2 (compulsory)	*Graduate course in Mathematics – Math. Education Specialization (elective)*	*DM*
Probability Theory (compulsory)	*Graduate course in Mathematics – Math. Education Specialization (elective)*	*DM*
Harmonic analysis (elective)	*Graduate course in Mathematics – Math.*	*DM*

	Education Specialization (elective)	
Coding Theory and Cryptography (compulsory)	*Graduate course in Mathematics – Math. Education Specialization (elective)* *Graduate course in Mathematics and Computer science – Education Specialization (elective)*	*DM*
Introduction to Databases (elective)	*Graduate course in Mathematics and Computer science – Education Specialization (compulsory)* *Graduate course in Mathematics – Math. Education Specialization (elective)* *Undergraduate single major program of Informatics (compulsory)*	*DCS*
Computer Networks 1 (elective)	*Graduate course in Mathematics and Computer science – Education Specialization (compulsory)* *Graduate course in Mathematics – Math. Education Specialization (elective)* *Undergraduate single major program of Informatics (compulsory)* *Undergraduate duble major program of Informatics (compulsory)*	*DCS*
Mathematics Education 1 (elective)	*Graduate course in Mathematics – Math. Education Specialization (compulsory)* *Graduate course in Mathematics and Computer science – Education Specialization (compulsory)*	*DM*
Seminar/M.Sc.thesis (compulsory)	*Graduate course in Mathematics – Math. Education Specialization (compulsory)* *Graduate course in Mathematics and Computer science – Education Specialization (compulsory)*	*DM*
Graduation (compulsory)	*Graduate course in Mathematics – Math. Education Specialization (compulsory)* *Graduate course in Mathematics and Computer science – Education Specialization (compulsory)*	*DM*
Vector Spaces 2 (elective)	*Graduate course in Mathematics – Math. Education Specialization (elective)*	*DM*
History of Mathematics (elective)	*Graduate course in Mathematics – Math. Education Specialization (compulsory)*	*DM*
Popularization of Science (elective)	*Graduate course in Mathematics – Math. Education Specialization (elective)* *Graduate course in Physics and Mathematics – Education Specialization (elective)* *Graduate course in Physics and Philosophy (elective)* *Graduate course in Physics and Computer science (elective)*	*DP*
Mathematics Education 2 (elective)	*Graduate course in Mathematics – Math. Education Specialization (compulsory)* *Graduate course in Mathematics and*	*DM*

	Computer science – Education Specialization (compulsory)	
Computer Networks 2 (elective)	*Graduate course in Mathematics – Math. Education Specialization (elective)* *Graduate course in Mathematics and Computer science – Education Specialization (elective)* *Undergraduate single major program of Informatics (compulsory)* *Undergraduate duble major program of Informatics (compulsory)*	*DCS*
Databases (elective)	*Graduate course in Mathematics – Math. Education Specialization (elective)* *Graduate course in Mathematics and Computer science – Education Specialization (elective)* *Undergraduate single major program of Informatics (compulsory)* *Graduate duble major program of Informatics (compulsory)*	*DCS*
Seminar 3 (elective)	*Graduate course in Mathematics – Math. Education Specialization (compulsory)* *Graduate course in Mathematics and Computer science – Education Specialization (compulsory)*	*DM*
Topics in Contemporary Mathematics (elective)	*Graduate course in Mathematics – Math. Education Specialization (elective)*	*DM*
Partial Differential Equations (elective)	*Graduate course in Mathematics – Math. Education Specialization (elective)*	*DM*

DM – Department of mathematics
DP – Department of physics
DCS – Department of computer science

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

This study program will be conducted in Croatian and English.

3.6. Allocated ECTS credits that enable national and international mobility

The proposed study enables mobility among the related studies in all Croatian universities and abroad. We expect especially good cooperation with the Department of mathematics, University of Ghent, Belgium, with which the Department of mathematics, University of Rijeka has signed bilateral Erasmus agreement and where exists many courses in the area of discrete mathematics.

3.7. Multidisciplinarity/interdisciplinarity of study programme

Through this study program, students will gain knowledge which will enable cooperation with scientists from other fields of science. Graph theory is widely used in chemistry and computer science, and students will be able to participate in scientific and professional work in these areas.
Knowledge of coding theory and cryptography will enable collaboration with experts in the field of Information and communication technology, while knowledge in designing experiments will qualify them for connecting with teams of experts who conduct experiments in various fields of science, for example, in studies in medicine and biotechnology. Knowledge gained from the optimization is also applicable in various fields of science, for example in scientific and professional work in the

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technical sciences. Through elective courses, which are realized in cooperation with the Department of informatics and Department of physics of our University, interdisciplinary of study program is additionaly induced.
3.8. Mode of study programme completion
The final part of the study is exam in front of committee consisting of three members. An integral part of the graduate exam is presentation and defense of thesis which student made during the last semester. Student has right to access final exam after he passed all exams and fulfilled all obligations assigned by study program.
3.8.1. Conditions of approval of final work /thesis and/or final/thesis exam application
Conditions for approval of application for the graduate exam are assigned by Regulation of thesis and final exam at the university graduate courses of Department of mathematics, University of Rijeka (http://www.math.uniri.hr/dokumenti.php).
3.8.2. Composing and furnishing of final work/thesis
Forming thesis is defined by Regulations of thesis and final exam at university graduate courses of Department of mathematics, University of Rijeka (http://www.math.uniri.hr/dokumenti.php).
3.8.3. Final work/thesis assessment procedure and evaluation and defense of final work/thesis
Evaluation process of thesis and graduate exam is defined by Regulations of thesis and final exam at the university graduate courses of Department of mathematics, University of Rijeka (http://www.math.uniri.hr/dokumenti.php).

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Table 1

3.1. List of compulsory and elective courses and/or modules with teaching hours required and ECTS credits allocated

LIST OF MODULES/COURSES							
Year of study: 1.							
Semester: winter							
MODULE	COURSE	COURSE COORDINATOR	L	E	S	ECTS	STATUS[1]
	Vector spaces 1		30	30	0	6	C
	Measure and Integral		30	30	0	6	C
	Algebra 1		30	30	0	6	C
	Linear programmning		30	30	0	6	C
	Graph theory		30	15	15	6	C

LIST OF MODULES/COURSES							
Year of study: 1.							
Semester: summer							
MODULE	COURSE	COURSE COORDINATOR	L	E	S	ECTS	STATUS[2]
	Statistics		30	30	0	6	C
	Algebra 2		30	30	0	6	C
	Probability theory		30	30	0	6	C
	Artificial intelligence		30	30	0	6	C
	Coding theory and cryptography		30	15	15	6	C

LIST OF MODULES/COURSES							
Year of study: 2.							
Semester: winter (5 ECTS on elective courses)							
MODULE	COURSE	COURSE COORDINATOR	L	E	S	ECTS	STATUS
	Permutation groups		30	15	15	6	C
	Number theory		30	30	0	6	C
	Introduction to design theory		30	15	15	6	C
	Design and analysis of experiments		30	15	15	6	C
	Nonlinear optimization		30	30	0	6	E

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

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	Harmonic analysis		30	0	15	6	E
	Introduction to databases		30	30	0	5	E
	Computer networks 1		30	30	0	5	E
	Mathematics education 1		30	0	30	6	E
	Finite geometries		30	0	15	6	E
	Vector spaces 2		30	30	0	6	E

LIST OF MODULES/COURSES							
Year of study: 2.							
Semester: summer (22 ECTS on elective courses)							
MODULE	COURSE	COURSE COORDINATOR	L	E	S	ECTS	STATUS
	Seminar / M. Sc. thesis		0	0	30	4	C
	Combinatorial optimization		30	30	0	6	E
	Machine learning		30	30	0	6	E
	Optimization techniques for data mining		30	15	15	5	E
	Optimization methods in finance		30	15	15	5	E
	History of mathematics		15	0	30	3	E
	Science popularization		15	15	0	2	E
	Mathematics education 2		30	0	30	6	E
	Computer networks 2		30	30	0	5	E
	Databases		30	30	0	5	E
	Statistical practicum		15	30	15	6	E
	Stochastic processes		30	30	0	6	E
	Seminar 3		0	0	30	4	E
	Topics in contemporary mathematics		15	0	15	3	E
	Partial differential equations		30	30	0	6	E
	Introduction to combinatorial topology		15	15	15	5	E
	Seminar of Applied Discrete Mathematics		0	15	15	4	E
	Graduation					4	C

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General information		
Lecturer		
Course title	Vector spaces 1	
Program	Discrete mathematics and its applications	
Course status	Compulsory	
Year	1	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 30 + 0

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students familiar with basic concepts of vector space theory. For this purpose, it is necessary within the course to:

- define vector space and describe characteristic examples of vector spaces,
- define linear operators and analyse their properties,
- analyse matrix representation of a linear operator,
- define adjoint space,
- define and analyse invariant subspaces and operator eigenvalues,
- describe reduction of operator on finite dimensional vector spaces,
- define bilinear form,
- define and describe properties of a normal operator.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- know basic examples of vector spaces and linear operators (A6, B6, C6, D4, E4, F3),
- solve problems related to the calculation of the rank (A6, B6, C6, D4, E5, F3),
- solve problems related to adjoint spaces (A6, B6, D4, E5, F3),
- construct Jordan basis (A6, B6, C6, D4, E5, F3),
- apply and understand the procedure of reduction of an operator on finite dimensional vector spaces in particular problems (A6, B6, D4, E5, F3),
- know bacis examples of unitary spaces (A6, B7, D4, E5, F3),
- classify main properties of bilinear forms (A6, B6, D4, E5, F3),
- classify main properties and examples of normal operators (A6, B6, D4, E5, F3),
- mathematically prove validity of all procedures and formulas that are used within the course (A6, B6, D4, E5, F3).

1.4. Course content

Vector space, basic notions and example. Quotient space. Linear operators, basic notions and examples. The space (X,Y). Limit in the space Hom(X,Y). Algebra. Minimal polynomial. Adjoint space and adjoint operator. Invariant subspaces and eigenvalues. Nilpotent operator. Reduction of operators on finite dimensional vector spaces. Jordan matrix of an operator. Operator functions. Resolvent.
Geometry of unitary spaces. The structure of bilinear forms. Normal operators.

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1.5. Modes of instruction	☒lectures ☐seminars and workshops ☒exercises ☐e-learning ☐field work	☒independent work ☐multimedia and the internet ☐laboratory ☐tutorials ☐other
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[3]

Class attendance	1.5	Class participation		Seminar paper		Experiment	
Written exam	2	Oral exam	2	Essay		Research work	
Project		Continuous assessment	0.5	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. S. Kurepa, Konačno dimenzionalni vektorski prostoi i primjene, Sveučilišna naklada Liber, Zagreb, 1976.
2. H. Kraljević, Vektorski prostori, Odjel za matematiku, Sveučilište u Osijeku

1.11. Recommended literature (when proposing the program)

1. P.R.Halmos, Finite Dimensional Vector Spaces, Van Nostrand, New York, 1958.
2. K.Horvatić, Linearna algebra, Golden marketing – Tehnička knjiga, Zagreb, 2004.
3. S.Lang, Linear algebra, Springer Verlag, Berlin, 1987.
4. S.Lang, Algebra, Addison-Wesley Publishing Company, cop. 1967.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[3] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Measure and Integral	
Program	Discrete mathematics and its applications	
Course status	Compulsory	
Year	1	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 30 + 0

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students acquainted with the basic notions of the measure and integral theory. For this purpose it is necessary within the course to:

- define the measure and analyse its properties,
- describe basic examples of a measure space,
- define the Lebesgue measure and analyse its properties,
- define the notion of a measurable function,
- define the integral of a function on a measure space and analyse its properties,
- prove Lebesgue's monotone and dominated convergence theorem and Fatou's lemma,
- describe the construction of a product measure and prove Fubini's theorem,
- describe the notions of absolute continuity and singularity of a measure,
- prove Radon – Nikodym theorem,
- analyse the connection between Riemann and Legesgue integral.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- use and understand the properties of a measure and integral (A7, B7, C7),
- analyse examples of a measure with a special emphasis on the Lebesgue measure (A7, B7, C7),
- use and understand the convergence theorems in problem solving (A7, B7, C7, F7),
- use and understand the Fubini's theorem in problem solving (A7, B7, C7, F7),
- analyse the notions of absolute continuity and singularity of a measure and the relations among them (A7, B7, C7, F7),
- analyse the connections and differences between Riemann and Lebesgue integral (A7, B7, C7),
- mathematically prove validity of all procedures and formulas that are used within the course (A7, B7, C7, F7).

1.4. Course content

Ring, algebra, σ-algebra of sets, Borel sets. Measure, outer measure. Lebesgue measure. Monotone and dominated convergence theorem, Fatou lemma. Product measures. Fubini's theorem. Absolute continuity and singularity of a measure. Radon-Nikodym theorem. Relationship between the Riemann and Lebesgue integral.

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1.5. Modes of instruction	☒lectures ☒seminars and workshops ☒exercises ☒e-learning ☐field work	☒independent work ☒multimedia and the internet ☐laboratory ☐tutorials ☐other consultations
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[4]

Class attendance	1.5	Class participation		Seminar paper		Experiment	
Written exam	2	Oral exam	2	Essay		Research work	
Project		Continuous assessment	0.5	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. S.Mardešić: Matematička analiza II, Školska knjiga, Zagreb, 1977.
2. Donald L. Cohn: Measure theory, Birkhäuser Boston, 1994.

1.11. Recommended literature (when proposing the program)

1. P. Halmos, Measure Theory, Springer-Verlag, New York, 1974.
2. N. Antonić, M. Vrdoljak: Mjera i integral, PMF-Matematički odjel, Zagreb 2001.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[4] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Algebra 1	
Program	Discrete mathematics and its applications	
Course status	Compulsory	
Year	1	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 30 + 0

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students acquainted with the advanced theory of permutation groups. For this purpose it is necessary within the course to:

- define categories and analyse different examples of categories,
- define free groups and analyse their properties,
- define modules and analyse their properties,
- define lattices of groups,
- define subgroup series and characterise different types of subgroup series,
- define solvable groups, analyse their properties and characterise them using different methods,
- define nilpotent groups, analyse their properties and characterise them using different methods.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- define and analyse properties of free groups, apply and understand the adequate method while solving problems (A7, B7, C7, D7, E5, F7, G7),
- differentiate and analyse different categories, apply and understand the adequate method while solving problems (A7, B7, C7, D7, E5, F7, G7),
- define and analyse properties of modules, apply and understand the adequate method while solving problems (A7, B7, C7, D7, E5, F7, G7),
- define solvable groups and characterize them using different methods, apply and understand the adequate method while solving problems (A7, B7, C7, D7, E5, F7, G7),
- define nilpotent groups and characterize them using different methods, apply and understand the adequate method while solving problems (A7, B7, C7, D7, E5, F7, G7),
- mathematically prove validity of all procedures and formulas that are used within the course (B7, F4).

1.4. Course content

Categories and functors. Free groups. Modules. Lattices and subgroup series. Solvable groups. Nilpotent groups.

1.5. Modes of instruction	☒lectures ☐seminars and workshops ☒exercises ☒e-learning ☐field work	☒independent work ☒multimedia and the internet ☐laboratory ☐tutorials ☐other
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[5]

Class attendance	2	Class participation		Seminar paper		Experiment	
Written exam	2	Oral exam	1.5	Essay		Research work	
Project		Continuous assessment	0.5	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. T.W. Hungerford: Algebra, Reinhart and Winston, NY, 1989.

1.11. Recommended literature (when proposing the program)

1. H. J. Rose: A Course on finite groups, Springer-Verlag London, 2009.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students
T.W. Hungerford: Algebra, Reinhart and Winston, NY, 1989.	2	15

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[5] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Linear programming	
Program	Discrete mathematics and its applications	
Course status	Compulsory	
Year	1	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 30 + 0

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students familiar with:

- basic types of the linear programming problems,
- basic principles and algorithms for solving problems of finding minimum and maximum values,
- notions of dual problems of linear programming,
- basic notions of the matrix game theory,
- basics of convex programming,
- basics of integer programming.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- classify basic convex sets of points in n-dimensional Euclidean space and proper analytical methods of solving linear programming problems (A6, B6, C6, D6, E6, F6),
- apply properties of a linear (affine) function to a linear programming problem with understanding (A6, B6, C6, D6, E6, F6),
- define the goal function in simple linear programming problems (A6, B6, C6, D6, E6, F6),
- apply and understand various algorithms for finding extreme values of a linear function on a convex set (A6, B6, C6, D6, E6, F6),
- solve the dual problem of linear programming (A6, B6, C6, D6, E6, F6),
- apply and understand the Simplex algorithm (A6, B6, C6, D6, E6, F6),
- analyse the concept of matrix games (A6, B6, C6, D6, E6, F6),
- solve problems of integer programming (A6, B6, C6, D6, E6, F6),
- analyse the basics of convex programming (A6, B6, C6, D6, E6, F6).

1.4. Course content

Convex sets in R^n. Polyhedral sets. Gauss-Jordan method for solving system of equations. Basic linear programming problems. Fourier-Motzkin method and some graphical methods for solving linear programming problems. Simplex method. Degeneracy case. Dual simplex method. Parametric linear programming. Duality. Integer linear programming. Transportation problems. Basics of matrix game theory. Basics of convex programming.

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1.5. Modes of instruction	☒lectures ☐seminars and workshops ☒exercises ☒e-learning ☐field work	☒ independent work ☒multimedia and the internet ☐ laboratory ☐tutorials ☒consultations ☐other
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[6]

Class attendance	1.5	Class participation		Seminar paper		Experiment	
Written exam	1.5	Oral exam	2	Essay		Research work	
Project		Continuous assessment	1	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. N.Linić, H.Pašagić, Č.Rnjak : Linearno i nelinearno programiranje, Informator, Zgb, 1978.
2. K.Murty : Linear and Combinatorial Programming, John Wiley and Sons, NY, 1983.

1.11. Recommended literature (when proposing the program)

1. R.V. Benson : Euclidean Geometry and Convexity, Mc Graw - Hill, NY, 1966.
2. L.Lyusternik : Convex Figures and Polyhedrons, Dover publications, NY, 1963.
3. M.Radić : Linearno programiranje, Školska knjiga, Zgb, 1974.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	*Number of copies*	*Number of students*
N.Linić, H.Pašagić, Č.Rnjak : Linearno i nelinearno programiranje, Informator, Zgb, 1978	5	10
K.Murty : Linear and Combinatorial Programming, John Wiley and Sons, NY, 1976	1	10

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[6] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Graph theory	
Program	Discrete mathematics and its applications	
Course status	Compulsory	
Year	1	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 15 + 15

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students acquainted with basic concepts in graph theory and applications of graph theory. For this purpose it is necessary within the course to:

- define basic concepts in graph theory and describe their basic properties,
- define Eulerian and Hamiltonian graph, prove some of their properties and describe its applications,
- define concepts of graph connectivity, analyse properties of connected graphs and the application in constructing reliable communication networks,
- define matching and perfect matching in graphs and elaborate corresponding statements and applications,
- define basic concepts in Ramsey theory for graphs,
- define basic concepts in directed graph theory, elaborate basic properties and some applications,
- analyse and compare certain algorithms.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing the course, the students are expected to:

- differentiate the concepts and graphs properties and apply and understand appropriate properties and statements in solving exercises (A7, B7, C7, D7, E5, F7, G7),
- analyse problems of graph connectivity and related properties (A7, B7, C7, D7, E5, F7, G7),
- analyse Eulerian and Hamiltonian graphs and apply and understand the definitions and properties in solving exercises (A7, B7, C7, D7, E5, F7, G7),
- solve problems related to a matching of graphs (A7, B7, C7, D7, E5, F7, G7),
- apply statements and algorithms elaborated within the course (A7, B7, C7, D7, E5, F7, G7),
- mathematically prove validity of all procedures and formulas that are used within the course (B7, F4).

1.4. Course content

Concepts and basic properties of graphs. Eulerian tours and Hamiltonian cycles. Chinese postman problem and Fleury's algorithm. Travelling salesman problem. Graph connectivity. Reliable communication networks. Matching in graphs. Perfect matchings. Employment problem and Hungarian matching algorithm. Optimal employment problem and Kuhn-Munkres algorithm. Independent sets, coverings and cliques. Ramsey theory for graphs. Directed graphs. Application to ranking for tournament graphs. Application to one-way street traffic flow. Transport networks. Ford-Fulkerson algorithm. Topological sorting.

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1.5. Modes of instruction	☒lectures ☒seminars and workshops ☒exercises ☒e-learning ☐field work	☒independent work ☒multimedia and the internet ☐laboratory ☒tutorials ☒other Consultations, project strategies
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[7]

Class attendance	1.5	Class participation		Seminar paper	0.7	Experiment	
Written exam	1.6	Oral exam	1.5	Essay		Research work	
Project		Continuous assessment	0.7	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. D.Veljan: Kombinatorika i diskretna matematika, Algoritam, Zagreb, 2001.
2. D.Veljan: Kombinatorika s teorijom grafova, Školska knjiga, Zagreb, 1989.

1.11. Recommended literature (when proposing the program)

1. N.Biggs: Discrete Mathematics, Clarendon Press, Oxford, 1989.
2. R.Diestel: Graph Theory, Fourth edition, Springer-Verlag, New York, 2010.
3. R.Balakrishnan, K.Ranganathan: A Textbook of Graph Theory, Springer-Verlag, Heidelberg, 2000.
4. R.Balakrishnan: Schaum's outline of Graph Theory: Included Hundreds of Solved Problems, McGraw-Hill, New York, 1997.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students
D.Veljan: Kombinatorika i diskretna matematika, Algoritam, Zagreb, 2001.	5	30
D.Veljan: Kombinatorika s teorijom grafova, Školska knjiga, Zagreb, 1989.	5	30

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[7] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Statistics	
Program	Discrete mathematics and its applications	
Course status	Compulsory	
Year	1	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 30 + 0

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students familiar with basic ideas and concepts of mathematical statistics. For that purpose, it is necessary within the course to:

- demonstrate basic ways of presentation of statistical dana,
- describe the classification of statistical variates,
- define parametres of a sequence of statistical dana,
- analyse continuous random variables and vectors that are important in statistics,
- define estimators and describe their properties,
- define confidence intervals,
- define and analyse statistical hypothesis testing,
- describe methods of hypothesis testing,
- enable students to independently use computer software for statistical data analysis.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- present statistical data in tabular and graphical form (A7, B7, E4, F5),
- explain the classification of statistical variables (A7, B7, E4, F5),
- analyse continuous random variables and vectors that are used in statistics (A7, B7, E4, F5),
- use and understand estimators and their properties within the specific statistical models (A7, B7, E4, F5),
- using a computer, construct confidence intervals and conduct a procedure of testing statistical hypotheses (A7, B7, E4, F5),
- using a computer, apply methods of statistical data analysis (A7, B7, E4, F5),
- mathematically prove validity of all procedures and formulas that are used within the course (A7, B7, E4, F5).

1.4. Course content

Descriptive statistics. Continuous random variables and vectors. Conditional distributions and mathematical expectation. Statistical structure. Estimations of parameters. Confidence intervals. Statistical hypothesis testing. ANOVA. Linear regression models.

1.5. Modes of instruction	☒lectures ☒seminars and workshops ☒exercises ☒e-learning ☐field work ☐practice	☒ independent work ☒multimedia and the internet ☐ laboratory ☐tutorials ☐consultations ☐other

	☐practicum	

1.6. Comments
1.7. Student requirements
Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).
1.8. Evaluation of assessment[8]

Class attendance	2	Class participation		Seminar paper		Experiment	
Written exam	2	Oral exam	1.5	Essay		Research work	
Project		Continuous assessment	0.5	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam
Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam. Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.
1.10. Required literature (when proposing the program)
1. Ž.Pauše, Uvod u matematičku statistiku, Školska knjiga, Zagreb, 1993. 2. F.Daly, D.J.Hand, M.C.Jones, A.D.Lunn, K.J.McConway, Elements of Statistics, Addison Wesley, 1995.
1.11. Recommended literature (when proposing the program)
1. N.Sarapa, Vjerojatnost i statsistika, II dio, Školska knjiga, Zagreb, 1996. 2. R.C.Mittelhammer, Mathematical statistics for economics and business, Springer Verlag, New York, 1996. 3. J.E.Freund, Mathematical Statistics, Prentice Hall, New York, 1992. 4. D.Williams, Weighing the Odds, Cambridge University Press, 2001. 5. R.B.Ash, Lectures on Statistics, University of Illinois, 2007. (http://www.math.uiuc.edu/~r-ash/Stat.html)
1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies
In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[8] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Algebra 2	
Program	Discrete mathematics and its applications	
Course status	Compulsory	
Year	1	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 30 + 0

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students acquainted with:

- basic notions of ring theory, especially theory of polynomial rings,
- basic notions of field theory and field extension theory,
- basic notions of Galois theory.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- define, give examples and recognise basic algebraic structures with two operations (A7, B7),
- have knowledge of the concept of ring, ideal and ring homomorphism (A7, B7),
- have knowledge of basic theorems of polynomial theory and be able to prove them (F3, B7),
- have knowledge of various types of field extensions and properly apply them (A7, B7, C7),
- successfully solve problems of determining Galois group (A7, B7),
- have knowledge of basics of Galois theory (A7, B7).

1.4. Course content

Rings and ideals. Integral domains. Euclidean domains, principal ideal domains, unique factorisation domains. Polynomial rings. Field extensions (simple, algebraic, finite dimensional, normal, separable, radical). Field automorphisms and Galois groups, Galois field extensions and Fundamental Theorem of Galois theory. Splitting fields for polynomials and algebraic closure. Solvability of Galois group as a condition for solvability of an algebraic equation in radicals. Finite fields.

1.5. Modes of instruction	☒lectures ☐seminars and workshops ☒exercises ☒e-learning ☐field work	☒independent work ☐multimedia and the internet ☐laboratory ☐tutorials ☐other
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

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1.8. Evaluation of assessment[9]

Class attendance	2	Class participation		Seminar paper		Experiment	
Written exam	2	Oral exam	1.5	Essay		Research work	
Project		Continuous assessment	0.5	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. T.W. Hungerford: Algebra, Reinhart and Winston, NY, 1989.
2. H. Kraljević: Algebra, Notes for the lectures held during 2006/07 at the University of Osijek

1.11. Recommended literature (when proposing the program)

1. Stewart: Galois Theory, Chapmann and Hall, London, 1973.
2. B. Širola: Rings, fields and algebras, Notes on Algebraic Structures, PMF, Zagreb

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students
T.W. Hungerford: Algebra, Reinhart and Winston, NY, 1989.	2	15

1.13. Quality assurances which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[9] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Probability theory	
Program	Discrete mathematics and its applications	
Course status	Compulsory	
Year	1	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 30 + 0

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students familiar with basic concepts, methods and results in probability theory. For that purpose, it is necessary within the course to:

- define random variables and analyse their basic properties,
- define distribution functions and describe the classification of random variables,
- define mathematical expectation and prove limit theorems for mathematical expectation,
- define variance and moments of random variables,
- prove basic inequalities in probability,
- describe basic types of convergence of random variables and their relations,
- prove weak and strong laws od large numbers,
- describe convergence of series of random variables,
- define notion of characteristic function of random variable and analyse basic properties of characteristic functions,
- prove inversion theorems and continuity theorems for characteristic functions,
- describe weak convergence of sequences of distribution functions,
- prove central limit theorem.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- apply and understand random variables and their properties in solving problems (A7, B7, E4, F5),
- explain the classification of random variables (A7, B7, E4, F5),
- apply and understand limit theorems for mathematical expectation (A7, B7, E4, F5),
- apply and understand basic probability inequalities (A7, B7, E4, F5),
- know basic types of convergence of random variables and their relations (A7, B7, E4, F5),
- know weak and strong laws of large numbers, and convergence of series of random variables (A7, B7, E4, F5),
- apply properties of characteristic functions in solving problems (A7, B7, E4, F5),
- explain inversion and continuity theorems for characteristic functions (A7, B7, E4, F5),
- explain weak convergence of sequence of distribution functions (A7, B7, E4, F5),
- apply and understand the central limit theorem (A7, B7, E4, F5),
- mathematically prove validity of all procedures and formulas that are used within the course (A7, B7, E4, F5).

1.4. Course content

Random variables. Distribution functions. Classification of random variables. Mathematical expectation. Limit theorems for mathematical expectation. Variance and moments. Important inequalities in probability. Convergence of random variables. Independence of random variables. Laws of large numbers. Convergence of series of random variables. Characteristic functions. Inversion theorem. Weak convergence. Continuity theorem. Central limit theorems.		
1.5. Modes of instruction	☒lectures ☐seminars and workshops ☒exercises ☒e-learning ☐field work ☐practice ☐practicum	☒ independent work ☒multimedia and the internet ☐ laboratory ☐tutorials ☐consultations ☐other _____
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[10]

Class attendance	2	Class participation		Seminar paper		Experiment	
Written exam	2	Oral exam	1.5	Essay		Research work	
Project		Continuous assessment	0.5	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. N. Sarapa, Teorija vjerojatnosti, Školska knjiga, Zagreb, 2002.
2. Ž. Pauše, Vjerojatnost – Informacija – Stohastički procesi, Školska knjiga, Zagreb, 2003.

1.11. Recommended literature (when proposing the program)

1. W.Feller, An Introduction to Probability Theory and Aplication, J.Wiley, New York, 1966.
2. N.Sarapa, Vjerojatnost i statistika, II dio, Školska knjiga, Zagreb, 1996.
3. C.M.Grinstead, J.L.Snell, Introduction to Probablility, American Mathematical Society, 1997. (http://aleph0.clarku.edu/~djoyce/ma217/book-5-17-03.pdf)
4. K.L.Chung, A Course in Probability Theory, Academic Press, 2000.
5. R.Durrett, Probability: theory and examples, Duxbury Press, Belmont, 1996.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	*Number of copies*	*Number of students*

[10] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies
In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

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General information		
Lecturer		
Course title	Artificial intelligence	
Program	Discrete mathematics and its applications	
Course status	Compulsory	
Year	1	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of this course is to get students acquainted with some some basic issues and algorithms in artificial intelligence. For this aim it is needed to:

- approach to artificial intelligence from an algorithmic, computer science perspective,
- provide some basic tools and algorithms required to produce artificial intelligence systems in the form of representing and reasoning with knowledge, planning and learning,
- introduce logic programming language associated with artificial intelligence.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing the course, students will be able to:

- analyse different perspectives on what are the problems of artificial intelligence, (A5, B5,C5,D3,E4,F7,G7),
- explain the basic knowledge representation, problem solving, and learning methods of artificial Intelligence, (A5, B5, C5, D3, E4,F7,G7),
- assess the applicability, strengths, and weaknesses of the basic knowledge representation, problem solving, and learning methods in solving particular problems, (A5, B5,C5,D5,E4,F7,G7),
- develop intelligent systems through examples of concrete computational problems, (A7, B6, C6,D5,F7,G7),
- design basic problem solving methods based on artificial intelligence - based search, reasoning, planning, and learning algorithms, (A7,B7,C5,D5,E4,F7,G7),
- describe logic programming language associated with artificial intelligence. (A5,B5,C4,E3,F4).

1.4. Course content

Perspectives and issues in artificial intelligence. History of development. Basic methods and theories. Problem solving. Knowledge representation and reasoning. Learning. Logic programming language associated with artificial intelligence.

1.5. Modes of instruction	☒lectures ☐seminars and workshops ☒exercises ☒e-learning ☐field work	☒independent work ☒multimedia and the internet ☐laboratory ☒tutorials ☐other
1.6. Comments		

1.7. Student requirements

Students are required to attend classes, actively participate in all forms of classes, earn a determined amount of points throughout semester and pass the final exam (details will be disclosed in the implementation plan of the course).

1.8. Evaluation of assessment[11]

Class attendance	1.5	Class participation		Seminar paper		Experiment	
Written exam		Oral exam	2.1	Essay		Research work	
Project		Continuous assessment	2.4	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during classes (e.g. exams, tests, seminars, online tests, homework, etc.) and at the final exam. The detailed elaboration of evaluating and assessing students' work will be disclosed in the implementation plan for the course.

1.10. Required literature (when proposing the program)

1. S. J. Russell, P. Norvig, Artificial Intelligence, A Modern Approach, Prentice Hall; 3rd edition, New Jersey,2010.
   (http://aima.cs.berkeley.edu/
2. P. Blackburn, J. Bos, K. Striegnitz: "LearnProlog Now!", http://www.learnprolognow.org/

1.11. Recommended literature (when proposing the program)

1. G. F. Luger, Artificial Intelligence: Structures and Strategies for Complex Problem Solving. Addison-Wesley, 2005.
2. S. Šegvić, Uvod u programski jezik Prolog, http://www.zemris.fer.hr/~ssegvic/pubs/prolog.pdf

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

Anonymous survey in which students will evaluate the quality of classes will be carried out during last week of classes. The analysis of students' success at final exams will be carried out at the end of semester.

[11] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Coding theory and cryptography	
Program	Discrete mathematics and its applications	
Course status	Compulsory	
Year	1.	
Credit values and modes of instruction	*ECTS credits / student workload*	6
	Hours (L+E+S)	30 + 15 + 15

COURSE DESCRIPTION

1.1. Course objectives

Main course objective is to get students acquainted with basic cryptography systems and basic methods in coding theory. For that purpose it is necessary within the course to:

- describe, compare and apply different cryptography systems,
- analyse the basic principles of cryptanalysis,
- analyse the basic principles of coding theory,
- define, differentiate and apply coding methods,
- analyse error detection methods in coding,
- describe methods of correcting errors in coding.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course students should be able to:

- differentiate and analyse cryptography systems and argumentedly apply adequate procedure in problem solving (A7,B7,C7,D7,E5,F7,G7),
- analyse and differentiate type codes and argumentedly apply adequate procedure in problem solving (A7,B7,C7,D7,E5,F7,G7),
- differentiate ways of detecting errors in data transfer with particular coding method and analyse the conditions under which it is possible to correct this error (A7,B7,C5,D5,E5,F5,G5),
- mathematically prove foundation of procedures and statements which they use within the course (B7, F4).

1.4. Course content

Basic terms of classical chriptography. Substitution chipers. Vigenere chiper. Playfair chiper. Hill's chiper. Enigma. History of DES. Description of the DES algorithm. Cryoanalysis DES. Some more modern block cryptosystems. The idea of a public key. RSA cryptosystem. Cryptoanalysis RSA cryptography. Other public key cryptosystems. Basic terms of coding theory. Hamming Distance. Code detection. Code correction. ISBN code. Length and weight of a code. Linear codes. Generator matrices and standard forms. Encoding. Nearest neighbour decoding. Dual code. Parity check matrix. Syndrome decoding. Finite fields. Cyclic codes. Reverse code. BCH and Reed-Solomon codes. Golay codes and perfect codes.

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1.5. Modes of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☒ e-learning	☒ independent work ☒ multimedia and the internet ☐ laboratory ☒ tutorials ☐ other
1.6. Comments		

1.7. Student requirements

Students' work will be evaluated and assessed during the semester and in the final exam. Total number of points student can achieve during the semester is 70 (to assess the activities listed in the table), while in the final exam student can achieve 30 points.
The detailed work out of monitoring and evaluation of students' work will appear in the executive program.

1.8. Evaluation and assessment[12]

Class attendance	1.5	Class participation		Seminar paper	1	Experiment	
Written exam	1	Oral exam	1.5	Essay		Research work	
Project		Continuous assessment	1	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and in the final exam

Students' work will be evaluated and assessed during the semester and in the final exam. Total number of points student can achieve during the semester is 70 (to assess the activities listed in the table), while in the final exam student can achieve 30 points.
The detailed work out of monitoring and evaluation of students' work will appear in the executive program.

1.10. Required literature (when proposing the program)

1. Dujella: Kriptografija (skripta dostupna online: http://web.math.hr/~duje/kript/kriptografija.html
2. J.I. Hall, Notes on Coding Theory, 2010 (skripta dostupna online: http://www.math.msu.edu/~jhall/classes/codenotes/coding-notes.html)
3. Igor S. Pandžić, Alen Bažant, Željko Ilić, Zdenko Vrdoljak, Mladen Kos, Vjekoslav Sinković: Uvod u teoriju informacija i kodiranja, Element, 2009

1.11. Recommended literature (when proposing the program)

1. Assmus, J.D. Key, Designs and their codes, Cambridge University Press, London, 1992.
2. A. Dujella, M. Maretić, Kriptografija, Element, Zagreb, 2007.
3. N. Koblitz, A Course in Number Theory and Cryptography, Springer Verlag, New York, 1994.
4. J.H. van Lint, Introduction to Coding Theory, Springer-Verlag, Berlin, 1982.
5. F.J. MacWilliams, N.J.A. Sloane, The theory of error-correcting codes, North-Holland, 1977.
6. B.Schneiner, Applied Cryptography, Wiley, NY 1995.
7. J. Seberry, J. Pieprzyk, Cryptography: an introduction to computer security, Prentice-Hall, 1989.
8. D.R.Stinson, Cryptography. Theory and Practice, CRC Press, Boca Raton, 1996.
9. D. Welsh, Codes and cryptography, Oxford: Clarendon Press, 1988.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	*Number of copies*	*Number of students*

[12] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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Igor S. Pandžić, Alen Bažant, Željko Ilić, Zdenko Vrdoljak, Mladen Kos, Vjekoslav Sinković: Uvod u teoriju informacija i kodiranja, Element, 2009	2	5

1.13.Quality assurance which ensure acquisition of knoxledge, skills and competencies

In the last week of the semester students will evaluate the quality of the lectures. At the end of each semester (March 1 and September 30 of the current academic year) results of the exams will be analyzed.

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General information		
Lecturer		
Course title	Permutation groups	
Program	Discrete mathematics and its applications	
Course status	Compulsory	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 15 + 15

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students acquainted with the advanced theory of the permutation groups. For this purpose it is necessary within the course to:

- define the action of a group on a set, differentiate various actions and analyse their properties,
- define a permutation group, differentiate various examples of a permutation group and analyse its properties,
- descrabe the constructions of primitive groups and O'Nan-Scott theorem and analyse its consequences,
- provide a short introduction into the theory of finite simple groups.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course the students are expected to:

- differentiate and analyse various actions of a group on a set, apply and understand adequate methods while solving problems (A7, B7, C7, D7, E5, F7, G7),
- differentiate and analyse various examples of permutation groups, apply and understand adequate procedures while solving problems (A7, B7, C7, D7, E5, F7, G7),
- construct different finite structures from permutation groups and analyse their properties (A7, B7, C7, D7, E5, F7, G7),
- apply and understand O'Nan-Scott theorem and its consequences (A7, B7, C7, D7, E5, F7, G7),
- describe classification of finite simple groups (A5, B5, C5, D5, E5, F4, G4),
- mathematically prove validity of all procedures and formulas that are used within the course (B7, F4).

1.4. Course content

Transitive and k-transitive groups. Regular groups. Primitive groups. O'Nan-Scott theorem and consequences. Simple groups. Construction of incidence structures from groups.

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1.5. Modes of instruction	☒lectures ☒seminars and workshops ☒exercises ☒e-learning ☐field work	☒independent work ☒multimedia and the internet ☐laboratory ☒practicum ☒tutorials ☐other
1.6. Comments		

1.7. Student requirements

Students are required to attend classes regularly and actively participate in them, they are required to achieve a certain number of points during the semester and to pass the final exam (details will be listed in the executive program).

1.8. Evaluation of assessment[13]

Class attendance	1.5	Class participation		Seminar paper	1	Experiment	
Written exam	0.8	Oral exam	1	Essay		Research work	
Project		Continuous assessment	1.7	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and in the final exam

Students' work will be evaluated and assessed during the semester and at the final exam. The total number of points a student can earn during the semester is 70 (the activities listed in the table are assessed), while at the final exam, a student can achieve 30 points.
The detailed elaboration of the monitoring and evaluation of students' work will be presented in the course curriculum.

1.10. Required literature (when proposing the program)

1. P. J. Cameron, Permutation groups, Cambridge University Press, 1999.
2. J. D. Dixon, B. Mortimer, Permutation groups, Springer, New York, 1996.

1.11. Recommended literature (when proposing the program)

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. At the end of each semester the analysis of the exam results will be conducted.

[13] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Number theory	
Program	Discrete mathematics and its applications	
Course status	Compulsory	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 30 + 0

1. COURSE DESCRIPTION

1.1. Course objectives

Number theory is a branch of mathematics which has always been considered as a motivation and foundation of all mathematics because of its simply formulated, but very difficult problems (some of which have been attempted to get solved for centuries). In solving these problems, the newest results in the fields of algebra, analysis and geometry are being applied. The main course objective is to get students familiar with the way of thinking and proving statements in the number theory, and especially with the algebraic and analytical methods in the number theory. For that purpose, it is necessary within the course to:

- analyse basic properties of integers: divisibility, prime numbers, prime factorization, Euclidean algorithm, congruencies,
- describe the solutions of quadratic congruency by using the Legendre symbol and compare those congruencies by using the quadratic law of reciprocity,
- analyse quadratic forms and display of integers by using quadratic forms, and specifically compare display of integers as sums of a fixed number of perfect squares,
- define arithmetic functions and compare basic examples,
- differentiate basic types of Diophantine equations and describe the methods of solving them,
- define elliptic curves, analyse their properties and applications in the number theory,
- apply the number theory in the public-key cryptography,
- describe algebraic methods in the number theory and their application,
- describe analytical methods in the number theory and their application.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- analyse basic properties of integers and apply those properties to simple problems in the number theory related to divisibility and divisibility algorithms (A6, B7, D6, E6, F6),
- calculate using modular arithmetics, solve congruency equations and systems of congruencies (A6, B7, D6, E6, F6),
- apply and understand the quadratic law of reciprocity and formulas for calculating the Legendre symbol, to solve quadratic congruencies (A6, B7, D6, E6, F6),
- describe the display of integers by using quadratic forms in simple cases, compare and classify different quadratic forms (A6, B7, D6, E6, F6),
- show and analyse basic multiplicative functions and their properties, check and show connections between them (A6, B6, D6, E6, F6),
- define basic types of Diophantine equations and describe the methods of solving them (A6, B7, D6, E6, F6),

- define elliptic curves, analyse their basic properties and describe important open problems (A6, B6, D6, E6, F6),
- apply and understand the methods in the number theory in analysis of the public-key cryptosystem (A6, B7, D6, E6, F6),
- describe and analyse algebraic and analytical methods in the number theory and apply them to important problems in the number theory (A6, B6, D6, E6, F6).

1.4. Course content

Divisibility. Greatest common factor. Euclidean algorithm. Prime numbers. Congruencies. Euler theorem. Chinese remainder theorem. Primitive roots and indices. Quadratic remainders. Legendre symbol. Quadratic law of reciprocity. Divisibility properties of Fibonacci numbers. Quadratic forms. Reduction of binary quadratic forms. Distribution of prime numbers. Diophantine equations. Linear Diophantine equations. Pythagorean triples. Pell equation. Elliptic curves. Application of the number theory in the public-key cryptography.

1.5. Modes of instruction	☒lectures ☐seminars and workshops ☒exercises ☒e-learning ☐field work ☐practice ☐practicum	☒ independent work ☒multimedia and the internet ☐ laboratory ☐tutorials ☐consultations ☐other _____
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[14]

Class attendance	2	Class participation		Seminar paper		Experiment	
Written exam	1	Oral exam	1	Essay		Research work	
Project		Continuous assessment	2	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. Baker: A Concise Introduction to the Theory of Numbers, Cambridge University Press, Cambridge, 1994.
2. Dujella A., Maretić M.: Kriptografija, Element, Zagreb, 2007.
3. Niven, H. S. Zuckerman, H. L. Montgomery: An Introduction to the Theory Numbers, Wiley, New York, 1991.

1.11. Recommended literature (when proposing the program)

[14] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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1. K. H. Rosen: Elementary Number Theory and Its Applications, Addison-Wesley, Reading, 1993.
2. K. Chandrasekharan: Introduction to Analytic Number Theory, Springer-Verlag, Berlin, 1968.
3. H. E. Rose: A Course in Number Theory, Oxford University Press, 1995.
4. W. M. Schmidt: Diophantine Approximation, Springer-Verlag, Berlin, 1996.
5. B. Pavković, D. Veljan: Elementarna matematika 2, Školska knjiga, Zagreb, 1995.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

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General information		
Lecturer		
Course title	Introduction to Design Theory	
Program	Discrete mathematics and its applications	
Course status	Compulsory	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 15 + 15

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students acquainted with:

- the basic definitions, concepts, procedures and theorems of the design theory,
- the relation between different combinatorial structures, link designs with codes, graphs, differential sets, latin squares,
- basic applications of a combinatorial design in the coding theory, to threshold schemes, visual cryptography and group testing.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- define the basic concepts of the design theory, apply and understand some basic procedures in the design theory (A7, B7),
- have knowledge of the basic theorems of the design theory and be able to prove them (B7, F4),
- construct examples of block designes and related combinatorial structures (C7, D7, E5, F7, G7),
- apply the design theory in the elementary problems of the coding theory, threshold schemes, visual cryptography and group testing (A7, B7, C7).

1.4. Course content

Basic definitions and properties of combinatorial designes; incidence matrices, isomorfisms and automorfisms, Fisher's inequality. Symmetric designs; differential sets, construction of differential sets, residual and derived designs, Hadamard matrices and designs, Bruck-Ryser-Chowla theorem. Resolvable designs; affine plane, projective plane, Bose's inequality, affine resolvable design. Steiner triple system; quasigroups, the Bose construction, the Skolem construction, cyclic Steiner triple systems. Orthogonal latin squares; mutually orthogonal latin squares, orthogonal arrays and transversal designs.
Applications of combinatoral designs; codes, threshold scheme, visual cryptography, group testing.

1.5. Modes of instruction	☒lectures ☐seminars and workshops ☒exercises ☒e-learning ☐field work ☐practice ☐practicum	☒independent work ☒multimedia and the internet ☐laboratory ☒project strategies ☒tutorials ☒other consultations
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and to do homework and project assignment. They are required to fulfill all obligations in accordance with the course curriculum.

1.8. Evaluation of assessment[15]

Class attendance	1.5	Class participation		Seminar paper		Experiment	
Written exam		Oral exam	1.3	Essay		Research work	
Project	1.5	Continuous assessment	1.7	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. D.R. Stinson: Combinatorial Designs with Selected Applications, Lecture Notes (www.cacr.math.uwaterloo.ca/~dstinson/papers/designnotes.ps)
2. E.F. Assmus, J. D. Key: Designs and their Codes, Cambridge University Press, 1992.

1.11. Recommended literature (when proposing the program)

1. Anderson, I. Honkala: A Short Course in Combinatorial Designs, Internet Edition, 1997. (www.utu.fi/~honkala/designs.ps)

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students
E.F. Assmus, J. D. Key: Designs and their Codes, Cambridge University Press, 1992.	2	15

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[15] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Design and analysis of experiments	
Program	Discrete mathematics and its applications	
Course status	Compulsory	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 15 + 15

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students familiar with the procedures for designing and analysing experiments and enable them to carry out these procedures in specific situations. For this purpose, it is necessary within the course to:

- describe basic principles and methods for designing experiments,
- define and analyse some standard experimental designs,
- describe and analyse a model for designs with one source of variation,
- describe and analyse contrasts,
- define and compare methods of multiple comparisons,
- analyse methods for checking model assumptions,
- analyse experiments with two or more crossed treatment factors,
- define and analyse complete block designs,
- update the knowledge about basic notions from design theory,
- describe and analyse basic notions in statistical design theory.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- describe and apply with understanding the basic principles and methods for designing and analysing experiments to particular examples in this field (A7, B7, E5, F5),
- analyse the model for designs with one source of variation (A7, B7, E4, F5),
- analyse and apply with understanding the methods of multiple comparisons (A7, B7, E4, F5),
- analyse models for two treatment factors (A7, B7, E4, F5),
- use the appropriate software package for solving problems in this field (A7, B7, E4, F5),
- analyse basic notions in statistical design theory (A7, B7, E4, F5),
- apply and use basic notions in statistical design theory to particular examples (A7, B7, E4, F5),
- mathematically prove validity of all procedures and formulas that are used within the course (A7, B7, E4, F5).

1.4. Course content

Basic principles and techniques for designing experiments. Planning experiments. Some standard experimental designs. Designs with one source of variation. Contrasts. Methods of multiple comparisons. Checking model assumptions. Experiments with two or more crossed treatment factors. Complete block designs. Statistical design theory.

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1.5. Modes of instruction	☒lectures ☒seminars and workshops ☒exercises ☒e-learning ☐field work ☐practice ☐practicum	☒ independent work ☒multimedia and the internet ☐ laboratory ☐ project strategies ☐tutorials ☐consultations ☐other
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[16]

Class attendance	1.5	Class participation		Seminar paper	1	Experiment	
Written exam	1	Oral exam	1	Essay		Research work	
Project	1	Continuous assessment	0.5	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. A. Dean, D. Voss: Design and Analysis of Experiments, Springer, 1999.
2. D.C. Montgomery, Design and Analysis of Experiments, 5th Edn. J. Wiley., 2004.

1.11. Recommended literature (when proposing the program)

1. W.Feller, An Introduction to Probability Theory and Aplication, J.Wiley, New York, 1966.
2. N.Sarapa, Vjerojatnost i statistika, II dio, Školska knjiga, Zagreb, 1996.
3. C.M.Grinstead, J.L.Snell, Introduction to Probablility, American Mathematical Society, 1997. (http://aleph0.clarku.edu/~djoyce/ma217/book-5-17-03.pdf)
4. K.L.Chung, A Course in Probability Theory, Academic Press, 2000.
5. R.Durrett, Probability: theory and examples, Duxbury Press, Belmont, 1996.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[16] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Nonlinear optimization	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

Mathematical optimization is at the core of every decision support methods and the cornerstone of Machine Learning and Artificial Intelligence. It has applications in Industrial applications, softer development and scientific research. In most of mentioned applications the objective and constraints are nonlinear functions of many variables which can be a hard problem to tackle without a proper tool. This course presents theoretical foundation, methods and numerical algorithms to solve optimization problems.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

On completion of this course students will:

- be able to list different methods of nonlinear optimization (A2, B3),
- be able to formulate problems in nonlinear optimization and appreciate their assumptions and limitations (A6, B6, C6),
- be able to choose appropriate method for solving nonlinear optimization problem using modern optimization methods and software (A7,C7, D6, E7).

1.4. Course content

Line search and trust-region methods for unconstrained optimization problems (steepest descent, Newton's method); gradient-based algorithms; linear and nonlinear least-squares. First-order and second-order optimality conditions for constrained optimization problems; overview of methods for constrained problems (active-set methods, sequential quadratic programming, interior point methods, penalty methods, filter methods).

1.5. Modes of instruction	▣ lectures ▣ seminars and workshops ▣ exercises ▣ e-learning ☐field work	☐independent work ☐multimedia and the internet ☐laboratory ☐tutorials ☐other
1.6. Comments		

1.7. Student requirements

Students are required to obtain certain number of points during the course and pass a final exam. .

1.8. Evaluation of assessment[17]

Class attendance	1.5	Class participation		Seminar paper	1	Experiment	
Written exam		Oral exam	1.3	Essay		Research work	
Project		Continuous assessment	2.2	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam. The detailed elaboration of evaluating and assessing students' work will be disclosed in the implementation plan for the course.

1.10. Required literature (when proposing the program)

Bertsekas, Dimitri P. *Nonlinear Programming*. 3nd ed. Athena Scientific Press, 1999.

1.11. Recommended literature (when proposing the program)

art, W.E., Laird, C.D., Watson, J.-P., Woodruff, D.L., Hackebeil, G.A., Nicholson, B.L., Siirola, J.D. Pyom
Optimization Modeling in Python, 20

Optimization Methods in Finance, G. Cornuejols and R. Tütüncü, Cambridge University Press. ISBN-10: 0521861705
https://nlopt.readthedocs.io/en/latest/

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

Anonymous survey in which students will evaluate the quality of classes will be carried out during last week of classes. The analysis of students' success at final exams will be carried out at the end of semester.

[17] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Harmonic analysis	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 0 + 15

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students familiar with basic ideas and concepts of harmonic analysis, elements of functional analysis and their application. For that purpose, it is necessary within the course to:

- define Hilbert spaces and analyse their structure and properties,
- determine orthonormal systems in a Hilbert space and analyse their completeness,
- calculate and analyse Fourier series, and compare them to their original functions,
- analyse the consequences of the Banach-Steinhaus theorem and the open mapping theorem related to Fourier series,
- calculate and analyse Fourier transforms,
- analyse the inversion theorem and compare Fourier transform to its original function,
- analyse Plancherel theorem and its consequences,
- compare Fourier transform with other integral transforms: for example Laplace, Mellin, discrete Fourier transform,
- calculate and analyse those other integral transforms.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- understand and determine the properties of Hilbert spaces, analyse linear independence, orthogonality, orthonormality, completeness of the sets in them (A7, B7, C7),
- calculate and understand Fourier series and analyse their connection with the original functions (A7, B7, C7, F7),
- apply and understand the above mentioned theorems about the Banach spaces and analyse their consequences related to Fourier series (A7, B7, C7, F7),
- calculate and understand the Fourier transform (A7, B7, C7),
- analyse the inversion theorem and compare Fourier transform with the original function (A7, B7, C7, F7),
- analyse and apply Plancherel theorem (A7, B7, C7, F7),
- calculate and apply other integral transforms (A7, B7, C7).

1.4. Course content

Hilbert space. Orthonormal sets. Fourier series. Banach-Steinhaus theorem. The open mapping theorem. Fourier transform. The inversion theorem. Plancherel teorem and Parseval's formula. Examples of other integral transforms and applications.

1.5. Modes of instruction	☒lectures ☒seminars and workshops ☒exercises ☒e-learning ☐field work ☐practice ☐practicum	☒ independent work ☒multimedia and the internet ☐ laboratory ☒tutorials ☒consultations ☐other _____
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[18]

Class attendance	1.2	Class participation		Seminar paper	1	Experiment	
Written exam	1.5	Oral exam		Essay		Research work	
Project		Continuous assessment	2.3	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. W. Rudin, Real and Complex Analysis, McGraw-Hill, New York, 1987.
2. Anton Deitmar: A First Course in Harmonic Analysis, 2nd edition, Springer, 2005.
3. George Bachmann, Lawrence Narici, Edward Beckenstein: Fourier and Wavelet Analysis, Springer, New York, 2000.

1.11. Recommended literature (when proposing the program)

1. Allan Pinkus, Samy Zafrany, Fourier Series and Integral Transforms, Cambridge University Press, 1997.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[18] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Introduction to databases	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	5
	Hours (L+E+S)	30 + 30 + 0

1. COURSE DESCRIPTION

1.1. Course objectives

- Introduce students to basic concepts of database theory with emphasize on relational databases,
- Make students competent for independent work with relational databases (SQL)

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing the course and meeting requirements in respect to course Introduction to Databases, students are expected to be capable of:

- Defining and updating relational database (SQL),
- Conducting relational algebra operation in relational database model,
- Access database using various program tools.

1.4. Course content

Introduction to databases. Database concepts. Relational data model. Relational algebra. Operations in relational model. Non-procedural languages for processing relational database – SQL. Integrity rules in relational data model. Concept of nul value and incomplete information. Elements of dependency theory. Normalization; Normal forms.
Temporal databases. Introduction to object-relational database. Basic of physical organization, B-tree, R-trees.

1.5. Modes of instruction	☒lectures ☐seminars and workshops ☒exercises ☐e-learning ☐field work ☐practice ☐practicum	☒ independent work ☐multimedia and the internet ☐ laboratory ☐tutorials ☒consultations ☐other _____
1.6. Comments	During exercises, students are introduced to relational database - Oracle SQL. Students are prepared to independently produce an application along with drawing up and producing a relational database.	

1.7. Student requirements

Students must satisfy the requirements for obtaining the signature (listed in the executive program) and to pass the final exam (written and oral).

1.8. Evaluation of assessment[19]

Class attendance	1.75	Class participation		Seminar paper		Experiment	
Written exam	0.5	Oral exam	0.5	Essay		Research work	
Project		Continuous assessment	1.25	Presentation		Practical work	1
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester and in the final exam. Total number of points student can achieve during the semester is 70 (to assess the activities listed in the table), while in the final exam student can achieve 30 points.
The detailed work out of monitoring and evaluation of students' work will appear in the executive program.

1.10. Required literature (when proposing the program)

1. R. Elmasri, S.B. Navathe: Fundamentals of Database Systems, Pearson - Addison Wesley, Boston, 2004.
2. R. A. Mata-Toledo, P. K. Cushman: Fundamentals of Relational Databases, Schaums Outline Series, McGraw-Hill, 2000.

1.11. Recommended literature (when proposing the program)

1. S. Tkalac: Relacijski model podataka, DRIP, Zagreb, 1992.
2. P. Atzeni, V. De Antonellis: Relational Database Theory; The Benjamin/Cummings Publ. Co., 1993.
3. A.U. Tansel et.al.: Temporal Databases, The Benjamin/Cummings Publ. Co., 1993.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of the semester students will evaluate the quality of the lectures. At the end of each semester (March 1 and September 30 of the current academic year) results of the exams will be analysed.

[19] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Computer networks 1	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	5
	Hours (L+E+S)	30 + 30 + 0

1. COURSE DESCRIPTION

1.1. Course objectives

- presenting to students the fundamental knowledge about the structure and architecture of computer networks and communication systems,
- teaching students to understand the basic principles of computer networks' implementation,
- training students for using Internet services.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

Upon completion of course, students will be able to do the following:

- describe and classify the structure and architecture of computer networks and communication systems,
- identify the basic principles of computer networks' implementation,
- develop skills for using basic network protocols and Internet services.

1.4. Course content

Organization of computer networks. OSI reference model.
The physical layer: theoretical basis, transmission media. Implementation of the physical layer, cabling.
The data link layer. Error detection and correction. Example data link protocols, HDLC, the data link layer in Internet. The medium access control sublayer (MAC), the channel allocation problem. IEEE 802 LAN standards.
The network layer. Routing and congestion controls algorithms. Internetworking. The network layer in Internet.
The transport layer services and elements of transport protocols. The transport layer in Internet.
The application layer. Internet applications and their protocols: DNS, e-mail, World Wide Web. Data compression. Examples of computer networks. Network security.

1.5. Modes of instruction	☒lectures ☐seminars and workshops ☒exercises ☐e-learning ☐field work ☐practice ☐practicum	☐ independent work ☐multimedia and the internet ☐ laboratory ☐tutorials ☒consultations ☐other _____
1.6. Comments	During exercises the students should acquire editing multimedia elements and development of simple multimedia forms by using appropriate software tools for producing images, sound, animation, and video.	

1.7. Student requirements

Students should actively participate in all forms of works, perform practical exercises and produce seminar papers. They should pass the exam consisting of practical and oral part.
The practical part of the exam regards the exercises by using computer. This practical exam and seminar papers are the prerequisite for the oral part of the exam where the complete knowledge of the student is examined and evaluated.

1.8. Evaluation of assessment[20]

Class attendance	1.5	Class participation		Seminar paper		Experiment	
Written exam	1	Oral exam	1	Essay		Research work	
Project		Continuous assessment	1.5	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester and in the final exam. Total number of points student can achieve during the semester is 70 (to assess the activities listed in the table), while in the final exam student can achieve 30 points.
The detailed work out of monitoring and evaluation of students' work will appear in the executive program.

1.10. Required literature (when proposing the program)

1. Radovan, M.: Računalne mreže, 2004. (digitalna skripta,)
2. Peterson, L. L., Davie, B. S.: Computer Networks: A System Approach, 3rd Edition

1.11. Recommended literature (when proposing the program)

1. Tanenbaum, A.S.: Computer Networks, 4th Edition. Prentice Hall, 2003.
2. Kurose, F. J., Ross, W. K.: Computer Networking: A Top-Down Approach Featuring the Internet, Pearson Addison Wesley, 2003.
3. Glass, K. M.: Beginning PHP, Apache, MySQL Web Development, Hungry Minds Inc, 2004.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of the semester students will evaluate the quality of the lectures. At the end of each semester (March 1 and September 30 of the current academic year) results of the exams will be analysed.

[20] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Mathematics education 1	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 0 + 30

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students acquainted with practical and theoretical aspects of the methods for teaching mathematics in higher grades of elementary schools and in secondary schools. For this purpose it is necessary within the course to:

- define and analyse basic and special theories of teaching mathematics in higher grades of elementary schools and in secondary schools,
- prepare students for organizing a math teaching class in accordance with teaching principles,
- introduce the national curriculum for mathematics in higher grades of elementary schools and in secondary schools,
- acquaint students with the mathematical knowledge that is necessary for effective teaching of mathematics in higher grades of elementary schools and in secondary schools.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- quote the principles of mathematics education and their basic properties, and use them with understanding (A7, B6, C6, D6, E6, F6),
- differentiate several forms of defining mathematical terms and highlight their advantages and deficiencies in school mathematics (A7, B6, C6, D6, E6, F6),
- interpret and compare different ways of proving mathematical theorems (A7, B6, C6, D6, E6, F6),
- analyse the national curriculum of mathematics in higher grades of elementary schools and in secondary schools (A6, B6, C5, D6, E5, F5),
- in accordance with the principles of teaching mathematics, clearly and precisely present mathematical content using teaching aids and facilities (A6, B6, C6, D6, E7, F7),
- use relevant and recent professional literature independently and critically (A6, B6, C6, D5, E7, F7),
- cooperate with colleagues to acquire and develop professional competences, and use the feedback in the aim of improving the teaching process (A6, B6, C5, D6, E7, F7),
- use the basic communication principles and techniques of effective professional communication, and express themselves accurately and fluently in spoken and written forms of communication in the language of teaching and in the official language (A6, B6, C6, D6, E6, F6).

1.4. Course content

The subject of teaching mathematics. The objectives and tasks of teaching mathematics. Principles of teaching mathematics – scientific approach (an axiom, a mathematical definition, the definition of a term, a theorem, a proof), activity, independence and awareness (a formalism in mathematics class), motivation (games in teaching

mathematics, mathematical billboard), individualization, visualization, suitability (factors that affect on the process of learning mathematics, degrees of knowing the mathematics, mathematical personality), systematicity, stability (remembering mathematical facts and procedures). In seminars, students will become familiar with the mathematical curriculum in the higher grades of elementary school and present selected topics in mathematics that are processed in the higher grades of elementary schools or in secondary school.

1.5. Modes of instruction	☒lectures ☒seminars and workshops ☐exercises ☒e-learning ☐field work	☒independent work ☒multimedia and the internet ☐laboratory ☐tutorials ☐other
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[21]

Class attendance	2	Class participation		Seminar paper	0.8	Experiment	
Written exam	0.4	Oral exam	1.2	Essay		Research work	
Project		Continuous assessment	1.6	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. Current textbooks for elementary and secondary schools
2. Matematika bez suza, ed. Ilona Posokhova, Ostvarenje, Lekenik, 2000.
3. Kurnik: Oblici matematičkog mišljenja, Element, Zagreb, 2013.
4. Kurnik: Posebne metode rješavanja matematičkih problema, Element, Zagreb, 2010.
5. Kurnik: Znanstveni okvir nastave matematike, Element, Zagreb, 2009.
6. Literature available in the e-library of the course

1.11. Recommended literature (when proposing the program)

1. Polya,G.: Kako ću riješiti matematički zadatak, Školska knjiga, Zagreb, 1984.
2. XXX: Matematika i škola, časopis za nastavu matematike, Element, Zagreb
3. Available methodical and science popularization journals (printed or online form)

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students
Aktualni udžbenici iz matematike o osnovnim i srednjim školama i odgovarajući priručnici za učitelje	20	15
Kurnik: Oblici matematičkog mišljenja, Element, Zagreb,	1	15

[21] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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2013		
Kurnik: Posebne metode rješavanja matematičkih problema, Element, Zagreb, 2010	2	15
Kurnik: Znanstveni okvir nastave matematike, Element, Zagreb, 2009	2	15
1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies		
In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.		

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General information		
Lecturer		
Course title	Finite geometries	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 0 + 15

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students acquainted with the finite geometry theory. For this purpose it is necessary within the course to:

- define affine and projective spaces over finite fields, a finite projective and a finite affine geometry, analyse properties of the mentioned spaces (geometries),
- analyse relationship between affine and projective spaces,
- introduce the coordinatization of a projective space,
- define and analyse a transformation of a projective space, especially dualities and polarities,
- define a dual and a polar space and analyse their properties,
- describe quadratics in projective spaces,
- analyse properties of finite projective planes,
- describe, analyse and differentiate Desargues and non-Desargues projective planes,
- describe, analyse and differentiate polarities and quadratics in finite projective planes.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- define basic concepts of finite geometry theories, apply and understand basic procedures in problem solving (A7, B7, C5, D5, E5, F5, G5),
- differentiate and analyse transformations of a projective space, apply and understand appropriate procedures in problem solving (A7, B7, C5, D5, E5, F5, G5),
- analyse and differentiate various finite projective planes, apply and understand appropriate procedures in problem solving (A7, B7, C7, D7, E5, F7, G7),
- analyse and differentiate polarities and quadratics in finite projective planes, apply and understand appropriate procedures in problem solving (A7,B7,C7,D7,E5,F7,G7)
- mathematically prove validity of all procedures and formulas that are used within the course (B7, F4).

1.4. Course content

1.5. Modes of instruction	☒lectures ☒seminars and workshops ☐exercises ☒e-learning ☐field work	☒independent work ☒multimedia and the internet ☐laboratory ☒tutorials ☐other _____

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1.6. Comments							
1.7. Student requirements							
Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).							
1.8. Evaluation of assessment[22]							
Class attendance	1.5	Class participation		Seminar paper	1.5	Experiment	
Written exam	0.5	Oral exam	1	Essay		Research work	
Project		Continuous assessment	1.5	Presentation		Practical work	
Portfolio							
1.9. Assessment and evaluation of students' work during the semester and on the final exam							
Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam. Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.							
1.10. Required literature (when proposing the program)							
1. P. J. Cameron, Projective and Polar Spaces (available online: http://www.maths.qmul.ac.uk/~pjc/pps/) 2. C. D. Godsil, Finite geometry (available online: http://quoll.uwaterloo.ca/mine/Notes/fgeom.pdf)							
1.11. Recommended literature (when proposing the program)							
1. H.S.M.Coxeter: Projektivna geometrija, Školska knjiga, Zagreb, 1982. 2. V. Krčadinac, Unitali (available online: http://web.math.hr/~krcko/radovi/unitali10.pdf) 3. D.Palman: Projektivna geometrija, Školska knjiga, Zagreb, 1984.							
1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course							
Title			Number of copies			Number of students	
Literature is available to students on-line (in the e-course).							
1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies							
In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.							

[22] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Vector spaces 2	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 30 + 0

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students familiar with the basics of the theory of normed and topological vector spaces. For this purpose it is necessary within the course to:

- define topological vector spaces,
- define normed space and describe typical examples of normed spaces,
- define and analyse local convexity, metrizability and completeness of spaces,
- analyse linear functionals.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- formulate examples of topological vector spaces (A6, B6, C6, D4, E4, F3),
- analyse the connection between linear and topological structure (A6, B6, C6, D4, E5, F3),
- formulate examples of normed spaces (A6, B6, C6, D4, E4, F3),
- analyse local convexity, metrizability and completeness of spaces (A6, B6, C6, D4, E4, F3),
- mathematically prove validity of all procedures and formulas that are used within the course (A6, B6, D4, E5, F3).

1.4. Course content

Topological vector spaces. Normed vector spaces. Local convexity. Metrizability. Completeness. Linear functionals and the Hahn-Banach theorem. Weak topologies. Dual spaces.

1.5. Modes of instruction	☒lectures ☐seminars and workshops ☒exercises ☐e-learning ☐field work ☐practice ☐practicum	☒ independent work ☐multimedia and the internet ☐ laboratory ☐tutorials ☐consultations ☐other _____
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

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1.8. Evaluation of assessment[23]

Class attendance	1.5	Class participation		Seminar paper		Experiment	
Written exam	2	Oral exam	2	Essay		Research work	
Project		Continuous assessment	0.5	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. S.Kurepa, Funkcionalna analiza, Školska knjiga, Zagreb, 1984.
2. W.Rudin, Functional analysis, McGraw-Hill, 1972.

1.11. Recommended literature (when proposing the program)

1. K.Yoshida, Functional analysis, Springer -Verlag, New York, 1985.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[23] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Seminar / M.Sc. thesis	
Program	Discrete mathematics and its applications	
Course status	Compulsory	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	4
	Hours (L+E+S)	0 + 0 + 30

1. COURSE DESCRIPTION

1.1. Course objectives

This seminar is the first step towards graduate thesis. The objective of the seminar is to enable students for:

- independent research and work with mathematical literature,
- presentation of mathematical contents.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- present mathematical concepts using teaching aids and facilities (B7, C6, D6, E6, F6),
- express correctly and fluently in speaking communication in the language of teaching and official language (D6),
- use different communication types and forms (D5),
- use relevant and recent professional literature independently and critically (B7, C6, D6, E6, F6).

1.4. Course content

All lecturers of the compulsory mathematics courses will participate in determining the content of this seminar by proposing the themes for the seminars (according to Regulations on graduate work and the final exam for the university graduate studies at the Department of mathematics, University of Rijeka). Each student will publicly present the theme and submit the work in the written form to the mentor. The work will present the basis for the graduate thesis which will be elaborated in conjunction with the mentor.

1.5. Modes of instruction	☐lectures ☒seminars and workshops ☐exercises ☒e-learning ☐field work	☒independent work ☒multimedia and the internet ☐laboratory ☒tutorials ☐other _____
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to prepare and publicly present their seminar. Students are required to attend presentations of other students and actively participate in their analysis.

1.8. Evaluation of assessment[24]							
Class attendance	1	Class participation		Seminar paper	3	Experiment	
Written exam		Oral exam		Essay		Research work	
Project		Continuous assessment		Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester.
Total number of points student can earn during the semester is 100. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

Literature for each seminar will be proposed by the mentor - proponent of the topic.

1.11. Recommended literature (when proposing the program)

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[24] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Combinatorial optimization	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to address both optimal and heuristic approaches in combinatorial optimization. It should develop an ability to formulate a wide range of management problems that can be solved to optimality by classical combinatorial optimization techniques and the knowledge of alternative solution approaches such as metaheuristics that can find nearly optimal solutions. It also raise an awareness how difficult some practical optimization problems can be.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

On completion of this course students will:

- be able to list different mehods of combinatorial optimization (A2, B3);
- be able to differ optimal and heuristic methods of combinatorial optimization (i.e. optimal and near-optimal solutions) (A5, B5, C4);
- be able to formulate problems in combinatorial optimization and appreciate their assumptions and limitations (A6, B6, C6);
- be able to choose appropriate method for solving combinatorial optimization problem using modern optimization methods and software (A7,C7,D6,E7).

1.4. Course content

Optimal and heuristic methods – cutting plane, branch-and-bound, branch-and-cut, Lagrangian relaxation, local search, simulated annealing, tabu search, genetic algorithms, and neural networks. Application on combinatorial optimization problems such as production planning and scheduling, operational management of distribution systems, timetabling, location and layout of facilities, routing and scheduling of vehicles and crews, etc.

1.5. Modes of instruction	×lectures ☐seminars and workshops ×exercises ×e-learning ☐field work	×independent work ×multimedia and the internet ☐laboratory ×tutorials ☐other _____
1.6. Comments		
1.7. Student requirements		

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[25]

Class attendance	1.5	Class participation		Seminar paper		Experiment	
Written exam		Oral exam	2.1	Essay		Research work	
Project		Continuous assessment	2.4	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam. The detailed elaboration of evaluating and assessing students' work will be disclosed in the implementation plan for the course.

1.10. Required literature (when proposing the program)

Combinatorial Optimization, Theoty and Algorithms, B. Korte and J. Vygen, Springer, 2012.
Genetic Algorithms + Data Structures = Evolution Programs, Z. Michalewicz, Springer, 1996

1.11. Recommended literature (when proposing the program)

Optimization Methods in Finance, G. Cornuejols and R. Tütüncü, Cambridge University Press. ISBN-10: 0521861705

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

Anonymous survey in which students will evaluate the quality of classes will be carried out during last week of classes. The analysis of students' success at final exams will be carried out at the end of semester.

[25] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Machine learning	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of this course is to get students acquainted with some some basic issues and algorithms in machine learning. For this aim it is needed to:

- introduce fundamental concepts and methods for machine learning,
- develop some basic learning algorithms and techniques and their applications,
- illustrate the application of these algorithms,
- introduce programming language associated with machine learning.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing the course, students will be able to:

- describe machine learning techniques and computing environment that are suitable for the applications, (A5, B5,C5,E3,F4),
- analyse different types of learning algorithms, (A5, B5,C5,E4,F4,G4),
- develop machine learning techniques and associated computing techniques and technologies for various applications, (A5, B5, C5,D3,E4,F7,G6),
- identify current real world problems that can benefit from emerging machine learning techniques, (A5,B5,C5,D5,E4,F7,G6),
- design machine learning and associated algorithms that can address real problem. (A7,B7,C5,D5,E4,F7,G6).

1.4. Course content

Perspectives and issues in machine learning. Concept Learning. Decision Tree Learning. Artificial Neural Networks. Bayesian Learning. Computational Learning Theory. Learning Sets of Rules. Analytical Learning. Reinforcement Learning.

1.5. Modes of instruction	☒lectures ☐seminars and workshops ☒exercises ☒e-learning ☐field work	☒independent work ☒multimedia and the internet ☐laboratory ☒tutorials ☐other

1.6. Comments
1.7. Student requirements
Students are required to attend classes, actively participate in all forms of classes, earn a determined amount of points throughout semester and pass the final exam (details will be disclosed in the implementation plan of the course).
1.8. Evaluation of assessment[26]

Class attendance	1.5	Class participation		Seminar paper		Experiment	
Written exam		Oral exam	2.1	Essay		Research work	
Project		Continuous assessment	2.4	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam
Students' work will be evaluated and assessed during classes (e.g. exams, tests, seminars, online tests, homework, etc.) and at the final exam. The detailed elaboration of evaluating and assessing students' work will be disclosed in the implementation plan for the course.
1.10. Required literature (when proposing the program)
1. E. Alpaydin, Introduction to Machine Learning, The MIT Press, 2009. 2. T. M. Mitchell, Machine Learning, McGraw-Hill Science, 1997.
1.11. Recommended literature (when proposing the program)
1. C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2007.
1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies
Anonymous survey in which students will evaluate the quality of classes will be carried out during last week of classes. The analysis of students' success at final exams will be carried out at the end of semester.

[26] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Optimization techniques for data mining	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	5
	Hours (L+E+S)	30+15+15

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of this course is to get students acquainted with some some basic issues and algorithms used in data mining i.e. in the process of discovering patterns in big data using mathematical techniques. For this aim it is needed to:

- introduce fundamental concepts and methods for data mining,
- develop some basic algorithms and techniques and their applications in data mining,
- illustrate the application of these algorithms in data mining,
- introduce programming language associated with data mining.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing the course, students will be able to:

- describe data mining techniques, (A5,B5,C5,E4,F4),
- analyse different types of algorithms in data mining, (A5,B5,C5,E4,F4),
- use some techniques of data mining in practice, (A5, B5,C6,D5,E4,F4,G7),
- design algorithms in data mining that can address real problem. (A7,B5,C7,D4,E4,F7,G7).

1.4. Course content

Data mining. Regression. Classification. Supervised learning. Support-Vector Machines. Learning from Nearest Neighbors. Comparison of Learning Methods. Unsupervised learning. Clusters.

1.5. Modes of instruction	☒lectures ☒seminars and workshops ☒exercises ☒e-learning ☐field work	☒independent work ☒multimedia and the internet ☐laboratory ☒tutorials ☐other

1.6. Comments

1.7. Student requirements

Students are required to attend classes, actively participate in all forms of classes, earn a determined amount of points throughout semester and pass the final exam (details will be disclosed in the implementation plan of the

course).

1.8. Evaluation of assessment[27]

Class attendance	1.5	Class participation		Seminar paper	0.7	Experiment	
Written exam		Oral exam	1.8	Essay		Research work	
Project		Continuous assessment	1	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during classes (e.g. exams, tests, seminars, online tests, homework, etc.) and at the final exam. The detailed elaboration of evaluating and assessing students' work will be disclosed in the implementation plan for the course.

1.10. Required literature (when proposing the program)

1. J. Leskovec, A. Rajaraman, J. D. Ullman, Mining of Massive Datasets, Cambridge University Press, 2014.

1.11. Recommended literature (when proposing the program)

1. B. Schölkopf, A. J. Smola, Learning with Kernels. Support Vector Machines, Regularization, Optimization, and Beyond, MIT Press, Massachusetts, 2002.
2. T. Hastie, R.Tibshirani, J. Friedman, Data Mining, Inference, and Prediction, Springer-Verlag New York, 2009.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

Anonymous survey in which students will evaluate the quality of classes will be carried out during last week of classes. The analysis of students' success at final exams will be carried out at the end of semester.

[27] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Optimization methods in finance	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	5
	Hours (L+E+S)	30+15+15

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to demonstrate how recent advances in optimization modeling, algorithms and software can be applied to solve practical problems in computational finance. The focus is on selected topics in finance (such as arbitrage detection, risk-neutral probability measure, portfolio theory and asset management), where the models can be formulated as deterministic or stochastic optimization problems. These problems have various forms (e.g., linear, quadratic, conic, convex, stochastic optimization) and hence various tools, techniques and methods from optimization need to be employed to solve them numerically.

1.2. Course prerequisite

Linear Programming. Nonlinear Optimization.

1.3. Expected outcomes for the course

On completion of this course students will:

- be able to define basic terms related to financial mathematics (A2, B2),
- be able to list different optimization mehods in finance (A2, B3),
- be able to formulate problems in financial mathematics and appreciate their assumptions and limitations (A5, B7, C6),
- be able to solve practical problems arising in finance using modern optimization methods and software (C7, D6, E7).

1.4. Course content

Basics of financial mathematics: portfolio selection and asset allocation, pricing and hedging of options, risk management, asset/liability management. Applications of linear and nonlinear programming in finance: asset pricing and arbitrage, risk-neutral probability measure, volatility estimation. Quadratic Optimization and its applications in finance: mean-variance portfolio selection (Markowitz model). Conic Optimization and its applications in finance: capital allocation line and Sharpe ratio. Stochastic Optimization and its apllications in finance: Asset/liability management, stochastic gradient descent, scenario generation

1.5. Modes of instruction	×lectures ×seminars and workshops ×exercises ×e-learning ☐field work	×independent work ×multimedia and the internet ☐laboratory ×tutorials ☐other
1.6. Comments		

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1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[28]

Class attendance	1.5	Class participation		Seminar paper	1	Experiment	
Written exam		Oral exam	1.2	Essay		Research work	
Project		Continuous assessment	1.1	Presentation	0.2	Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam. The detailed elaboration of evaluating and assessing students' work will be disclosed in the implementation plan for the course.

1.10. Required literature (when proposing the program)

Optimization Methods in Finance, G. Cornuejols and R. Tütüncü, Cambridge University Press. ISBN-10: 0521861705

1.11. Recommended literature (when proposing the program)

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

Anonymous survey in which students will evaluate the quality of classes will be carried out during last week of classes. The analysis of students' success at final exams will be carried out at the end of semester.

[28] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	History of mathematics	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	3
	Hours (L+E+S)	15 + 0 + 30

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students acquainted with:

- an introduction to the development of mathematical theories and fundamental branches of mathematics, as well as with work and historical significance of some mathematicians,
- analysis of the ways in which certain branches of mathematics developed.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- indicate problems from the everyday life that can be solved using mathematics and point out a relation with other subjects (A7,B5,E5, F5),
- present used mathematical knowledge in the historical and mathematical context (A7, B5, C7, D5, E7, F7, G7),
- relate and explain causes and effects of the development of mathematical ideas and methods, the role of mathematics in science, art and society (A6,B7),
- use different types and forms of communication including information and communication technology (A3,B3, C3, E7, F7),
- mathematically prove validity of all procedures and formulas that are used within the course (A7,B5,E5, F5).

1.4. Course content

History of mathematics in the period before ancient Greece. The ancient greek mathematics. Chinese, Arabic, Indian mathematics, mathematics of the New age. Development of probability and statistics, algebra, set theory, mathematical logic. New directions in mathematics.

1.5. Modes of instruction	☒lectures ☒seminars and workshops ☐exercises ☐e-learning ☐field work	☒independent work ☒multimedia and the internet ☐laboratory ☐tutorials ☐other _____
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course

curriculum).

1.8. Evaluation of assessment[29]

Class attendance	1.2	Class participation		Seminar paper	0.9	Experiment	
Written exam		Oral exam	0.9	Essay		Research work	
Project		Continuous assessment		Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. Dadić, Žarko: Razvoj matematike. Ideje i metode egzatnih znanosti u njihovu povijesnom razvoju, Školska knjiga, Zagreb,1975.
2. Dadić, Žarko: Povijest ideja i metoda u matematici i fizici, Školska knjiga, zagreb,1992.
3. L. Hogben, Sve o matematici, Mladost, Zagreb, 1970.
4. 4.Z. Šikić, Kako je stvarana novovjekovna matematika, Školska knjiga, Zagreb, 1989.

1.11. Recommended literature (when proposing the program)

1. Z. Šikić, Filozofija matematike, Školska knjiga, Zagreb, 1995.
2. P.J.Davis, R.Hersh, E.A.Marchisotto, Doživljaj matematike, Tehnička knjiga, Zagreb, 2004.
3. V. Devide, Matematika kroz kulture i epohe, Školska knjiga, Zagreb, 1979.
4. J. Stillwell, Mathematics and its history, Springer Verlag, 2001.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[29] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Science popularization	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	2
	Hours (L+E+S)	15 + 15 + 0

1. COURSE DESCRIPTION

1.1. Course objectives

Science popularization is an integral part of teacher's and scientist's profession in any subject.
The main course objective is to:

- develop the consciousness of the social context for the science and the need for its popularization,
- train for active professional popularization,
- develop the abilities for planning and conducting activities for popularization of science, scientific topics and scientific research results.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing the course, the students are expected to:

- describe and analyse the need and importance of the science popularization,
- differentiate and analyse the channels for the science popularization,
- describe types of popularization activities and their extent, scope, advantages and disadvantages,
- describe the influence of public media on the promotion of scientific activities,
- describe and analyse the interaction between social structures and the promotion of science
- (local community, educational system, the strategy of the University)
- create a plan for the popularization contributions and activities,
- implement the plan within the field work and within the Rijeka Science Festival.

1.4. Course content

Social context of science. Concept and short history of science popularization and communication and their role in knowledge based society. Channels for science popularization. Methods for direct science promotion (public lectures, presentations, workshops, science cafés, interactive exhibitions). Methods for promotion science in media (public relations, press announcements, articles, radio and TV, multimedia materials suitable for Internet publication). Specialty of popularization of natural sciences. Popularization of mathematics and physics. Social context of mathematics and physics. Popularization of mathematics and physics among kids. Popular literature. Mathematics in the everyday life. Margins of science. Unexplained phenomena.

1.5. Modes of instruction	☒lectures ☒seminars and workshops ☐exercises ☒e-learning ☒field work	☒independent work ☒multimedia and the internet ☐laboratory ☐tutorials ☒other Consultations, project strategies
1.6. Comments		

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1.7. Student requirements

Students are required to participate in a field work and to participate in the popularization of science.

1.8. Evaluation of assessment[30]

Class attendance	0.75	Class participation		Seminar paper		Experiment	
Written exam		Oral exam		Essay		Research work	
Project	0.5	Continuous assessment		Presentation		Practical work	0.75
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester. There is no final exam within the course. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. B.Jergović (ur.): Znanost i javnost, Izvori, Zagreb, 2002.
2. Znanstveno popularne radio emisije «Baltazar», CD, Zlatni rez i Radio Rijeka, 2010, urednica R.Jurdana-Šepić
3. Aktivnosti Udruge Zlatni rez www.zlatnirez.hr

1.11. Recommended literature (when proposing the program)

1. A.Simonić, Znanost najveća avantura i izazov ljudskog roda, Vitagraf, Rijeka, 1999.
2. M. Alley : The Craft of Scientific Presentations: Critical Steps to Succeed and Critical Errors to Avoid. Springer-Verlag, 2002
3. T. Caulton: Hands-On Exhibitions: Managing Interactive Museums and Science Centres (The Heritage, Care-Preservation-Management). Routledge, 1998
4. S.M. Cutlip, A.H. Center, G.M. Broom: Odnosi s javnošću (prijevod 'Effective public relations'). Mate, Zagreb, 2003
5. A.Einstein: Moja teorija, Kronos, Zagreb, 1991.
6. A.Einstein: Moj pogled na svijet, Izvori, Zagreb, 1991.
7. Krauss M.L., Fizika zvjezdanih staza, Jesenski i Turk, Zagreb 2004.
8. R. Feynman: Osobitosti fizikalnih zakona, ŠK, Zagreb, 1986.
9. C.Sagan: Kosmos, Izvori, Zagreb 2004.
10. L.Lederman, D.Teresi: Božja čestica, Izvori, Zagreb, 2000.
11. J.Gribbin: U traganju za Schrodingerovom mačkom, Prosveta, Beograd, 1989.
12. J. Walker: The Flying Circus of Physics, J.Willey and Sons, New York, 1977.
13. W.R. Wood: FUNtastic Science activities for Kids, McGrow Hill, New York, 1997
14. W.R. Wood: Physics for Kids, Mc Geaw-Hill, New York, 1997.
15. A.Wilson, J. Gregory, S. Miller; S. Earl: Handbook of science communication, Institute of Physics Publishing, 1998

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students
B.Jergović (ur.): Znanost i javnost, Izvori, Zagreb, 2002.	2	10
Znanstveno-popularne radio emisije «Baltazar», CD	2	10

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

[30] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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Student's Portfolio: Monitoring students' work while giving them a feedback on their success and improvement. *Questionnaire*: Introductory questionnaire on student's expectations. At the end of the course, anonymous questionnaire of the course quality will be conducted. After the passing the oral exam, the professor requires the feedback for achieved learning objectives: learning methods, potential difficulties while learning the course content, and suggestions for the course.

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General information		
Lecturer		
Course title	Mathematics education 2	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 0 + 30

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students acquainted with practical and theoretical aspects of the methods for teaching mathematics in higher grades of elementary schools and in secondary schools. For this purpose it is necessary within the course to:

- introduce the national curriculum for mathematics in higher grades of elementary schools and in secondary schools,
- prepare students for choosing the appropriate methods in the process of teaching mathematics,
- acquaint students with the mathematical knowledge that is necessary for effective teaching of mathematics in higher grades of elementary schools and in secondary schools,
- prepare students for organizing a math teaching class in higher grades of elementary schools and in secondary schools.

1.2. Course prerequisite

Mathematics education 1.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- analyse the mathematical curriculum in higher grades of elementary schools and in secondary schools (A6, B6, C5, D6, E5, F5),
- differ and valorise different methods of teaching mathematics, especially methods according to the mathematical topics (A7, B6, C6, D6, E7, F7),
- organize a mathematics teaching class in higher grades of elementary schools and in secondary schools in accordance with contemporary teaching methods and principles while using suitable teaching strategies (A7, B6, C6, D6, E7, F7),
- plan and organize a mathematics teaching class in accordance with contemporary teaching methods and principles while using suitable teaching strategies, with the aim of developing mathematical processes and better understanding of mathematical concepts (A7, B6, C6, D6, E7, F7),
- present mathematical content using the teaching aids and facilities (e.g. informational communicational technology) with the proper use of mathematical terminology and language (A6, B6, C6, D6, E7, F7),
- independently create teaching materials in mathematics with or without using the advanced tools of ICT (A6, B6, C6, D6, E7, F7),
- independently adjust current teaching materials in mathematics for becoming motivational for learning and suitable for accomplishing the planned learning outcomes (A6, B5, C5, D6, E5, F5),
- use relevant and recent professional literature independently and critically (A6, B6, C6, D5, E7, F7),
- cooperate with colleagues to acquire and develop professional competences, and use the feedback in the aim of improving the teaching process (A6, B6, C5, D6, E7, F7),
- use the basic communication principles and techniques of effective professional communication, and express themselves accurately and fluently in spoken and written forms of communication in the

language of teaching and in the official language (A6, B6, C6, D6, E6, F6).

1.4. Course content

Methods of teaching mathematics (methods according to the source of knowledge and methods according to the mathematical topics). Empirical methods, induction, deduction, analysis and synthesis, generalization, abstraction, concretization, problem-solving methods (heuristics, solving problems), analogy and comparison, special mathematical cases. Methods for specific mathematical topics. In seminars, students will become familiar with the mathematical curriculum in the higher grades of elementary school and in secondary schools. Students will present selected topics in mathematics that are processed in higher grades of elementary school or in secondary schools.

1.5. Modes of instruction	☒lectures ☒seminars and workshops ☐exercises ☒e-learning ☐field work	☒independent work ☒multimedia and the internet ☐laboratory ☐tutorials ☐other _____
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[31]

Class attendance	2	Class participation		Seminar paper	1.5	Experiment	
Written exam	0.5	Oral exam	1	Essay		Research work	
Project		Continuous assessment	1	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. Current textbooks for elementary and secondary schools and teachers' manuals
2. Matematika bez suza, ed. Ilona Posokhova, Ostvarenje, Lekenik, 2000.
3. Kurnik: Oblici matematičkog mišljenja, Element, Zagreb, 2013.
4. Kurnik: Posebne metode rješavanja matematičkih problema, Element, Zagreb, 2010.
5. Kurnik: Znanstveni okvir nastave matematike, Element, Zagreb, 2009.
6. Literature available in the e-library of the course

1.11. Recommended literature (when proposing the program)

1. Polya,G.: Kako ću riješiti matematički zadatak, Školska knjiga, Zagreb, 1984.
2. XXX: Matematika i škola, časopis za nastavu matematike, Element, Zagreb
3. Available methodical and science popularization journals (printed or online form)

[31] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

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General information		
Lecturer		
Course title	Computer networks 2	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	5
	Hours (L+E+S)	30 + 30 + 0

1. COURSE DESCRIPTION

1.1. Course objectives

This course is a continuation of the course "Computer networks 1". The aims of the course are:
(1) to present the methods of recording of the contents of various kinds, the methods of data compression and the transmission protocols; (2) to present the basic elements of the protection of secrecy and integrity of contents, and of the authenticity of communicators in computer networks; (3) to present the main network services of the application level. In the framework of the exercises, students have to learn to use the main network services and the language HTML.

1.2. Course prerequisite

In this course it is continued with the presentation of the basic knowledge of the computer networks and communication systems. The content of this course draws on those courses that deal with information systems, computer architecture and computer programming, and it directly extends the content of the course "Computer networks 1".

1.3. Expected outcomes for the course

Students are expected to acquire the basic knowledge about the methods of recording of the information contents of various kinds, about the methods of data compression and about the transmission protocols. They have to get familiar with the basic methods of the protection of secrecy and integrity of contents, and of the authenticity of communicators in computer networks, as well as with the network services of the application level, as specified in the "Course content" below. In the framework of the exercises, students have to learn to use the main network services and the language HTML.

1.4. Course content

Digital recording of the information contents: principles and methods. Basic formats and protocols: GIF, JPEG, MPEG, MP3. Compressing the digital records, with and without the loss of the information contents: principles and the ways of use. Compression and transmission: on-line transmission (video-conferencing). ITU-T network standards (H-series).
Security and protection. Protecting the secrecy of contents, protecting the integrity of messages, establishing the identity of communicators: principles, protocols (algorithms) and methods of work. Protocols DES, RSA, MR5. Systems PEM, PGP, TLS. "Reliable third side"; firewall, proxy, filters.
The application layer. The Internet applications (services) and their protocols. Domain name system (DNS), electronic mail system (SMTP), web page system (HTTP), multimedia and interactive applications (VIP, VIC). Controlling the functioning of a compound computer network. Administration and optimization; a system for managing of the functioning of computer network (SNMP).

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1.5. Modes of instruction	☒lectures ☐seminars and workshops ☒exercises ☐e-learning ☐field work ☐practice ☐practicum	☒ independent work ☐multimedia and the internet ☐ laboratory ☐tutorials ☒consultations ☐other _____
1.6. Comments		

1.7. Student requirements

Students should actively participate in all forms of works, perform practical exercises and produce seminar papers. They should pass the exam consisting of practical and oral part.
The practical part of the exam regards the exercises by using computer. This practical exam and seminar papers are the prerequisite for the oral part of the exam where the complete knowledge of the student is examined and evaluated.

1.8. Evaluation of assessment[32]

Class attendance	1.5	Class participation		Seminar paper		Experiment	
Written exam	1	Oral exam	1	Essay		Research work	
Project		Continuous assessment	1.5	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester and in the final exam. Total number of points student can achieve during the semester is 70 (to assess the activities listed in the table), while in the final exam student can achieve 30 points.
The detailed work out of monitoring and evaluation of students' work will appear in the executive program.

1.10. Required literature (when proposing the program)

1. Radovan, M.: Računalne mreže, 2004. (digitalna skripta,)
2. Peterson, L. L., Davie, B. S.: Computer Networks: A System Approach, 3rd Edition, Morgan Kaufmann Publishers, 2003.

1.11. Recommended literature (when proposing the program)

1. Tanenbaum, A.S.: Computer Networks, 4th Edition. Prentice Hall, 2003.
2. Kurose, F. J., Ross, W. K.: Computer Networking: A Top-Down Approach Featuring the Internet, Pearson Addison Wesley, 2003.
3. Glass, K. M.: Beginning PHP, Apache, MySQL Web Development, Hungry Minds Inc, 2004.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of the semester students will evaluate the quality of the lectures. At the end of each semester (March 1 and September 30 of the current academic year) results of the exams will be analysed.

[32] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Databases	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	5
	Hours (L+E+S)	30 + 30 + 0

1. COURSE DESCRIPTION

1.1. Course objectives

- Extend students' knowledge acquired on course Introduction to databases,
- Train students for independent work with relational databases (SQL).

1.2. Course prerequisite

Introduction to databases.

1.3. Expected outcomes for the course

After completing the course and meeting requirements in respect to course Databases**,** students are expected to be capable of:

- Defining and updating relational database (SQL),
- Producing a object-oriented database model (UML),
- Designing database using CASE tool.

1.4. Course content

Database management system. Saved procedures. Triggers. Transactions. Database recovery after crash. Prevention of unauthorized access. Query optimization. Client-server architecture. Distributed databases. Object databases. Object-relational databases. Object-oriented database model – UML.
Semi-structured databases - text and multimedia databases, web as a semi-structured database. Computer aided data and database design – CASE, review of CASE tools.

1.5. Modes of instruction	☒lectures ☐seminars and workshops ☒exercises ☐e-learning ☐field work ☐practice ☐practicum	☒ independent work ☐multimedia and the internet ☐ laboratory ☐tutorials ☒consultations ☐other _____
1.6. Comments	During exercises, students continue with hands-on work on computers (connected to course Introduction to databases) using Oracle SQL / PLSQL. Also, students are introduced to some CASE tools and usage of these tools.	

1.7. Student requirements

Students should actively participate in all forms of works, pass the exam consisting of written and oral part. During exercises, students should produce a complete work, proving their capabilities in using software independently.

1.8. Evaluation of assessment[33]

Class attendance	1.75	Class participation		Seminar paper		Experiment	
Written exam	0.5	Oral exam	0.5	Essay		Research work	
Project		Continuous assessment	1.25	Presentation		Practical work	1
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. Date, C. J.,An Introduction to Database Systems, 8th edition, Addison-Wesley, 2004.
2. H. Garcia-Molina, J. D. Ullman, J. Widom, Database Systems: The Complete Book, Prentice Hall, 2002.

1.11. Recommended literature (when proposing the program)

1. R. Simon; Strategic Database Technology, Morgan Kaufmann Publishers, 1995
2. P. Valduriez, M. T. Ozsu: Principles of Distributed Database Systems, Pearson Education, 1999
3. M. Varga: Baze podataka; konceptualno, logičko i fizičko modeliranje podataka, DRIP, Zagreb, 1994.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[33] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Statistical practicum	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	15 + 30 + 15

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to train students for application of numerical and statistical software packages in mathematical modeling. For that purpose, it is necessary within the course to:

- describe the simulation of outcomes of discrete and continuous random variables and vectors,
- describe the selection of parametric model and execute the adaptation to dana,
- define the point and interval methods for parameter estimation,
- describe the statistical hypothesis testing,
- define the Kolmogorov - Smirnov test,
- define the c2-test,
- describe the estimation of distribution and parameters of statistics by using Monte Carlo method,
- describe methods of comparing two or more populations,
- describe methods of testing hypotheses of independence and correlation tests on two-dimensional statistical features,
- describe methods of estimation and model selection in regression analysis.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- select and understand the parametric model and adapt to data (A7, B7, E4, F5),
- apply the Kolmogorov - Smirnov and c2 - test (A7, B7, E4, F5),
- estimate the distribution and parameters of statistics by using Monte Carlo method (A7, B7, E4, F5),
- apply the methods of comparing two or more populations (A7, B7, E4, F5),
- apply the methods of testing hypotheses of independence and correlation tests on the two-dimensional statistical characteristics (A7, B7, E4, F5),
- apply the methods of estimation and model selection in regression analysis (A7, B7, E4, F5),
- use numerical and statistical software packages in the mathematical modeling (A7, B7, E4, F5),
- mathematically prove validity of all procedures and formulas that are used within the course (A7, B7, E4, F5).

1.4. Course content

Simulation of outcomes of discrete and continuous random variables and vectors. Selection of parametric model and adaptation to data. Point and interval methods of parameter estimation. Statistical hypothesis testing. Kolmogorov - Smirnov test. c^2 - test and the strength of a test. Estimation of distributions and parameters of statistics by using Monte Carlo method. Comparison of two populations. Comparison of several populations. Two-dimensional statistical features. Checking the hypothesis of independence. Tests of correlation. Evaluation

and selection of models and tests on parameters in regression analysis.

1.5. Modes of instruction	☒lectures ☒seminars and workshops ☒exercises ☒e-learning ☐field work ☐practice ☐practicum	☒ independent work ☒multimedia and the internet ☐ laboratory ☐tutorials ☐consultations ☐other
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[34]

Class attendance	2	Class participation		Seminar paper	1.5	Experiment	
Written exam	1.7	Oral exam		Essay		Research work	
Project		Continuous assessment	0.8	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. Ž.Pauše, Uvod u matematičku statistiku, Školska knjiga, Zagreb, 1993.
2. D.Nolan, T.Speed, Stat Labs, Springer Verlag, 2001.

1.11. Recommended literature (when proposing the program)

1. G.K.Bhattacharyya, R.A.Johnson, Statistical Concepts and Methods, John Wiley & Sons, 1977.
2. R.Christensen, Advanced Linear Modeling, Springer Verlag, 2001.
3. G.McPearson, Applying and Interpreting Statistics, Springer Verlag, 2001.
4. J.P.Marques de Sa, Applied Statistics using SPSS, STATISTICA and MATLAB, Springer Verlag, 2003.
5. A.Sen, M.Srivastava, Regression analysis: Theory, Methods, and Applications, Springer, 1990.
6. G.S.Fishman, Monte Carlo: Concepts, Algorithms, and Applications, Springer Verlag, 1995.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[34] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Stochastic processes	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 30 + 0

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students familiar with basic concepts of theory of stochastic processes. For that purpose, it is necessary within the course to:

- define generating functions and convolutions, and analyze their basic properties,
- describe a simple branching process,
- describe limit distributions and prove the continuity theorem,
- define a simple random walk and analyse its basic properties,
- describe the construction of Markov chains,
- describe the decomposition of state space of Markov chain,
- define transience, recurrence and periodicity,
- describe invariant measures and stationary distributions,
- define and analyse Markov chains with continuous time,
- give the basics of renewal theory.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- use and understand generating functions and their properties in study of stochastic processes (A7, B7, E4, F5),
- analyse simple branching processes and their properties (A7, B7, E4, F5),
- analyse limit distributions and continuity theorem (A7, B7, E4, F5),
- analyse and understand the properties of simple random walks (A7, B7, E4, F5),
- carry out and understand the construction of a Markov chain (A7, B7, E4, F5),
- describe the decomposition of state space of a Markov chain (A7, B7, E4, F5),
- investigate properties of transience, recurrence and periodicity for Markov chains (A7, B7, E4, F5),
- analyse Markov chains with continuous time and their properties (A7, B7, E4, F5),
- describe basic concepts and results of the renewal theory (A7, B7, E4, F5),
- mathematically prove validity of all procedures and formulas that are used within the course (A7, B7, E4, F5).

1.4. Course content

Generating functions. Convolutions. Simple branching process. Limit distributions and continuity theorem. Simple random walk. Stopping times. Construction of Markov chains. Decomposition of the state space. The principle of dissection. Transience and recurrence. Periodicity. Absorption probability. Invariant measures and stationary distributions. Markov chains with continuous time. The backward equation and generating matrix.

Laplace transformation method. Poisson process. Renewal processes.		
1.5. Modes of instruction	☒lectures ☐seminars and workshops ☒exercises ☒e-learning ☐field work ☐practice ☐practicum	☒ independent work ☒multimedia and the internet ☐ laboratory ☐tutorials ☐consultations ☐other
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[35]

Class attendance	2	Class participation		Seminar paper		Experiment	
Written exam	2	Oral exam	1.5	Essay		Research work	
Project		Continuous assessment	0.5	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. S. I. Resnick, Adventures in Stochastic Processes, Birkhauser, Boston, 1992.
2. D. Nualart, Stochastic Processes, Universitat de Barcelona, 2003. (http://orfeu.mat.ub.es/~nualart/StochProc.pdf)

1.11. Recommended literature (when proposing the program)

1. W. Feller, An Introduction to Probability Theory and Aplication, J.Wiley, New York, 1966.
2. N. Sarapa, Teorija vjerojatnosti, Školska knjiga, Zagreb, 2002.
3. J. Mališić, Slučajni procesi, teorija i primjena, Građevinska knjiga, Beograd, 1989.
4. J. R. Norris, Markov Chains, Cambridge University Press, 1997.
5. N. U. Prabhu, Stochastic Processes. Basic Theory and Its Application, Worls Scientific Publishing Company, 2008.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

[35] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

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General information		
Lecturer		
Course title	Seminar 3 – Foundations of mathematics	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	4
	Hours (L+E+S)	0 + 0 + 30

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students acquainted with the basic concepts of the foundations of mathematics. For this purpose it is necessary within the course to:

- describe the axiomatic method and analyse mathematical-logical-philosophical reasons for its introduction to mathematics,
- describe and analyse Euclidean geometry and its logical shortcomings,
- analyse the problem of "obviously true" statements,
- use visualization in the proof of theorems,
- have knowledge of the paradoxes introduced in mathematics at the beginning of the 20th century and their influence on further development of mathematics,
- describe and analyse Hilbert axiomatic system, Principia Mathematica and Gödel theorems,
- describe the ZFC system of axioms and the theory of categories as an alternative way of foundation of mathematics.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- describe and analyse some axiomatic systems (A6, B7),
- relate and explain causes and consequences of the development of mathematical ideas and methods, and the role of mathematics in science, art and society (A6, B7),
- use different communication types and forms, including information and communication technology (A6, B6, C6, E7, F7),
- use relevant and recent professional literature independently and critically (A6,B7,E6),
- express yourself accurately and fluently in spoken and written communication in the correct official language (D6).

1.4. Course content

Axiomatic method and axiomatic system: historical overview. Problems with visualization and intuition, paradoxes, Hilbert's formalism, Frege's logicism. Gödel's results. The ZFC system of axioms and the theory of categories as an alternative way of foundation of mathematics.

1.5. Modes of instruction	☐lectures ☒seminars and workshops ☐exercises ☐e-learning ☐field work	☒independent work ☐multimedia and the internet ☐laboratory ☐tutorials ☐other

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1.6. Comments	

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[36]

Class attendance	0.75	Class participation		Seminar paper	3.25	Experiment	
Written exam		Oral exam		Essay		Research work	
Project		Continuous assessment		Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (seminars) and on the final exam.
Total number of points student can earn during the semester is 100. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. Frege, G., 1995, Osnove Aritmetike i drugi spisi, Kruzak, Zagreb.
2. Moore, A.W., 1990, The Infinite, Routledge, London
3. http://mathforum.org/library/drmath/view/51849.html
4. http://plato.stanford.edu/entries/intuitionism/
5. https://web.math.princeton.edu/~nelson/papers/int.pdf
6. http://www.philosophie.ch/philipp/teaching/papers/vanGarrel_FregeHilbert.pdf
7. http://dialecticonline.wordpress.com/dialectic-autumn-11/is-choosing-semantics-enough/

1.11. Recommended literature (when proposing the program)

1. Wittgenstein, L., 1937-44/1972, Remarks on the Foundations of Mathematics, The M.I.T. Press, Cambridge.
2. Benacerraf, P. i Putnam, H., 1983, Philosophy of Mathematics-Selected Readings, second edition, Cambridge University Press, Cambridge.
3. Boolos, G., 1998, Logic, Logic and Logic, Harvard University Press.
4. Nagel, E. i Newman, J.R., 2001, Gödelov dokaz, Kruzak, prevedeno iz Nagel, Newman, 1993, Gödel's Proof, Routledge
5. Brown, J.R., 1999, An Introduction to the World of Proof and Pictures, Routledge

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students

1.13. Quality assurances which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[36] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Topics in contemporary mathematics	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	3
	Hours (L+E+S)	15 + 0 + 15

1. COURSE DESCRIPTION

1.1. Course objectives

Objective of this course is to familiarize students with selected topics and current problems of contemporary mathematics.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course students will be prepared for independent research, for working with professional literature and research papers and for mathematical topics presentation.

1.4. Course content

1.5. Modes of instruction	☒lectures ☒seminars and workshops ☐exercises ☒e-learning ☐field work ☐practice ☐practicum	☒ independent work ☒multimedia and the internet ☐ laboratory ☒tutorials ☒consultations ☐other _____
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[37]

Class attendance	0.8	Class participation		Seminar paper	1.8	Experiment	
Written exam		Oral exam		Essay		Research work	
Project		Continuous assessment	0.4	Presentation		Practical work	
Portfolio							

[37] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. P. J. Davis, R. Hersh, E. A. Marchisotto, Doživljaj matematike, Golden marketing - Tehnička knjiga, Zagreb, 2004.
2. T. Gowers (editor), Princeton Companion to Mathematics, Princeton University Press, 2008.
3. N. J. Higham (editor), Princeton Companion to Applied Mathematics, Princeton University Press, 2015.
4. literature for each seminar will be determined according to the topic of the seminar

1.11. Recommended literature (when proposing the program)

1. T. Gowers, Mathematics: A Very Short Introduction, Oxford University Press, 2002.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

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T: (051) 406-500 • F: (051) 216-671; 216-091
W: www.uniri.hr • E: ured@uniri.hr

General information		
Lecturer		
Course title	Partial differential equations	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	6
	Hours (L+E+S)	30 + 30 + 0

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students familiar with the basics of the theory of partial differential equations.
With that purpose the students are presented the following units:

- classification of second order equations: eliptic, hiperbolic and parabolic equations and examples,
- Laplace equation, wave equation and equation of heat conducting,
- Dirichlet's and Green's representation,
- Cauchy's problem,
- Fourier's method, principle of maximum.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing this course, the students are expected to:

- analyse partial differential equations in the sense of their classifications (A7, B7, E4, F5),
- differentiate boundary and initial conditions (A7, B7, E4, F5),
- apply different theorems in analizing eliptic, hiperbolic and parabolic equations (A7, B7, E4, F5),
- solve Laplace equation, analyse Dirichle's and Neumann's problem and apply maximum principle (A7, B7, E4, F5),
- apply Poisson's formula and Green's function (A7, B7, E4, F5),
- solve the heat equation with different initial-boundary conditions (A7, B7, E4, F5),
- solve the wave equation and analyse Cauchy's problem (A7, B7, E4, F5),
- apply Fourier's method in solving partial differential equations (A7, B7, E4, F5),
- mathematically prove validity of all procedures and formulas that are used within the course (A7, B7, E4, F5).

1.4. Course content

Classification of second order equations. Eliptic, hiperbolic and parabolic equations. Examples. Laplace equation. Dirichle's and Neumann's problem. Green's representation. Green's function. Poisson's formula. Principle of maximum. Potentials. Wave equation. Cauchy's problem. D´Alambert's formula. Initial-boundary problem. Fourier's method. Equation of heat conducting. Principle of maximum. Cauchy's problem. Poisson's formula. Initial-boundary problem. Fourier's method.

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1.5. Modes of instruction	☒lectures ☒seminars and workshops ☒exercises ☒e-learning ☐field work ☐practice ☐practicum	☒ independent work ☐multimedia and the internet ☐ laboratory ☒tutorials ☒consultations ☐other
1.6. Comments		

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

1.8. Evaluation of assessment[38]

Class attendance	1.5	Class participation		Seminar paper		Experiment	
Written exam	2.4	Oral exam	1.5	Essay		Research work	
Project		Continuous assessment	0.6	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. D.Gilber, S.Trudinger: Eliptic partial differential equations of second order, Springer, 1977.
2. L. C. Evans: Partial Differential Equations, American Mathematical Sociaty, 2002.
3. H. Levine: Partial Differential Equations, American Mathematical Sociaty, 1997.

1.11. Recommended literature (when proposing the program)

1. I. Aganović, K. Veselić: Linearne diferencijalne jednadžbe, Element, Zagreb, 1997.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	*Number of copies*	*Number of students*

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[38] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Introduction to combinatorial topology	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	5
	Hours (L+E+S)	15 + 15 + 15

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students acquainted with:
- elements of combinatorial topology and counting problems,
- classification convex polytopes according to their „combinatorial properties".

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing the course, the students are expected to:
- define basic concepts of combinatorial topology of convex polytopes, apply and understand basic procedures for determining number of faces (A7, B7),
- have knowledge of basic theorems in the field of combinatorial topology of convex polytopes and be able to prove them (B7, F4),
- draw Schlegel diagrams for 3-polytopes (B5, C7, D7, F7),
- independently or in groups examine a given problem (C7, E7, F7, G7).

1.4. Course content

Introduction, convex sets, partially ordered set, polytopes, simplexes, pyramids, bipyramids, Euler's theorem, Dehn-Sommerville equations. Number of faces of simplicial polytopes, lower bound conjecture, number of faces of cyclic polytopes, upper bound conjecture. Lower bound conjecture for simplicial spheres,
abstract simplicial complexes, diagrams - Schlegel diagrams, h-vectors, upper bound conjecture for simplicial sphere.
Some properties of h-vectors, McMullen's conditions, Cohen-Macaulay and Gorenstein complexes, monotonicity property of
h-vectors.

1.5. Modes of instruction	☒lectures ☒seminars and workshops ☒exercises ☒e-learning ☐field work	☒independent work ☒multimedia and the internet ☐laboratory ☒tutorials ☒other Consultations, project strategies
1.6. Comments		

1.7. Student requirements

Students are required to attend classes, to do homework and to create seminar on an assigned topic. Furthermore, they are required to fulfil all the obligations described in the course curriculum.

1.8. Evaluation of assessment[39]

Class attendance	1.4	Class participation		Seminar paper	1.2	Experiment	
Written exam		Oral exam	1.2	Essay		Research work	
Project		Continuous assessment	1.2	Presentation		Practical work	
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

1. Branko Grunbaum: Convex Polytopes, Springer-Verlag, New York Inc, 2003.
2. Darko Veljan: D. Veljan, Kombinatorna i diskretna matematika, Algoritam, Zagreb, 2001.
3. materijali dostupni u okviru e-kolegija

1.11. Recommended literature (when proposing the program)

1. Jean Gallier, Notes on Convex sets, Polytopes, Polyhedra, Combinatorial Topology, Voronoi Diagrams and Delaunay Triangulations, Book in Progress (2009), http://www.cis.upenn.edu/~cis610/convex67.pdf

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students
Branko Grunbaum: Convex Polytopes, Springer-Verlag, New York Inc, 2003.	1	10
Darko Veljan: D. Veljan, Kombinatorna i diskretna matematika, Algoritam, Zagreb, 2001.	5	10

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[39] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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General information		
Lecturer		
Course title	Seminar of Applied Discrete Mathematics	
Program	Discrete mathematics and its applications	
Course status	Elective	
Year	2	
Credit values and modes of instruction	ECTS credits / student workload	4
	Hours (L+E+S)	0 + 15 + 15

1. COURSE DESCRIPTION

1.1. Course objectives

The main course objective is to get students acquainted with some possibilities of the applied Discrete mathematics through the acquaintance of the real system in the economy and some problem from the system which can be solved using Discrete mathematics. In addition, the course objective is to develop an ability of mathematical modelling of such problems, and communication and presentation skills while presenting problems, their models and solutions.

1.2. Course prerequisite

None.

1.3. Expected outcomes for the course

After completing the course, the students are expected to:

- express themselves accurately and fluently in speech communication in the language of teaching and the correct official language (D6),
- use a variety of communication means and forms (D5),
- mathematically model a problem of the economy using Discrete mathematics (A6, B6, C4, D5, E4, F4),
- apply and understand the methods of Discrete mathematics while modeling and simulating real problems, and analyse obtained results (A6, B5, C5, D6, E4, F5).

1.4. Course content

Seminar is based on the previously attended courses in the field of Discrete mathematics and represents their expansion. The content of the seminar is the application of Discrete mathematics in problems related to the management of business entities (e.g. optimization of business/production processes).

1.5. Modes of instruction		
	☐ lectures ☒ seminars and workshops ☐ exercises ☒ e-learning ☒ field work	☒ independent work ☐ multimedia and the internet ☐ laboratory ☒ tutorials ☐ other

1.6. Comments

1.7. Student requirements

Students are required to attend classes and actively participate in them. They are required to explore a given problem, get acquainted with the real environment to which the problem relates, and prepare and in the written form submit the seminar paper and publicly present it.

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1.8. Evaluation of assessment[40]							
Class attendance	1	Class participation		Seminar paper	1	Experiment	
Written exam		Oral exam		Essay		Research work	1
Project		Continuous assessment		Presentation		Practical work	1
Portfolio							

1.9. Assessment and evaluation of students' work during the semester and on the final exam

Students' work will be evaluated during the public presentation of the seminar and through the written work. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

1.10. Required literature (when proposing the program)

Seminar is based on the courses in the field of Discrete mathematics and represents their expansion, and therefore, required literature, depending on the topic of a seminar, is based on the literature of the previously attended courses.

1.11. Recommended literature (when proposing the program)

Recommended literature will be given by the mentor of the seminar paper, and it will depend on the topic of a given problem.

1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course

Title	Number of copies	Number of students

1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies

Anonymous survey in which students will evaluate the quality of classes will be carried out during last week of classes. The analysis of students' success at final exams will be carried out at the end of semester.

[40] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.