Department of Mathematics

PhD program in Mathematics
The University of Vlora

General requirements

Any student who graduates with a PhD program in mathematics must have 300 graduate credits, from which 180 must be in residence at UV. No more than 90 credits of research or reading courses can count toward this requirement.

Course Requirements:

1. MAT 521, Analysis I
2. MAT 522, Analysis II
3. MAT 525, Topology
4. MAT 551, Algebra I
5. MAT 552, Algebra II

Choose three of the following:

1. STAT 551, Statistics I,
2. STAT 552, Statistics II,
3. MAT 631, Complex Analysis
4. MAT 632, Riemann Surfaces
5. MAT 641, Computational Algebra I,
6. MAT 642, Computational Algebra II,
7. MAT 651,Commutative Algebra I,
8. MAT 652, Commutative Algebra II,
9. MAT 657, Coding Theory I,
10. MAT 658, Coding Theory II
11. MAT 661, Mathematics of Communications I
12. MAT 662, Mathematics of Communications II
13. MAT 771, Algebraic Number Theory I
14. MAT 772, Algebraic Number theory II
15. MAT 851, Algebraic Geometry I
16. MAT 852, Algebraic Geometry II
17. MAT 870, Independent Research

Qualifying exams: There are two types of qualifying exams:

Qualifier of first level:

- Exam 1: Analysis I, II
- Exam 2: Algebra I, II

The exams will be graded

- -Master pass/fail

- -PhD pass/fail

Students who indent to get a continue with the PhD program need to get a PhD pass. First level exams must be passed no later than student's third year of graduate study.

Qualifier of second level:

The student can choose under the supervision of his/her advisor two subjects in which he/she can take the second level qualifying exams.

Each graduate student will become a PhD candidate when he/she passes the PhD qualifying exams. The exams will be all written and have a duration of 5 hours.

Thesis Committee: This committee has 5 members who must be selected as follows:

-thesis advisor, who must be an active mathematician and have an international reputation. It is not necessary that the thesis advisor be from the faculty of UV
- two committee members must be from the subject area in which the student is writing the thesis
- one committee member must be from another department of the university which has a PhD program
- for the first 10 students who get PhD degrees it is required that a committee member is from a mathematics department outside Albania which has had a PhD program for at least 25 years. It is required that this member has supervised at least one PhD student and is an active researcher.

Oral Exam: This exam is taken when the student starts working on the PhD thesis. It is a preview of what the student intends to accomplish in the thesis.

PhD Thesis: The PhD thesis must satisfy all the requirements set by the Graduate school. The work must be original and publishable in a professional mathematics journal.

- The PhD candidate must present his/her work to the open public for the first 60 minutes.
- The committee has the right to to ask questions to the candidate in private
- The committee must discuss the thesis and the work presented by the candidate without the candidate presence. After that the committee votes.

A unanimous vote is required for the candidate to pass.

Course Descriptions:

MAT 421, Real Analysis I (8): Lebesgue measure, measurable functions and the Lebesgue integral; convergence theorems; monotone functions, bounded variation and absolute continuity. Prerequisite: MAT 351.

MAT 422, Real Analysis II (8): The Lp spaces; product measures and Fubini's theorem; the Radon-Nikodym theorem. Prerequisite: MAT 421.

MAT 451, Introduction to Algebra I, 8: This is an introduction to the graduate algebra. Groups, normal and simple groups, permutation groups, Abelian groups, Sylow theorem, Jordan-Holder theorem.

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MAT 452, Introduction to Algebra II, 8: An introduction to rings and ideals; integral domains; and field and field extensions. Geometric constructions and an introduction to Galois theory.

MAT 462: Geometric Structures (8): A study of topics from Euclidean geometry, projective geometry, non-Euclidean geometry and transformation geometry. Prerequisite: Enrollment in the Masters of Teaching Program.

MAT 472, Number Theory, 8: Structure of the integers, prime factorization, congruences, multiplicative functions, primitive roots and quadratic reciprocity.

MAT 481, Cryptography (8): Elementary concepts in cryptography; classical cryptosystems; modern symmetric cryptography; public key cryptography; digital signatures, authentication schemes; modular arithmetic, primitive roots, primality testing. At least one mathematics course at or above the 3000 level and facility with either a programming language or a computer algebra system is required. 4176: Discrete logs; pseudoprime tests; Pollard rho factoring; groups; quadratic residues; elliptic curve cryptosystems and factoring; coding theory; quantum cryptography.

MAT 521, Complex Analysis (8): This is one of the basic courses for students beginning study towards the Ph.D. degree in mathematics. The approach is theoretical and rigorous and emphasizes abstract concepts and proofs. Review of analysis in R^2 including metric spaces, differentiable maps, Jacobians; analytic functions, Cauchy-Riemann equations, conformal mappings, linear fractional transformations; Cauchy's theorem, Cauchy integral formula; power series and Laurent expansions, residue theorem and applications, maximum modulus theorem, argument principle; harmonic functions; global properties of analytic functions; analytic continuation; normal families, Riemann mapping theorem. Prerequisite: MAT 422.

MAT 522, Analysis (8): Topics include Lebesgue measure on the real line; measurable functions and integration on R; differentiation theory, fundamental theorem of calculus; function spaces, L^p(R), C(K), Holder and Minkowski inequalities, duality; general measure spaces, product measures, Fubini's Theorem; Radon-Nikodym Theorem, conditional expectation, signed measures, introduction to Fourier transforms. Prerequisite: MAT 422.

MAT 551, Algebra I (8): Groups, Sylow theorems, solvable and simple groups, computation in permutation groups. GAP will be used to perform computations with groups. Free groups, finitely generated Abelson groups, semi-direct products, extension of groups. Introduction to rings, Euclidean domains, PID's, UFD's, polynomial rings, irreducibility criteria for polynomials.

MAT 552, Algebra II (8): A detailed study of module theory, decomposition theorems, linear algebra. Theory of fields, field extensions, finite fields, geometric constructions, Galois theory, solvability by radicals, computing Galois groups of polynomials.

STAT 551, Introduction to Mathematical Statistics, 8: The distribution of random variables, conditional probability and stochastic independence, special distributions, functions of random variables, interval estimation, sufficient statistics and completeness, point estimation, tests of hypothesis and analysis of variance. Prerequisites: MAT 421

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MAT 525: Topology(8): An introductory course with emphasis on the algebraic and differential topology of manifolds. Topics include simplicial and singular homology, de Rham cohomology, and Poincare duality.

MAT 631 Complex Analysis II (8): Rapid survey of properties of complex numbers, linear transformations, geometric forms and necessary concepts from topology. Complex integration. Cauchy's theorem and its corollaries. Taylor series and the implicit function theorem in complex form. Conformality and the Riemann-Caratheodory mapping theorem. Theorems of Bloch, Schottky, and the big and little theorems of Picard. Harmonicity and Dirichlet's problems.

MAT 632 Riemann Surfaces (8): An introduction to Riemann Surfaces from both the algebraic and function-theoretic points of view. Topics include projective algebraic curves, differential forms, integration, divisors of poles and zeroes, linear systems, the Riemann-Roch theorem, Serre duality, and applications. Prerequisites: MAT 521 or MAT 631.

MAT 641 Computational Algebra I (8): A study of the mathematics and algorithms which are used in symbolic algebraic manipulation packages. Topics include computer representation of symbolic mathematics, polynomial ring theory, field theory and algebraic extensions, modular and p-adic methods, subresultant algorithm for polynomial GCD's.

MAT 642 Computational Algebra II (8): Groebner bases for polynomial ideals and Buchberger's algorithm, factorization and zeros of polynomials. Prerequisite: MTH 256 and knowledge of a scientific programming language or permission of instructor.

MAT 651, Commutative Algebra I (8): Rings and ideals, modules, exact sequences, tensor products, integral dependence and valuations, the going-up and going -down theorem, chain conditions,

MAT 652, Commutative Algebra II (8): Notherian rings, dicrete valuation rings, Dedekind domains. Basic knowledge of commutative ring theory, field theory, Galois theory, and group theory will be assumed.

MAT 655 Computational Group Theory, 8: An introduction to computational group theory using computer algebra packages such as GAP.

MAT 657, Coding Theory I (8): We will be focusing on channel coding theory. In the first part of the course, a brief introduction will be given to information and coding theory in order to see what is the best one should expect from a good code. Introduction to the basic algebra concepts needed in codding theory.

MAT 658, Coding Theory II (8): The approach that we will follow will be more on the computational aspects of groups, finite fields, polynomials, etc other than the rigorous mathematical approach. We will use software to do many computational problems (see below). These concepts will be utilized for the construction of polynomial and cyclic codes. BCH codes and Reed-Solomon (RS) codes will be covered in detail.

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MAT 661, Mathematics of Communications I (8): An introduction to mathematical concepts of digital communications. Random processes, Shanon's theorem, communication channels, antena theory, source coding, etc.

MAT 662, Mathematics of Communications II (8): A continuation of MAT 661, algebraic coding, turbo codes, LDPC codes, new developments in digital communications.

MAT 771, Algebraic Number Theory I (8): Algebraic number fields, integrality and Notherian properties, Dedekeind Domains,

MAT 772, Algebraic Number Theory II (8): Extensions, ramified and non-ramified extensions, ramification in Galois extensions, class groups and units, cyclotomic fields, L-functions, Dedekind zeta-function, Brauer relations.

MAT 773, Special topics (8): This course is offered every winter and is open only to students who are accepted in the PhD program. Special research topics are discussed. Permission of instructor is needed to enroll.

MAT 851, MAT 852, Algebraic Geometry I: Introduction to affine and projective spaces, algebraic varieties, maps between varieties, Hilbert's Nullstellensatz, Zariski topology, abelian varieties, the Riemann-Roch theorem, Jacobians of curves. Prerequisites MAT 652.

MAT 852, Algebraic Geometry II: Abelian varieties, sheaves and cohomology. Prerequisites MAT 851.

MAT 870: Independent Research (8): Open only to students who have passed the PhD qualifying exams. Students are expected to complete a research projects at the end of this course.