

8. FIELDS OF SPECIALIZATION

Students in the Department of Mathematics Graduate Program can study a variety of specialized fields within Mathematics. In order to write a thesis in any field, it is necessary to take several courses in order to obtain the necessary background. To aid the student in planning a program of graduate studies, this section provides general guidance on the courses that should be taken for pursuing independent study and research in the chosen field of specialization. None of these courses are required in any sense, and the student in cooperation with the thesis adviser is free to formulate a highly individualized study program which takes full advantage of the student's research interests and previous preparation for graduate study.

8.1 Actuarial Science	
Math 408, 409, 471, 472	
Basic Courses: Math 567, 568	
Faculty Members in Actuarial Science	
Rick Gorratt	Actuarial science
Paul Johnson	Actuarial science
Esther Portnoy, Professor Emeritus	Application of statistical methods to demographic problems, especially mortality differences by race and gender, and at high ages

8.2 Algebra

Math 415, 416, 417, 418, 426, 427

Basic Courses: Math 500, 501 and selected courses from 502, 503, 504, 505, 506, and 511

Faculty Members in Algebra

Maarten Bergvelt	Representation theory of infinite dimensional Lie algebras, algebraic geometry, super geometry
Sankar Dutta	Commutative algebra
Iwan Duursma	Cryptography, algebraic geometry
William J. Haboush	Algebraic geometry
Sergei Ivanov	Combinatorial group theory and its applications
Ilya Kapovich	Geometric and combinatorial group theory
Sheldon Katz	Algebraic geometry, string theory
Rinat Kedem	Mathematical physics, representation theory of infinite dimensional Lie algebras, quantum groups, and vertex algebras, integrable models statistical mechanics and quantum field theory
Anton Malkin	Geometric representation theory, equivariant symplectic and algebraic geometry
Randy McCarthy	Algebraic K-theory, algebraic topology
Igor Mineyev	Geometric group theory, hyperbolic groups, bounded cohomology, and Baum-Connes conjecture
Thomas Nevins	Algebraic geometry and interactions with noncommutative algebra and integrable systems
Bruce Reznick	Combinatorial methods in algebra, analysis, number theory, combinatorics, geometry
Faculty Members in Areas Related to Algebra	
Lou van den Dries	Applications of logic to algebra
Paul E. Schupp	Group theory, logic, formal language theory and their Interconnections

8.3 Algebraic Geometry

(no undergrad classes!)

Basic Courses: Math 511

Faculty Members in Algebraic Geometry

Steven Bradlow	Differential geometry, gauge theory, holomorphic vector bundles, moduli spaces
Elizabeth Csima	Algebraic geometry
Iwan Duursma	Number theory, arithmetic geometry, coding theory and cryptography
William Haboush	Algebraic groups and homogeneous spaces
Sheldon Katz	Algebraic geometry, string theory
Anton Malkin	Geometric representation theory, equivariant symplectic and algebraic geometry
Thomas Nevins	Algebraic geometry and interactions with noncommutative algebra and integral systems
Bruce Reznick	Combinatorial methods in algebra, analysis, number theory, combinatorics, geometry
Henry Schenck	Commutative algebra and algebraic geometry

Faculty Members in Areas Related to Algebraic Geometry

Matthew Ando	Algebraic topology
John D'Angelo	Several complex variables and complex geometry
Maarten Bergvelt	Representation theory of infinite dimensional Lie algebras, algebraic geometry, super geometry
Sankar Dutta	Commutative algebra
Rinat Kedem	Mathematical physics, representation theory of infinite dimensional Lie algebras, quantum groups, and vertex algebras, integrable models statistical mechanics and quantum field theory

8.4 Analysis

Math 424, 425, 444, 446, 447, 448

Basic Courses: Real Analysis: Math 540 and 541
Complex Analysis: Math 542 and 543

Faculty Members in Analysis

Florin Boca	Operator algebras, number theory, mathematical physics
John P. D'Angelo	Several complex variables, complex geometry, partial differential equations
Burak Erdogan	Harmonic analysis on Euclidean spaces and related geometric measure theory problems, PDEs, probability
Pierre Fima	analysis
Aimo Hinkkanen	One complex variable, Möbius groups, Teichmüller theory, quasiconformal maps, complex dynamics
Dirk Hundertmark	Analytic, probabilistic problems in math physics; eigenvalue moments for Schrödinger operators; spectral theory of random Schrödinger operators and statistical mechanics
Marius Junge	Banach and operator spaces, operator algebras, noncommutative probability
Ely Kerman	Relation between Hamiltonian dynamics and symplectic topology; symplectic topology and geometry, Hamiltonian dynamical systems
Richard Laugesen	Differential equations, mathematical physics, and complex analysis; specialty - extremal problems
Jiri Lebl	Several complex variables, real and complex geometry
Xiaochun Li	Hilbert transform along the vector field; Multilinear oscillatory integrals; multilinear Carleson theorem
John Mackay	Analysis, geometry/topology
Tao Mei	Harmonic analysis for operator(matrix) valued functions, noncommutative martingales, operator space
Sergiy Merenkov	Geometric theory of conformal and quasiconformal maps, with applications to areas such as geometric group theory and analysis on fractals
Joseph B. Miles	Entire and meromorphic functions, complex function theory, classical analysis
Igor Nikolaev	Quasiconformal mappings, Monge-Ampere equations, regularity problems in Riemannian geometry

Faculty Members in Analysis, Continued	
Julian I. Palmore	Dynamical systems, chaos theory, and frameworks for analysis, stability, and verification, validation and visualization of distributed interactive simulations
Joseph Rosenblatt	Harmonic analysis, ergodic theory
Zhong-Jin Ruan	Operator spaces and operator algebras
Richard Sowers	Probability theory, stochastic analysis, partial differential equations
Alexander E. Tumanov	Several complex variables, differential geometry, partial differential equations
Jeremy Tyson	Geometric function theory, quasiconformal maps, analysis in nonsmooth metric spaces, sub-Riemannian geometry
Bartomeu Sureda	probability
Jang-Mei Wu	Potential theory, conformal mapping, exceptional sets, complex function theory
Faculty Members in Areas Related to Analysis	
Robert Bauer	Stochastic analysis on manifolds
Bruce C. Berndt	Classical analysis, in particular, as related to Ramanujan's notebooks, infinite series, elliptic and modular functions, special functions, asymptotic series, and contour integration
Lee Deville	Stochastic analysis, differential equations, dynamical systems
C. Ward Henson	Relations between analysis and mathematical logic, especially non-standard analysis, applications of model theory in functional analysis, model theory of Banach spaces, decision problems and definability problems in analysis, model theoretic properties of the real exponential function
Eduard Kirr	Existence and stability of coherent structures in equations from mathematical physics, their coupling with radiation under perturbations, theory and numerical simulation of waves in homogeneous and random media.
Robert G. Munaster	Invariant manifolds, asymptotic behavior, nonlinear elasticity, gas theory
Bruce Reznick	Combinatorial methods in analysis, inequalities
Kenneth B. Stolarsky	Exponential polynomials, location of zeros, inequalities
Nikolaos Tzirakis	Harmonic Analysis and Dispersive Partial Differential Equations

8.5 Combinatorics and Optimization

Math 412, 413, 492, 484

Basic Courses: Math 580, 581, 582, 583, 584, 587, 588 and 589

Faculty Members in Combinatorics and Optimization

Jozef Balog	Bootstrap percolation, interacting particle systems, extremal graph theory, graph theory, hypergraphs, combinatorics, and discrete computational geometry
Zoltan Furedi	Theory of finite sets with applications in geometry, designs, computer science
Alexandr Kostochka	Graph theory, random graphs, finite ordered sets, graph coloring
Sujith Vijay	Combinatorial number theory, discrepancy theory, Ramsey theory, integer sequences
Douglas B. West	Combinatorics, graph theory, discrete algorithms
Alexander Yong	Combinatorics, its applications, and its interactions with other areas of mathematics, including algebraic geometry, commutative algebra, representation theory, probability theory, and algorithms

Faculty Members in Areas Related to Combinatorics and Optimization

Robert G. Muncaster	Applied mathematics, non-linear elasticity and the kinetic theory of gases, analysis of asymptotic behavior in mechanical theories through use of semigroups and invariant manifolds
Julian I. Palmore	Dynamical systems and chaos theory
Bruce Reznick	Combinatorial methods in algebra, analysis, number theory, combinatorics, geometry
Paul E. Schupp	Automata, formal languages, group theory
Kenneth B. Stolarsky	Combinatorics, number theory

8.6 Differential Equations and Applied Mathematics

Math 441, 442, 487, 489, 489

Basic Courses: Math 550 and 553

Faculty Members in Differential Equations and Applied Mathematics

Jared Bronski	Applied mathematics
Lee Deville	Stochastic analysis, differential equations, dynamical systems
Burak Erdogan	Harmonic analysis on Euclidean spaces and related geometric measure theory problems, PDEs, probability
Robert Ghrist	Topology (contact geometry/topology, Morse theory, braid theory), dynamics (flows, bifurcation theory, Conley index), and applications (fluids, robotics, computational topology)
Dirk Hundertmark	Analytic, probabilistic problems in math physics; eigenvalue moments for Schrödinger operators; spectral theory of random Schrödinger operators and statistical mechanics
Ely Kerman	Relation between Hamiltonian dynamics and symplectic topology; symplectic topology and geometry, Hamiltonian dynamical systems
Eduard Kirr	Existence and stability of coherent structures in equations from mathematical physics, their coupling with radiation under perturbations, theory and numerical simulation of waves in homogeneous and random media.
Richard Laugesen	Differential equations and mathematical physics
Xiaochun Li	Hilbert transform along the vector field; Multilinear oscillatory integrals; multilinear Carleson theorem
Robert G. Muncaster	Differential equations and invariant manifolds, bifurcation theory, theoretical mechanics, mathematical modeling of political and social phenomena
Igor Nikolaev	Non-linear Monge-Ampere PDEs, PDEs and Riemannian spaces
Julian I. Palmore	Dynamical systems, chaos theory, frameworks for analysis, stability, verification, validation and visualization of distributed interactive simulations
Zoi Rapti	Non-Linear PDE's, mathematical physics and biology
Nikolaos Tzirakis	Harmonic Analysis and Dispersive Partial Differential Equations
Vadim Zharnitsky	Differential equations and dynamical systems and their applications in physics and engineering

**Faculty Members in Areas Related to
Differential Equations and Applied Mathematics**

Maarten Bergvelt	Completely integrable Hamiltonian systems, solitons
Florin Boca	Operator algebras, number theory, mathematical physics
John P. D'Angelo	Several complex variables, geometry
Eugene Lerman	Symplectic geometry, symmetric Hamiltonian systems
Bruce Reznick	Combinatorial methods in analysis and algebra
Joseph Rosenblatt	Harmonic analysis, inverse problems, sampling

8.7 Geometry and Topology

Math 402, 403, 423, 432

Basic Courses: Geometry: Math 518, 519, 521, 522, and 524

Topology: Math 525, 526, 527, 533, 534, 535

Faculty Members in Geometry and Topology

Stephanie Alexander	Differential geometry, global analysis
Matthew Ando	Homotopy theory, formal groups, analysis on loop spaces, elliptic cohomology and representation theory
Maarten Bergvelt	Completely integrable systems, Infinite dimensional Grassmannians, vector bundles and gauge theory
Steven Bradlow	Differential geometry, gauge theory, holomorphic vector bundles, moduli spaces
Nathan Dunfield	3-dimensional geometry and topology, hyperbolic geometry, geometric group theory, experimental mathematics, connections to number theory.
George K. Francis	Geometrical graphics, numerical geometry, descriptive topology, differential topology, dynamical systems, low dimensional geometry and topology
Robert Ghrist	Topology (contact geometry/topology, Morse theory, braid theory), dynamics (flows, bifurcation theory, Conley index), and applications (fluids, robotics, computational topology)
Bertrand Guillou	Algebraic topology
Ely Kerman	Relation between Hamiltonian dynamics and symplectic topology; symplectic topology and geometry, Hamiltonian dynamical systems
Christopher Leininger	Mapping class groups, Teichmüller theory, knot theory and three-manifolds, and hyperbolic geometry.
Eugene Lerman	Symplectic geometry, symmetric Hamiltonian systems
Anton Malkin	Geometric representation theory, equivariant symplectic and algebraic geometry
Randy McCarthy	Spectra, calculus of functors, K-theory
Igor Mineyev	Geometric group theory, hyperbolic groups, bounded cohomology, and Baum-Connes conjecture
Charles Rezk	Geometry and topology
Susan Tolman	Symplectic geometry
Alexander Tumanov	Complex analysis and geometry

Faculty Members in Areas Related to Geometry and Topology	
John P. D'Angelo	Complex geometry
Zoltan Furedi	Theory of finite sets with applications in geometry, designs, and computer science
Aimo Hinkkanen	Complex analysis, geometry, dynamics
Sergei Ivanov	Combinatorial group theory and its applications
Ilya Kapovich	Geometric and combinatorial group theory
Jiri Lebl	Several complex variables, real and complex geometry
Sergiy Merenkov	Geometric theory of conformal and quasiconformal maps, with applications to areas such as geometric group theory and analysis on fractals
Igor Nikolaev	Investigations of spaces of bounded curvature; regularity of the generalized solutions of the Monge-Ampere equation
Julian I. Palmore	Dynamical systems, celestial mechanics
Zhong-Jin Ruan	Operator algebra
Paul E. Schupp	Combinatorial group theory, decision problems, automata theory and formal language theory, computational complexity
Kenneth B. Stolarsky	Number theory, geometry
Jeremy Tyson	Geometric function theory, quasiconformal maps, analysis in nonsmooth metric spaces, sub-Riemannian geometry

8.8 Logic

Math 414

Basic Courses: Math 570, 571, 573 and 574

Faculty Members in Logic

Lou van den Dries	Model theory and its applications
C. Ward Henson	Model theory, geometry of Banach spaces, nonstandard analysis; decision problems
Paul E. Schupp	Combinatorial group theory, decision problems, automata theory and formal language theory, computational complexity
Slawomir Solecki	Set theory, applications of descriptive set theory to topology and analysis

Faculty Members in Areas Related to Logic

Sergei Ivanov	Combinatorial group theory and its applications
Ilya Kapovich	Geometric and combinatorial group theory

8.9 Number Theory

Math 453

Basic Courses: Math 530 and 531

Faculty Members in Number Theory

Scott Ahlgren	Modular forms and connections to number theory, partitions, character sums, Diophantine equations
Bruce Berndt	Analytic number theory, classical analysis, including special functions, classical modular forms, elliptic functions, q-series, and continued fractions. Ramanujan notebooks, Dirichlet series and arithmetic functions
Florin Boca	Diophantine approximation, spacing statistics
Iwan Duursma	Algebraic number theory, cryptography, coding theory, combinatorics
Kevin Ford	Waring's problem and variants, distribution of values of arithmetic functions, comparative prime number theory, Riemann zeta function, sieve theory
A. J. Hildebrand	Analytic number theory, probabilistic number theory, problems at the interface of number theory and other areas such as analysis, combinatorics, and probability theory
Rinat Kedem	Mathematical physics, representation theory of infinite dimensional Lie algebras, quantum groups, and vertex algebras, integrable models statistical mechanics and quantum field theory
Bruce Reznick	Sums of squares of polynomials, combinatorial number theory
Paul Pollack	Number theory
Mathew Rogers	Number theory
Jeremy Rouse	Elliptic curves, modular forms, and analytic number theory
Andrew Schultz	Galois theory (cohomology, groups, of rings and schemes) and algebraic geometry
Kenneth B. Stolarsky	Diophantine approximation, special functions, geometry of zeros of polynomials
Alexandru Zaharescu	Analytic and algebraic number theory
Faculty Members in Areas Related to Number Theory	
Sujith Vijay	Combinatorial number theory, discrepancy theory, Ramsey theory, integer sequences

8.10 Probability Theory

Math 461, 463, 464

Basic Courses: Math 561 and 562

Faculty Members in Probability Theory

Robert Bauer	Stochastic analysis on manifolds, random simple curves on 2-dimensional domains and Riemann surfaces, SLE, mathematical physics.
Dirk Hundertmark	Analytic, probabilistic problems in math physics; eigenvalue moments for Schrödinger operators; spectral theory of random Schrödinger operators and statistical mechanics
Tao Mei	Harmonic analysis for operator(matrix) valued functions, noncommutative martingales, operator space
Ditlev Monrad	Stochastic processes
Renming Song	Stochastic analysis, Markov processes, mathematical physics, mathematical finance
Richard Sowers	Applied stochastic processes, asymptotics of stochastic processes, randomly-perturbed dynamical systems, and stochastic PDE's

Faculty Members in Areas Related to Probability Theory

Lee Deville	Stochastic analysis, differential equations, dynamical systems
Burak Erdogan	Harmonic analysis on Euclidean spaces and related geometric measure theory problems, PDEs, probability
Zoltan Furedi	Theory of finite sets with applications in geometry, designs, and computer science
A. J. Hildebrand	Analytic number theory, probabilistic number theory, arithmetic functions
Eduard Kirr	Existence and stability of coherent structures in equations from mathematical physics, their coupling with radiation under perturbations, theory and numerical simulation of waves in homogeneous and random media.
Joseph Rosenblatt	Harmonic analysis, ergodic theory
Jang-Mei Wu	Potential theory, conformal mapping, exceptional sets, complex function theory