Mathematical Sciences

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The Mathematical Sciences department offers the following graduate degree programs:

- Master of Arts
- Master of Science
- Doctor of Philosophy
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Admission Requirements

In addition to fulfilling School of Graduate Studies admission requirements, all applicants for graduate study in mathematics or applied mathematics should have completed the equivalent of

- a complete calculus sequence,
- courses in linear algebra,
- abstract algebra,
- introduction to real analysis, and
- six additional semester hours in upper-division undergraduate mathematics courses.

Students deficient in more than two undergraduate courses in mathematics must remove these deficiencies before admission to the mathematics graduate program. Such students should consult the graduate program director of the department on how best to remove these deficiencies.

For unconditional admission, applicants must satisfy requirements of the School of Graduate Studies. Only the aptitude portion of the Graduate Record Examination (GRE) is required by the department.

Program Objective

Our objective is to provide excellent instruction and resources for the mathematics education of our students and to help produce the new generations of well-educated mathematicians that are critical for the progress of mankind. Our second objective is to have graduates prepared for careers in government, industry, teaching at a secondary school level, or for graduate study in mathematics, and be admitted to graduate school or employed within one year of graduation.

Learning Outcomes

Students will demonstrate:

- Critical thinking skills to construct clear, valid, and succinct proofs
- Knowledge of a variety of technological tools, including computer algebra systems, probability, statistical packages, or computer programming languages
- Good mathematical communication skills, including the ability to convey mathematical knowledge in a variety of settings, both orally and in writing

Master's Programs in Mathematical Sciences

The Master of Science degree is conferred under Plan I (thesis) or Plan II (non-thesis). Students should explore with their faculty advisor which plan is better for their particular objectives. For the M.S. degree, a Program of Study must include a minor area in the College of Engineering (http://catalog.uah.edu/search/?P=College%20of%20Engineering) or the College of Science (http://catalog.uah.edu/search/?P=College%20of%20Science). All minors must be outside of the department and must include at least six semester hours of approved graduate coursework. Master's programs that include a thesis (Plan I) require at least 18 semester hours of graduate coursework in mathematics and at least 24 semester hours of total graduate coursework, and programs without a thesis (Plan II) require at least 33 semester hours of graduate coursework and at least 24 semester hours of these should be in mathematics. At least 50 percent of the coursework semester hours must be completed in 600-level courses and 50 percent of mathematics courses should be numbered 609 or above. MA 538 (http://catalog.uah.edu/search/?P=MA%20538) and MA 544 (http://catalog.uah.edu/search/?P=MA%20544) should be included in every Program of Study.

Students should plan a Program of Study for the master's degree with the help of a faculty advisor prior to the completion of 12 semester hours of coursework. Courses taken without an approved Program of Study may not apply toward a degree. Various areas of mathematics may be stressed in the program of study depending on the student's needs. For example, the coursework for a non-thesis Program of Study concentrating in probability and statistics might be:

MA 538	METRIC SPACES W/APPLICA	3
MA 544	LINEAR ALGEBRA	3
MA 585	PROBABILITY	3
MA 653	REAL ANALYSIS I	3
MA 656	COMPLEX ANALYSIS I	3
MA 685	STOCHASTIC PROC/APPLI I	3
ST 687	THEORY OF STATISTICS I	3
MA 686	STOCHASTIC PROC/APPLI II	3
ST 787	THEORY OF STATISTICS II	3
Total Semester Hours		**27**

In addition, three approved graduate courses, including at least one mathematics course numbered 609 or above.

The coursework for a non-thesis program of study concentrating in numerical analysis might be:

MA 515	INTRO NUMERICAL ANALYSIS	3
MA 526	PARTIAL DIFF EQUA I	3
MA 538	METRIC SPACES W/APPLICA	3
MA 544	LINEAR ALGEBRA	3
MA 614	NUM METHODS/LINEAR ALGEBRA	3
MA 615	NUM METHODS PARTIAL DIFF EQ	3
MA 626	PARTIAL DIFF EQUA II	3
MA 715	NUM METHODS PART DIFF EQ II	3
Total Semester Hours		**24**

In addition, three approved graduate courses, including at least two mathematics courses numbered 609 or above.

Other possible concentration areas include differential equations and discrete mathematics.

Master's Degree Final Examination

A final comprehensive examination is required of all candidates for a master's degree. The candidate will be examined on the coursework and thesis in Plan I and on the coursework in Plan II. In the Mathematical Sciences Department this examination is oral, except that Plan II students who have passed a joint program examination for the Ph.D. degree in applied mathematics may use that examination as their master's degree final examination.

Mathematical Sciences, MA

Additional Information

Master of Arts with Class A Teaching Certification

Teachers who hold the Alabama Class B Middle/Junior High or High School Certificate may pursue a program of study in mathematics that leads to a Master of Arts degree with Alabama Class A certification. The coursework for such a Program of Study is as follows:

MA 538	METRIC SPACES W/APPLICA	3
MA 542	ALGEBRA	3
MA 544	LINEAR ALGEBRA	3
MA 585	PROBABILITY	3
MA 614	NUM METHODS/LINEAR ALGEBRA	3
MA 633	GEOMETRY	3
ST 687	THEORY OF STATISTICS I	3
9 semester hours of appropriate graduate education courses		9
One approved MA or ST course numbered 609 or above		3

Individuals who are interested in obtaining a Master of Arts degree with Alabama Class A certification in mathematics, but who have not completed more than 12 semester hours in teacher education (graduate or undergraduate) courses, should consider the Non-Traditional Fifth Year Program. The MA and ST courses given in the preceding paragraph would be appropriate for such a program. Students should contact the Education Department for preliminary advisement on admission, general program requirements, and more details on the Non-Traditional Fifth Year Program.

Applied Mathematics, PhD

The Ph.D. degree program in Applied Mathematics is designed to enable students to master a significant body of mathematics, including a specialty in Applied Mathematics; to relate this knowledge to a coherent area of science or engineering other than mathematics; and to carry on fundamental research in Applied Mathematics. Students who are interested in the program should contact the graduate program director of the department.

Each Program of Study requires at least 54 semester hours of graduate coursework, and must include a major area of concentration consisting of at least six courses in addition to the four common core courses, and a minor consisting of at least four related graduate courses in some area outside of the department. The major, minor, and other courses in the Program of Study must be selected so that the student will be prepared to conduct research in an area of Applied Mathematics.

Students must pass three examinations:

- Joint program examination
- Comprehensive qualifying examination
- Dissertation defense

The joint program examination is a written test of the student's ability to successfully pursue a Ph.D. in Applied Mathematics. It covers a four course common core in real analysis (MA 653 (http://catalog.uah.edu/search/?P=MA%20653), MA 654 (http://catalog.uah.edu/search/?P=MA%20654)) and linear and numerical linear algebra (MA 544 (http://catalog.uah.edu/search/?P=MA%20544), MA 614 (http://catalog.uah.edu/search/?P=MA%20614)). The joint program examination cannot be taken more than twice.

The comprehensive qualifying examination covers the entire Program of Study and the student's proposal for a dissertation topic, and is administered by the student's graduate study supervisory committee on behalf of the School of Graduate Studies. The examination is part written and part oral. It cannot be taken more than twice. Upon successful completion of the comprehensive qualifying examination and dissertation proposal, the student is admitted to candidacy for the Ph.D. degree.

The dissertation defense is an oral presentation of the dissertation in the form of a seminar before the student's graduate study supervisory committee. The dissertation is evidence that the student can independently identify a problem of contemporary significance through familiarity with the current literature in some area of Applied Mathematics, organize and execute a program of research, recognize and analyze the results, and present them in cogent, well-written exposition. It must include mathematical results suitable for publication in a nationally recognized journal.

The Ph.D. degree program in Applied Mathematics is a joint program with the other two campuses (Birmingham and Tuscaloosa) of the University of Alabama System. All requirements of the program can be completed at the University of Alabama in Huntsville.

MA 502 - INTRO TO REAL ANALYSIS
Semester Hours: 3

Individualized special projects in mathematics and its applications for inquisitive and wellprepared senior level undergraduate students. No credit allowed toward a major or minor in mathematics. S/U grading.

MA 503 - INTRO COMPLEX ANALYSIS
Semester Hours: 3

Complex algebra, analytic functions, Cauchy-Riemann equations, exponential, trigonometric, and logarithmic functions, integration, Cauchy integral theorem, Morera's theorem, Liouville's theorem, maximum modulus theorem, residue theory, Taylor and Laurent series, and applications.

MA 506 - METHODS PARTIAL DIFF EQUA
Semester Hours: 3

Survey of theory and methods for solving elementary partial differential equations. Topics include first-order equations and the method of characteristics, second-order equations, reduction to canonical form, the wave equation, the heat equation, Laplace's equation, separation of variables, and Fourier series.

MA 508 - APPLIED LINEAR ALGEBRA
Semester Hours: 3

Fundamental concepts of linear algebra are developed with emphasis on real and complex vector spaces, linear transformations, and matrices. Solving systems of equations, finding inverses of matrices, determinants, vector spaces, linear transformations, eigenvalues and eigenvectors, normal matrices, canonical forms of matrices, applications to systems of linear differential equations, and use of computer software such as MATLAB.

MA 515 - INTRO NUMERICAL ANALYSIS
Semester Hours: 3

Rigorous analysis and derivation of numerical methods for the approximate solution of nonlinear equations; interpolation and integration of functions, and approximating solutions of ordinary differential equations.

MA 520 - INTERM DIFFERENTIAL EQUATIONS
Semester Hours: 3

This is a second course in differential equations. Course topics include series solutions for second order differential equations and the method of Frobenious; eigenvalue and eigenvector methods for solving systems of linear first order equations; the qualitative theory of nonlinear equations; boundary value problems and the Sturm-Liouville theory. No credit given to students who have successfully completed MA 524.

MA 524 - DYNAMICAL SYSTEMS I
Semester Hours: 3

Scalar autonomous equations; existence, uniqueness, stability, elementary bifurcations; planar autonomous equations; general properties and geometry, conservative systems, elementary bifurcations linear systems, reduction to canonical forms, stability and instability from linearization. Liapunov functions, center manifolds, Hopf bifurcation.

MA 526 - PARTIAL DIFF EQUA I
Semester Hours: 3

Introduction to the theory for solving partial differential equations. No graduate credit given to students who have completed MA 506 for graduate credit. Topics include second-order equations, reduction to canonical form, well-posedness, the classical equations (wave, heat, and Laplace?s) in one and several dimensions, separation of variables, Fourier series, general eigenfunction expansions, Sturm-Liouville theory, first-order linear and quasilinear equations, and shocks. Prerequisite: MA 502.

MA 538 - METRIC SPACES W/APPLICA
Semester Hours: 3

Metric spaces, continuous functions, compactness, connectedness, completeness, Arzela-Ascoli theorem, Stone-Weierstrass theorem, Hilbert spaces, contraction mappings, applications to existence and uniqueness of solutions of differential and integral equations. Prerequisites: MA 502.

MA 539 - MULTIDIMENSIONAL ANALYSIS
Semester Hours: 3

Finite-dimensional Euclidean space and sequential approach to its topology, continuous functions and their properties, differentiability and implicit function theorem, Riemann integral, elements of vector calculus, flows and their generating vector fields, introduction to metric spaces. Prerequisite: MA 544.

MA 540 - COMBINATORIAL ENUMERATION
Semester Hours: 3

Counting, pigeonhole principle, permutations and combinations, generating functions, principle of inclusion and exclusion, Polya's theory of counting.

MA 542 - ALGEBRA
Semester Hours: 3

Topics from group theory and ring theory: subgroups, normal subgroups, quotient groups, homomorphisms, isomorphism theorems, ideals, principal ideal domains, Euclidean domains, fields, extension fields, elements of Galois theory.

MA 544 - LINEAR ALGEBRA
Semester Hours: 3

Vector spaces over a field, bases, linear transformations, matrices, determinants, eigenvalues, similarity, Jordan canonical forms, dual spaces, orthogonal and unitary transformations.

MA 561 - INTRO TO FOURIER ANALYSIS
Semester Hours: 3

See MA 460. This course is taught as MA 460/561. Course completion and/or grade requirements for the MA 561 course will differ from those for the MA 460 course.

MA 562 - INTERMEDIATE FOURIER ANALYSIS
Semester Hours: 3

(Formerly MA 560). Brief review of classical Fourier analysis, Parseval?s equality, Gaussian test functions. Introduction to generalized functions, the generalized transform, the generalized derivative, sequences and series of generalized functions, regular periodic arrays of delta functions, sampling, the discrete transform, the fast Fourier transform (other topics as time and interest permit).

MA 565 - INTERM MATH MODELING
Semester Hours: 3

Designed for beginning graduate students. No prior experience in formal mathematical modeling is required. In-depth discussion of some types of models from physics, the life sciences, and/or the social sciences, with formulation, analysis, and criticism of the models. Process of and factors involved in formulating a model is of prime importance. Content is divided into approximately one-half deterministic modeling and one-half stochastic modeling.

MA 585 - PROBABILITY
Semester Hours: 3

Course topics include probability spaces, random variables, conditional probability, independence, modes of convergence, and an introduction to sigma-algebras and measurability; distributions, including discrete, continuous, joint and marginal distributions, transformations of random variable, distribution and quantile functions, and convergence in distribution; expected value, including properties of general expected value, mean, variance, covariance, generating functions, and conditional expected value; special models and distributions, including Bernoulli trials and the binomial and negative binomial distributions, the Poisson model and the Poisson and gamma distributions, the normal distribution, finite sampling models and the hypergeometric distribution; the law of large numbers and the central limit theorem.

MA 590 - SELECTED TOPICS IN MATH
Semester Hours: 3

Requested selected topics.

MA 607 - MATHEMATICAL METHODS I
Semester Hours: 3

Review of vector calculus and coordinate systems, introduction to tensors, matrices, infinite series, complex variables with applications to calculus of residues, partial differential equations, and Sturm-Liouville theory. Orthogonal functions, gamma functions, Bessel functions, Legendre functions, special functions, Fourier series, integral transform and equations. (Same as PH 607.).

MA 609 - MATHEMATICAL METHODS II
Semester Hours: 3

Continuation of MA 607. (Same as PH 609.).

MA 614 - NUM METHODS/LINEAR ALGEBRA
Semester Hours: 3

Norms and vector spaces, matrix factorizations and direct solution methods, stability and conditioning, iterative methods for large linear systems, the algebraic eigenvalue problem.

MA 615 - NUM METHODS PARTIAL DIFF EQ
Semester Hours: 3

Finite difference methods for parabolic, elliptic, and hyperbolic partial differential equations, error analysis, stability, and convergence of finite difference methods.

MA 624 - DYNAMICAL SYSTEMS II
Semester Hours: 3

Brief review of linear systems; local theory for nonlinear systems; existence, uniqueness, differentiability, asymptotic behavior, the stable manifold theorem, Hartman-Grobman theorem, Hamiltonian systems; global theory for nonlinear systems; limit sets and attractors, the Poincare map, the Poincare-Bendixson theorem; some aspects of bifurcation theory and chaos; bifurcations at nonhyperbolic fixed points and periodic orbits, homoclinic bifurcations, Melnikov's method, chaos.

MA 626 - PARTIAL DIFF EQUA II
Semester Hours: 3

Continuation of MA 526. Qualitative results for solutions to the classical equations (energy inequalities, propagation of discontinuities, maximum principles, smoothness of solutions, existence and uniqueness, etc.), non-homogeneous equations, Poisson's equation, Green's functions, and the Cauchy-Kowalewski theorem.

MA 633 - GEOMETRY
Semester Hours: 3

Axioms of incidence and order, affine and metric properties, isometries, similarities, transformation groups, projective planes.

MA 638 - GENERAL TOPOLOGY
Semester Hours: 3

Set theory, logic, well-ordering principle, axiom of choice, topological spaces, product spaces, quotient spaces, continuous functions, connectedness, path connectedness, local connectedness, compactness, local compactness, countability and separation, generalized products, Tychonoff theorem.

MA 640 - GRAPH THEORY
Semester Hours: 3

Graphs, subgraphs, trees, connectivity, Euler tours, Hamilton cycles, matchings, edge colorings, independent sets, vertex colorings, planar graphs, Kuratowski?s theorem, four color theorem, directed graphs, networks, cycle and bond spaces.

MA 643 - GROUP THEORY
Semester Hours: 3

MA 644 - MATRIX THEORY
Semester Hours: 3

Functions of matrices, invariant polynomials, elementary divisors, similarity of matrices, normal forms of a matrix, matrix equations, generalized inverses, non-negative matrices, localization of igenvalues.

MA 645 - COMBINATORIAL DESIGN
Semester Hours: 3

Systems of distinct representatives, difference sets, coding theory, block designs, finite geometries, orthogonal Latin squares, and Hadamard matrices.

MA 653 - REAL ANALYSIS I
Semester Hours: 3

Countable sets, characterization of open and closed sets, Heine-Borel theorem, Riemann integral, Lebesgue measure and outer measure, measurable functions, Lebesgue integral, Fatou?s lemma, and Lebesgue-dominated convergence theorem.

MA 654 - REAL ANALYSIS II
Semester Hours: 3

Differentiability of monotone functions, functions of bounded variation, absolute continuity, convex functions, Minkowski and Holder inequalities, Lp spaces, Riesz-Fischer representation theorem, Fubini's theorem and selected topics.

MA 656 - COMPLEX ANALYSIS I
Semester Hours: 3

Topology of the complex plane, analytic functions of one complex variable, elementary functions and their mapping properties, power series, complex integration, Cauchy?s theorem and its consequences, isolated singularities, Laurent series, residue theory.

MA 658 - INTRO TO FUNCTIONAL ANALYSIS
Semester Hours: 3

Normed and inner product spaces, finite dimensional spaces, product and quotient spaces, equivalent norms, Hahn-Banach theorem, principle of uniform boundedness, openmapping theorem, Riesz representation theorem, complete orthonormal sets, Bessel's inequality, Parseval's identity, and conjugate spaces.

MA 661 - SPECIAL FUNCTIONS
Semester Hours: 3

MA 662 - ASYMPT/PERTURBATION METHOD
Semester Hours: 3

Asymptotic series, regular and singular perturbation theory, asymptotic matching, Laplace's method, stationary phase, steepest descents, WKB theory.

MA 667 - CALC VAR/OPTIMAL CONTROL
Semester Hours: 3

Euler necessary condition for local extremum, Euler-Lagrange equation, Weierstrass necessary condition, Jacobi?s necessary condition, corner conditions, problems of optimal control, Pontryagin maximum principles, transversality conditions, applications.

MA 685 - STOCHASTIC PROC/APPLI I
Semester Hours: 3

Discrete and continuous Markov chains, Poisson processes, counting and renewal processes, and applications.

MA 686 - STOCHASTIC PROC/APPLI II
Semester Hours: 3

Gaussian and Wiener processes, general Markov processes, special types of processes from queueing and risk theory, and selected advanced topics.

MA 690 - SP TOPICS IN MATHEMATICS
Semester Hours: 3

Offered upon demand. Advanced selected topics of interest in areas such as discrete mathematics, numerical analysis, differential equations, and stochastic processes.

MA 695 - GRADUATE SEMINAR
Semester Hour: 1

Selected topics in advanced mathematics, conducted as a research seminar.

MA 699 - MASTER'S THESIS
Semester Hours: 3-9

Required each semester a student is receiving direction on a master?s thesis. A minimum of two terms is required. Maximum of nine hours credit awarded upon successful completion of the master's thesis.

MA 715 - NUM METHODS PART DIFF EQ II
Semester Hours: 3

Finite element methods for parabolic, elliptic, and hyperbolic partial differential equations; error analysis stability, and convergence. Prerequisites: MA 538 and MA 615.

MA 726 - THRY PART DIFFERNTL EQUA
Semester Hours: 3

Hilbert space theory of existence, uniqueness, and regularity for partial differential equations.

MA 740 - COMBINATORIAL ALGORITHMS
Semester Hours: 3

Linear, polynomial and exponential graph theoretic algorithms, generating combinatorial objects, and NP-completeness.

MA 756 - COMPLEX ANALYSIS II
Semester Hours: 3

Applications of residue theory, harmonic functions and their applications, Mittag-Leffler theorem, infinite products, Weierstrass product theorem, conformal mapping and Riemann mapping theorem, univalent functions, analytic continuation and Riemann surfaces, Picard's theorems, and selected topics.

MA 785 - ADV PROBABILITY THEORY
Semester Hours: 3

Measure and integration, probability spaces, convergence concepts, law of large numbers, random series, characteristic functions, central limit theorem, random walks, conditioning, Markov properties, conditional expectations, and elements of martingale theory.

MA 790 - SPECIAL TOPICS
Semester Hours: 3

Offered upon demand. Advanced selected topics of interest in areas such as discrete mathematics, numerical analysis, differential equations, and stochastic processes.

MA 795 - GRADUATE SEMINAR
Semester Hour: 1

Selected topics in advanced mathematics, conducted as a research seminar.

MA 799 - DOCTORAL DISSERTATION
Semester Hours: 3-9

Required each semester a student is receiving direction on a Ph.D. dissertation.