Mathematical Sciences (MASC)

Faculty
John R. Akeroyd, Professor
Mark E. Arnold, Associate Professor
Ariel Barton, Assistant Professor
Dennis W. Brewer, Professor
Avishek Chakraborty, Assistant Professor
Matt Clay, Associate Professor
Jyotisha Datta, Assistant Professor
Matthew B. Day, Associate Professor
Shannon Wayne Dingman, Associate Professor
William A. Feldman, Professor
Chaim Goodman-Strauss, Professor
Phil Harrington, Associate Professor
Edmund O. Harriss, Clinical Assistant Professor
Mark Johnson, Professor
Deborah Korth, Clinical Associate Professor
Daniel H. Luecking, Professor
Paolo Mantero, Assistant Professor
Wenbo Niu, Assistant Professor
Giovanni Petris, Professor
Andrew Seth Raich, Associate Professor
Yo'av Rieck, Professor
John Ryan, Professor
Boris M. Schein, Distinguished Professor
Maria Tjani, Associate Professor
Jeremy Van Horn-Morris, Assistant Professor
Janet C. Woodland, Clinical Assistant Professor
Qingyang Zhang, Assistant Professor

Mark Johnson
Department Chair
309 Science Engineering Building
479-575-3351
E-mail: markj@uark.edu

Maria Tjani
Graduate Coordinator
321B Science Engineering Building
479-575-7309
E-mail: mtjani@uark.edu

Department of Mathematical Sciences website (http://fulbright.uark.edu/departments/math)

Degrees Conferred:
M.S., Ph.D. (MATH)
M.A. in Secondary Mathematics (SMTH)

Primary Areas of Faculty Research: Analysis, algebra, geometric topology, numerical analysis, statistics.

Master of Science in Mathematics
Prerequisites to Degree Program: Prospective candidates for the Master of Science degree in Mathematics are expected to have completed a program equivalent to that required by the department for a B.S. degree, as set forth in the current catalog of the Fulbright College of Arts and Sciences. Deficiencies may be removed either by taking the appropriate undergraduate courses or by examination. In addition to the application for admission to the Graduate School and the transcripts required for Graduate School admission, applicants for admission to the degree programs of the Department of Mathematical Sciences must submit a) three letters of recommendation from persons familiar with the applicant’s previous academic and professional performance and b) official scores from the Graduate Record Examination (General Test).

The degree of Master of Science is intended for collegiate teachers of mathematics, non-teaching professional mathematicians, and those who desire to continue advanced study.

Requirements for the Master of Science Degree: This degree is offered under three separate options: a general option, a computational mathematics option, and a thesis option. The general and thesis options are intended for students who plan to be collegiate teachers of mathematics, continue advanced study in mathematics, or obtain a broad background for preparation as a non-teaching professional mathematician. The computational mathematics option is intended for students who intend to specialize in computational and applied mathematics in preparation for professional employment in an interdisciplinary or computationally intensive environment.

The program of a candidate will be determined in conference with the candidate’s graduate adviser. A comprehensive examination must be passed by each candidate for the Master of Science degree. It should be taken near the end of the last semester of residence. At least four weeks prior to the scheduled date, students must notify the department of their intention to take the examination. No student may take the comprehensive examination more than three times. MATH 5001, MATH 504V, MATH 507V, MATH 5013, and MATH 5033 are not applicable to the Master of Science degree in mathematics. The program will include at least two semesters of one-hour credit in MATH 510V Mathematics Seminar.

All candidates must complete a minimum of 32 semester hours of approved graduate course work, including 12 semester hours in mathematics at the 5000-6000 level (excluding MATH 510V). All selected courses are subject to the approval of the Graduate Committee.

Students in the general option may include up to nine semester hours of graduate work in courses outside the department. The comprehensive examination for the general option will be a written exam including material covered in graduate course work. The candidate for the computational mathematics option must include at least six but not more than twelve semester hours of graduate work in courses outside of mathematics. The comprehensive examination for the computational mathematics option will be similar to the examination for the general option but must include material covered in six semester hours of MATH 5393 (formerly MATH 4353) and MATH 5383 (formerly MATH 4363).

Students in the thesis option must complete 6 semester hours of MATH 610V with the candidate’s thesis adviser, which will count toward the 32 semester hours of approved graduate course work. In addition to a written comprehensive exam, the candidate will be required to complete an oral defense of the thesis. Reading copies of the thesis should be delivered to members of the Thesis Committee at least three weeks prior to undertaking the final examination.
Students should also be aware of Graduate School requirements with regard to master’s degrees (http://catalog.uark.edu/graduatecatalog/degreerequirements/#mastersdegreestext).

**Master of Arts in Secondary Mathematics**

Requirements for the Master of Arts Degree with a Major in Secondary Mathematics: This program is designed for secondary school teachers of mathematics. It requires 30 semester hours of graduate work.

Prospective candidates for the Master of Arts degree in secondary mathematics are expected to have earned a baccalaureate degree or equivalent with a major in a mathematical science (mathematics, statistics, operations research, or computer science), engineering, or a physical science, and credit in courses equivalent to MATH 2564, MATH 3083, MATH 3113, and MATH 3773.

The program has four components in which to earn a minimum of 30 semester hours of credit:

1. Graduate course work in mathematics content and content-based pedagogy. At least 12 hours of credit in graduate course work specifically designed for preparation for teaching secondary mathematics. The content will include probability, statistics, algebra, geometry, applied mathematics and advanced calculus with connections to secondary school mathematics. At least one of the courses must be in probability and statistics; one in algebra; and one in advanced calculus. Candidates will sit for examinations in three of the following areas: probability and statistics; algebra; geometry; advanced calculus; and mathematics education. Candidates will also present a portfolio describing the body of work with samples of student work and explanations of connections to secondary school mathematics. These courses are to be selected from:

   - MATH 4153 Mathematical Modeling (Irregular) 3
   - STAT 4003 Statistical Methods (Sp, Fa) (with corequisite STAT 4001L) 3
   - STAT 5103 Introduction to Probability Theory (Fa) 3
   - MATH 5001 Connections to School Mathematics (Irregular) 1
   - MATH 5013 Abstract Algebra with Connections to School Mathematics (Irregular) 3
   - MATH 5033 Advanced Calculus with Connections to School Mathematics Teaching (Irregular) 3
   - MATH 5153 Advanced Linear Algebra (Fa) (Formerly MATH 4103) 3
   - MATH 5393 Numerical Linear Algebra (Sp) (formerly MATH 4353) 3

   Other graduate mathematics or statistics courses may be used in place of these courses with the approval of the student’s committee.

2. Independent study and research in mathematics or mathematics education. From three to six hours of credit is available in independent study and research under the direction of mathematical sciences faculty. The results will be evidenced by a report roughly equivalent to a master’s thesis.

3. Advanced work in professional teacher preparation. Up to six hours of credit in MATH 507V is available for advanced work in preparation for teaching AP calculus, AP statistics, International Baccalaureate (IB) mathematics, or for achieving National Board Certification in (Adolescence and Young Adulthood) Mathematics. Other professional development activities with quality control features similar to those of the AP, IB, and National Board programs may be presented for consideration for credit. All such work must be sanctioned by the sponsoring organizations.

4. Graduate courses in education. Up to six hours of credit is available in graduate courses in education. The student’s committee must approve the courses. Recommended courses include:

   - CIED 5483 Teaching Mathematics (Irregular) 3
   - CIED 6013 Curriculum Theory, Development, and Evaluation (Odd years, Fa) 3
   - CIED 6023 Instructional Theory (Irregular) 3
   - CIED 6033 Content Specific Pedagogy (Irregular) 3
   - CIED 6043 Analysis of Teacher Education (Odd years, Sp) 3
   - CIED 6053 Curriculum and Instruction: Learner Assessment and Program Evaluation (Even years, Fa) 3

Other graduate courses in education may be used in place of these courses with the approval of the student’s advisory committee.

If allowed by Graduate School rules, credit previously earned may be applied to the requirements for this degree with the approval of the student’s advisory committee.

Each person receiving the Master of Arts degree in secondary mathematics must pass a written examination in three of the following areas: probability and statistics; algebra; geometry; advanced calculus; and mathematics education. No student will be allowed to take the examination more than three times. Candidates will also present a portfolio describing the body of work with samples of their work as students and explanations of connections to secondary school mathematics.

Students should also be aware of Graduate School requirements with regard to master’s degrees (http://catalog.uark.edu/graduatecatalog/degreerequirements/#mastersdegreestext).

**Doctor of Philosophy in Mathematics**

Requirements for the Doctor of Philosophy Degree: Candidates for the degree of Doctor of Philosophy with a major in mathematics will be required to earn not less than 60 semester hours of course credit beyond the bachelor’s degree in mathematics and closely related fields. The number of hours and the courses for each student will be determined by the advisory committee. The candidate must fulfill the course requirements for the Master of Science degree in mathematics.

The basic requirement for the Ph.D. degree is the preparation of an acceptable dissertation. This dissertation must demonstrate the candidate’s ability to do independent, original, and significant work in mathematics. It is required that this dissertation possess the degree of excellence of research papers ordinarily published in the leading mathematical journals.

Students should also be aware of Graduate School requirements with regard to doctoral degrees (http://catalog.uark.edu/graduatecatalog/degreerequirements/#phdandddegreestext).

A comprehensive examination is given each year during the weeks preceding the beginning of the fall and spring semesters. This examination is taken by all students in the graduate program who have completed the course requirements for the M.S. degree. The prospective candidate for the Ph.D. will be allowed to take the examination at most two times. A second failure to qualify eliminates a student from the graduate program in mathematics. After qualifying, a candidacy
examination will be given covering the intended areas of specialization beyond the level of the qualifying comprehensive examination. It may be repeated once.

Students who wish to specialize in mathematics education must complete and pass qualifying examinations in two graduate sequences in mathematics plus one in mathematics education. Students must complete two of MATH 5013, MATH 5023, and MATH 5053 that are not in the topics of the two graduate qualifying sequences in mathematics. Students must complete four education graduate courses to study quantitative methods in education research and qualitative methods in education research. The recommended courses are ESRM 6413, ESRM 6423, ESRM 6533, and ESRM 6653, although these may be altered depending on the student’s previous study of STAT courses. Students must complete 15 hours of independent study in mathematics education to prepare for dissertation research. The areas of this study are: K-14 curriculum; learning theory; art of teaching and teacher education; and assessment and technology. The 15 hours must include a three-hour research project that will result in a pre-dissertation research report.

In addition to extending knowledge by personal reading and research, a doctoral graduate in mathematics will normally communicate knowledge to others. Therefore each student in the Ph.D. program is required to acquire the equivalent of one semester of full-time experience in teaching; this requirement may be fulfilled by part-time experience over several semesters. Typically, teaching assistantship appointments will satisfy this requirement, but other similar experience may qualify as approved by the department.

Courses

MATH 405V. Internship in Professional Practice. 1-3 Hour.
Professional work experience involving significant use of mathematics or statistics in business, industry or government. Prerequisite: Departmental consent. May be repeated for up to 3 hours of degree credit.

MATH 4113. Introduction to Abstract Algebra II (Sp). 3 Hours.
Topics in abstract algebra including finite abelian groups, linear groups, factorization in commutative rings and Galois theory. Prerequisite: MATH 3113.

MATH 4153. Mathematical Modeling (Irregular). 3 Hours.
Mathematical techniques for formulating, analyzing, and criticizing deterministic models taken from the biological, social, and physical sciences. Techniques include graphical methods, stability, optimization, and phase plane analysis. Prerequisite: MATH 2584.

MATH 4163. Dynamic Models in Biology (Irregular). 3 Hours.
Mathematical and computational techniques for developing, executing, and analyzing dynamic models arising in the biological sciences. Both discrete and continuous time models are studied. Applications include population dynamics, cellular dynamics, and the spread of infectious diseases. Prerequisite: MATH 2554. This course is cross-listed with BIOL 4163.

MATH 4253. Symbolic Logic I (Fa). 3 Hours.
Rigorous analyses of the concepts of proof, consistency, equivalence, validity, implication, and truth. Full coverage of truth-functional logic and quantification theory (predicate calculus). Discussion of the nature and limits of mechanical procedures (algorithms) for proving theorems in logic and mathematics. Informal accounts of the basic facts about infinite sets. Prerequisite: MATH 2603, MATH 2803, or PHIL 2203. This course is cross-listed with PHIL 4253.

MATH 4443. Complex Variables (Fa). 3 Hours.
Complex analysis, series, and conformal mapping. Additional applications for graduate credit. Prerequisite: MATH 2603 or MATH 2803, and MATH 2584 or MATH 2584C.

MATH 4503. Differential Geometry (Irregular). 3 Hours.
Topics include: classical differential geometry of curves and surfaces in 3-space, differential forms and vector fields. Prerequisite: MATH 2574 or MATH 2574C.

MATH 499V. Research Topics in Mathematics (Irregular). 1-3 Hour.
Current research interests in mathematics, at an advanced undergraduate or beginning graduate level. Prerequisite: Departmental consent. May be repeated for up to 12 hours of degree credit.

MATH 5001. Connections to School Mathematics (Irregular). 1 Hour.
This course is a supplement to any graduate course in statistics, algebra, analysis, or geometry. The purpose is to connect the content of the graduate course to school mathematics. Prerequisite: Departmental consent. May be repeated for up to 6 hours of degree credit.

MATH 5013. Abstract Algebra with Connections to School Mathematics (Irregular). 3 Hours.
Basic structures of abstract algebra (rings, fields, groups, modules and vector spaces) with emphasis on rings and fields as generalizations of the ring of integers and field of rational numbers. Degree credit will not be awarded for both MATH 4113 (or MATH 5123) plus MATH 5001 and for MATH 5013. Prerequisite: Graduate standing or departmental consent.

MATH 5023. Geometry with Connections to School Mathematics (Odd years, Fa). 3 Hours.
School geometry from an advanced perspective including conformity to the Common Core State Standards for Mathematics. Study will include historical developments and geometry based on transformations of two- and three-dimensional space. Prerequisite: Graduate standing.

MATH 5033. Advanced Calculus with Connections to School Mathematics Teaching (Irregular). 3 Hours.
Rigorous development of the real numbers, continuity, differentiation, and integration. Degree credit will not be awarded for both MATH 4513 (or MATH 5503) plus MATH 5001 and for MATH 5033. Prerequisite: Departmental consent.

MATH 504V. Special Topics for Teachers (Irregular). 1-6 Hour.
Current topics in mathematics of interest to secondary school teachers. Prerequisite: Graduate standing or departmental consent. May be repeated for degree credit.

MATH 5053. Probability & Statistics with Connections to School Mathematics (Sp). 3 Hours.
An advanced perspective of probability and statistics as contained in the high school mathematics curriculum with connections to other components of school mathematics. The content is guided by the content of the high school probability and statistics of the Common Core State Standards for Mathematics. Prerequisite: Graduate standing.

MATH 507V. Professional Development for Secondary Mathematics Teaching (Irregular). 1-3 Hour.
Validated participation in professional development mathematics workshops or institutes sanctioned by national or international educational organizations such as the College Board, International Baccalaureate Program, and the National Board for Professional Teaching Standards. Prerequisite: Enrollment in Secondary Mathematics Teaching, MA degree program or departmental consent. May be repeated for up to 6 hours of degree credit.

MATH 510V. Mathematical Seminar (Sp, Fa). 1-3 Hour.
Mathematical and computational techniques for developing, executing, and criticizing deterministic models taken from the biological, social, and physical sciences. Techniques include graphical methods, stability, optimization, and phase plane analysis. Prerequisite: MATH 2584. This course is cross-listed with BIOL 4163.

MATH 5123. Algebra I (Fa). 3 Hours.
What the beginning graduate student should know about algebra: groups, rings, fields, modules, algebras, categories, homological algebra, and Galois Theory. Prerequisite: MATH 3113, and graduate standing in mathematics or statistics, or departmental consent.
MATH 5133. Algebra II (Sp). 3 Hours.
Continuation of MATH 5123. Prerequisite: MATH 5123, and graduate standing in mathematics or statistics.

MATH 5153. Advanced Linear Algebra (Fa). 3 Hours.
(Formerly MATH 4103.) Linear functionals, matrix representation of linear transformations, scalar product, and spectral representation of linear transformations. Graduate degree credit will not be given for both MATH 4103 and MATH 5153. Prerequisite: Graduate standing.

MATH 5213. Advanced Calculus I (Fa). 3 Hours.
(Formerly MATH 4513.) The real and complex number systems, basic set theory and topology, sequences and series, continuity, differentiation, and Taylor's theorem. Emphasis is placed on careful mathematical reasoning. Graduate degree credit will not be given for both MATH 4513 and MATH 5213. Prerequisite: Graduate standing.

MATH 5223. Advanced Calculus II (Sp). 3 Hours.
(Formerly MATH 4523.) The Riemann-Stieltjes integral, uniform convergence of functions, Fourier series, implicit function theorem, Jacobians, and derivatives of higher order. Graduate degree credit will not be given for both MATH 4523 and MATH 5223. Prerequisite: MATH 4513 or MATH 5213 (formerly MATH 4513).

MATH 5303. Ordinary Differential Equations (Fa). 3 Hours.
Existence, uniqueness, stability, qualitative behavior, and numerical solutions. Prerequisite: MATH 2584 and MATH 4513, and graduate standing in mathematics or statistics, or departmental consent.

MATH 5313. Partial Differential Equations (Sp). 3 Hours.
Classification, boundary value problems, applications, and numerical solutions. Prerequisite: MATH 4423 and MATH 4513, and graduate standing in mathematics or statistics, or departmental consent.

MATH 5333. Scientific Computation and Numerical Methods (Fa). 3 Hours.
An introduction to numerical methods used in solving various problems in engineering and the sciences. May not earn credit for this course and MATH 4353 or MATH 4363. Prerequisite: Graduate standing in mathematics or statistics, or departmental consent. This course is cross-listed with PHYS 5363.

MATH 5383. Numerical Analysis (Fa). 3 Hours.
(Formerly MATH 4363.) General iterative techniques, error analysis, root finding, interpolation, approximation, numerical integration, and numerical solution of differential equations. Graduate degree credit will not be given for both MATH 4363 and MATH 5383. Prerequisite: Graduate standing.

MATH 5393. Numerical Linear Algebra (Sp). 3 Hours.
(Formerly MATH 4353.) Numerical methods for problems of linear algebra, including the solution of very large systems, eigenvalues, and eigenvectors. Graduate degree credit will not be given for both MATH 4353 and MATH 5393. Prerequisite: Graduate standing.

MATH 5423. Introduction to Partial Differential Equations (Sp, Fa). 3 Hours.
Matrices, Fourier analysis, and partial differential equations. Does not count towards degree credit in MATH. Prerequisite: Graduate standing.

MATH 5453. Functional Analysis I (Odd years, Sp). 3 Hours.
Banach Spaces, Hilbert Spaces, operator theory, compact operators, dual spaces and adjoints, spectral theory, Hahn-Banach, open mapping and closed graph theorems, uniform boundedness principle, weak topologies. Prerequisite: MATH 5513, and graduate standing in mathematics or statistics, or departmental consent.

MATH 5503. Theory of Functions of a Real Variable I (Fa). 3 Hours.
Real number system, Lebesque measure, Lebesque integral, convergence theorems, differentiation of monotone functions, absolute continuity and the fundamental theorem of calculus L^P spaces, Holder and Minkowski inequalities, and bounded linear functionals on the L^P spaces. Prerequisite: MATH 4523 or MATH 5223 (formerly MATH 4523), and graduate standing in mathematics or statistics, or departmental consent.

MATH 5513. Theory of Functions of a Real Variable II (Sp). 3 Hours.
Measure and integration on abstract measure spaces, signed measures, Hahn decomposition, Radon-Nikodym theorem, Lebesque decomposition, measures on algebras and their extensions, product measures, and Fubini's theorem. Prerequisite: MATH 5503, and graduate standing in mathematics or statistics, or departmental consent.

MATH 5523. Theory of Functions of a Complex Variable I (Fa). 3 Hours.
Complex numbers, analytic functions, power series, complex integration, Cauchy's Theorem and integral formula, maximum principle, singularities, Laurent series, and Mobius maps. Prerequisite: MATH 4513 or MATH 5213 (formerly MATH 4513).

MATH 5533. Theory of Functions of a Complex Variable II (Sp). 3 Hours.
Riemann Mapping Theorem, analytic continuation, harmonic functions, and entire functions. Prerequisite: MATH 5523, and graduate standing in mathematics or statistics, or departmental consent.

MATH 5703. Topology I (Even years, Fa). 3 Hours.
An introduction to topology. Topics include metric spaces, topological spaces and general point-set topology, homotopy and the fundamental group, covering spaces, the classification of surfaces. Prerequisite: MATH 4513 or MATH 5213 (formerly MATH 4513), and graduate standing in mathematics or statistics, or departmental consent.

MATH 5713. Topology II (Odd years, Sp). 3 Hours.
The continuation of Topology I. Topics include: advanced homotopy and covering spaces, the Seifert-van Kampen theorem, homology and the Mayer-Vietoris sequence. Prerequisite: MATH 5703, and graduate standing in mathematics or statistics, or departmental consent.

MATH 5723. Differential Topology I (Odd years, Fa). 3 Hours.
An introduction to the topology of smooth manifolds: applications of the inverse function theorem to smooth maps, Sard's theorem, transversality, intersection theory, degrees of maps, vector fields and differential forms on manifolds, integration on manifolds. Prerequisite: MATH 4513 or MATH 5213 (formerly MATH 4513) and graduate standing in mathematics or statistics, or departmental consent.

MATH 5733. Differential Topology II (Even years, Sp). 3 Hours.
The continuation of Differential Topology I, with additional advanced topics. Possible advanced topics may include: Morse theory, de Rham cohomology theory, Poincare duality, Riemannian geometry, and Lie groups and Lie algebras. Prerequisite: MATH 5723 and graduate standing in mathematics or statistics, or departmental consent.

MATH 589V. Topics in Math Education (Sp, Su, Fa). 1-6 Hours.
Topics in mathematics education research including curriculum, teacher education, learning theory, and assessment. Prerequisite: Graduate standing. May be repeated for up to 12 hours of degree credit.

MATH 609V. Topics in Math Education (Sp, Su, Fa). 1-6 Hour.
Current research interests in algebra. Prerequisite: Graduate standing in mathematics or statistics, or departmental consent. May be repeated for degree credit.
MATH 659V. Topics in Analysis (Sp, Su, Fa). 1-6 Hour.
Current research interests in analysis. Prerequisite: Graduate standing in mathematics or statistics, or departmental consent. May be repeated for degree credit.

MATH 679V. Topics in Topology (Sp, Su, Fa). 1-6 Hour.
Current research interest in topology. Prerequisite: Graduate standing in mathematics or statistics, or departmental consent. May be repeated for degree credit.

MATH 700V. Doctoral Dissertation (Sp, Su, Fa). 1-18 Hour.
Doctoral Dissertation. Prerequisite: Doctoral candidacy in mathematics. May be repeated for degree credit.