Mathematics lies at the foundation of many disciplines in the sciences, engineering fields, and the social sciences, and this influence is growing as these subjects become increasingly quantitative. Recognizing this important role in the wide variety of directions available to our degree recipients, the program in mathematics provides undergraduates with a spectrum of choices. These range from nontheoretical treatments of calculus and courses in combinatorics, elementary number theory, and projective geometry to a broad variety of sophisticated mathematics, including real and complex analysis, differential geometry, abstract algebra, algebraic and geometric topology, algebraic geometry, dynamics, and partial differential equations.

Faculty research interests range from differential geometry, ergodic theory, group representations, partial differential equations, and probability to real analysis, mathematical physics, complex variables, algebraic geometry, number theory, combinatorics, geometric topology, algebraic topology, and dynamics.

**Bachelor's Programs**
- Bachelor of Arts (BA) Degree with a Major in Mathematics (ga.rice.edu/programs-study/departments-programs/natural-sciences/mathematics/mathematics-ba)
- Bachelor of Science (BS) Degree with a Major in Mathematics (ga.rice.edu/programs-study/departments-programs/natural-sciences/mathematics/mathematics-bs)

**Minor**
- Minor in Mathematics (ga.rice.edu/programs-study/departments-programs/natural-sciences/mathematics/mathematics-minor)

**Master's Program**
- Master of Arts (MA) Degree in the field of Mathematics*

**Doctoral Program**
- Doctor of Philosophy (PhD) Degree in the field of Mathematics (ga.rice.edu/programs-study/departments-programs/natural-sciences/mathematics/mathematics-phd)

* Although students are not normally admitted to a Master of Arts (MA) degree program, graduate students may earn the MA as they work towards the PhD.

**Chair**
Michael Wolf

**Professors**
- Michael Boshernitzan
- David Damanik
- Robert M. Hardt
- Shelly Harvey
- Frank Jones
- Alexander Kiselev
- Alan Reid
- Stephen W. Semmes

**Associate Professors**
- Zhiyong Gao
- Anthony Varilly-Alvarado

**Assistant Professors**
- Gregory Chambers
- Milivoje Lukic
- Ronen Mukamel

**Professors Emeriti**
- Robin Forman
- F. Reese Harvey
- John Hempel
- John C. Polking
- Raymond S. Wells

**Sr. Instructor**
- Stephen Wang

**Instructors**
- Gokalp Alpan
- Jennifer Berg
- John Calabrese
- Anastassia Etropolski
- Neil Fullarton
- Betul Orcan-Ekmekci
- Siran Li
- Arindam Roy
- Selim Sukhataiev
- Changhui Tan

**Clinical Assistant Professor**
- Robin Ward (with RUSMP)

**Adjunct Faculty**
- Ray Johnson

**Research Professor**
- Michael Field

For Rice University degree-granting programs:
To view the list of official course offerings, please see Rice's Course Catalog (https://courses.rice.edu/admweb/!SWKSCAT.cat?p_action=cata)
To view the most recent semester's course schedule, please see Rice's Course Schedule (https://courses.rice.edu/admweb/!SWKSCAT.cat)
Mathematics (MATH)

MATH 101 - SINGLE VARIABLE CALCULUS I
Short Title: SINGLE VARIABLE CALCULUS I
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Lower-Level
Description: Limits, continuity, differentiation, integration, and the Fundamental Theorem of Calculus. Mutually Exclusive courses may only be taken with instructor permission. May substitute MATH 111-112 or take MATH 101 after completing MATH 111. Should not be taken if student already has credit for MATH 102, MATH 211, MATH 212, or MATH 221, without permission. Mutually Exclusive: Credit cannot be earned for MATH 101 and MATH 112.
Course URL: math.rice.edu

MATH 102 - SINGLE VARIABLE CALCULUS II
Short Title: SINGLE VARIABLE CALCULUS II
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Lower-Level
Description: Continuation of MATH 101. Includes further techniques of integration, the Fundamental Theorem of Calculus, techniques of integration and applications. Should not be taken if student already has credit for MATH 102, MATH 211, MATH 212, or MATH 221, without permission. Mutually Exclusive: Credit cannot be earned for MATH 112 and MATH 101.
Course URL: math.rice.edu

MATH 111 - CALCULUS: DIFFERENTIATION AND ITS APPLICATIONS
Short Title: CALCULUS: DIFFERENTIATION
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Lower-Level
Description: Study of calculus, forming with MATH 112 a version of MATH 101/102 that does not cover infinite series. MATH 111 covers functions, limits, continuity, and derivatives and their applications. Mutually Exclusive courses may only be taken with instructor permission. Should not be taken if student already has credit for MATH 101, MATH 102, MATH 112, MATH 211, MATH 212, or MATH 221 without permission.
Course URL: math.rice.edu

MATH 112 - CALCULUS: INTEGRATION AND ITS APPLICATIONS
Short Title: CALCULUS: INTEGRATION + APPS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Lower-Level
Description: Continuation of the study of calculus from MATH 111. Integration, the Fundamental Theorem of Calculus, techniques of integration and applications. Should not be taken if student already has credit for MATH 102, MATH 211, MATH 212, MATH 221, without permission. Mutually Exclusive: Credit cannot be earned for MATH 112 and MATH 101.
Course URL: math.rice.edu

MATH 211 - ORDINARY DIFFERENTIAL EQUATIONS AND LINEAR ALGEBRA
Short Title: ORD DIFFERENTIAL EQUATIONS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Lower-Level
Description: Study of ordinary differential equations (e.g., solutions to separable and linear first-order equations and to higher-order linear equations with constant coefficients, the properties of solutions to differential equations, and numerical solution methods) and linear algebra (e.g., vector spaces and solutions to algebraic linear equations, dimension, eigenvalues, and eigenvectors of a matrix), as well as the application of linear algebra to first-order systems of differential equations and the qualitative theory of nonlinear systems and phase portraits.
Course URL: math.rice.edu

MATH 212 - MULTIVARIABLE CALCULUS
Short Title: MULTIVARIABLE CALCULUS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Lower-Level
Description: Calculus of multiple variables. Vectors, partial derivatives and gradients, double and triple integrals, vector fields, line and surface integrals, Green's theorem, Stokes's theorem, and Gauss's theorem. May substitute Math 221 and 222. Mutually Exclusive: Credit cannot be earned for MATH 212 and MATH 222.
Course URL: math.rice.edu
MATH 221 - HONORS CALCULUS III
Short Title: HONORS CALCULUS III
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Lower-Level
Description: This course and MATH 222 include the material of MATH 212 and much more. Topology of R^n, calculus for functions of several variables, linear and multilinear algebra, theory of determinants, inner product spaces, integration on manifolds.

MATH 222 - HONORS CALCULUS IV
Short Title: HONORS CALCULUS IV
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Lower-Level
Description: See MATH 221. A student may not receive credit for both MATH 222 and MATH 212. Mutually Exclusive: Credit cannot be earned for MATH 222 and MATH 212.

MATH 238 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Internship/Practicum, Lecture, Laboratory, Seminar
Credit Hours: 1-4
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Lower-Level
Description: Topics and credit hours may vary each semester. Contact Department for current semester’s topic(s). Repeatable for Credit.

MATH 300 - TOPICS IN UNDERGRADUATE MATH
Short Title: TOPICS IN UNDERGRADUATE MATH
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 102
Description: Treatment of topics in undergraduate mathematics. Topics vary by year. May be repeated for credit with permission of department.
Course URL: math.rice.edu

MATH 302 - ELEMENTS OF ANALYSIS
Short Title: ELEMENTS OF ANALYSIS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 102
Description: Introductory treatment of topics in analysis and topology, with the real line as a central example. Techniques include connected and compact sets, sequences and subsequences, continuity, and uniform approximation. Clear, cogent, and complete mathematical arguments are emphasized.

MATH 304 - ELEMENTS OF KNOT THEORY
Short Title: ELEMENTS OF KNOT THEORY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 221 or MATH 354 or MATH 355
Description: Introduction to the mathematical theory of knots. Techniques to distinguish knots from one another, Reidemeister moves, mod-p colorings, knot determinants, knot polynomials, Seifert surfaces, Euler characteristic, knot groups, and untying knots in four dimensions. We will also discuss open problems in knot theory.
Course URL: math.rice.edu

MATH 306 - ELEMENTS OF ABSTRACT ALGEBRA
Short Title: ELEMENTS OF ABSTRACT ALGEBRA
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (MATH 354 or MATH 355) and (MATH 302 or MATH 354 or MATH 221)
Description: Introductory treatment of the basic structures of abstract algebra: groups, rings, and fields. Clear, cogent, and complete mathematical arguments are emphasized. A student may not receive credit for both MATH 306 and MATH 356. Mutually Exclusive: Credit cannot be earned for MATH 306 and MATH 356.
Course URL: math.rice.edu
MATH 321 - INTRODUCTION TO ANALYSIS I
Short Title: INTRODUCTION TO ANALYSIS I
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 221 or MATH 354 or MATH 302
Description: A thorough treatment of the foundations of real analysis such as metric spaces, compactness, sequences and series of functions, differentiation, Riemann integration. Mutually Exclusive: Credit cannot be earned for MATH 321 and MATH 331.
Course URL: math.rice.edu

MATH 322 - INTRODUCTION TO ANALYSIS II
Short Title: INTRODUCTION TO ANALYSIS II
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 321 or MATH 331
Description: Further study in real analysis. Possible topics include analysis in higher dimensions, Hilbert spaces, Fourier series, Sturm-Liouville theory. Repeatable for Credit.
Course URL: math.rice.edu

MATH 331 - HONORS ANALYSIS
Short Title: HONORS ANALYSIS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 221 or MATH 302 or MATH 354
Description: A careful treatment of basic topics in real analysis, including metric spaces and their topology, sequences and series, continuity, and differentiation. The content of this course is similar to that of MATH 321, but the intensity and conceptual level will be higher. Mutually Exclusive: Credit cannot be earned for MATH 331 and MATH 321.
Course URL: math.rice.edu

MATH 354 - HONORS LINEAR ALGEBRA
Short Title: HONORS LINEAR ALGEBRA
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Description: Vector spaces, linear transformations and matrices, theory of systems of linear equations, determinants, eigenvalues and diagonalizability, inner product spaces; and optional material chosen from: dual vector spaces, spectral theorem for self-adjoint operators, Jordan canonical form. Content is similar to that of MATH 355, but with more emphasis on theory. The course will include instruction on how to construct mathematical proofs. This course is appropriate for potential Mathematics majors and others interested in learning how to construct rigorous mathematical arguments. Recommended Prerequisite(s): A 200-level math class. Mutually Exclusive: Credit cannot be earned for MATH 354 and MATH 355.
Course URL: math.rice.edu

MATH 355 - LINEAR ALGEBRA
Short Title: LINEAR ALGEBRA
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Description: Linear transformations and matrices, solution of linear equations, inner products eigenvalues and eigenvectors, the spectral theorem for real symmetric matrices, applications of Jordan canonical form. Mutually Exclusive: Credit cannot be earned for MATH 355 and MATH 354.

MATH 356 - ABSTRACT ALGEBRA I
Short Title: ABSTRACT ALGEBRA I
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (MATH 354 or MATH 355) and (MATH 302 or MATH 354 or MATH 221)
Description: Group theory: normal subgroups, factor groups, Abelian groups, permutations, matrix groups, and group action. Recommended Prerequisite(s): MATH 354 or MATH 355; and some proof-based course such as MATH 302, MATH 354, or MATH 365. Mutually Exclusive: Credit cannot be earned for MATH 356 and MATH 306.
Course URL: math.rice.edu
MATH 356. Exterior Differentiation, Differentiation Forms, Vector Fields, Stokes' Theorem

MATH 356. Exterior Differentiation, Differentiation Forms, Vector Fields, Stokes' Theorem

MATH 365. Number Theory

Prerequisite(s): Linear Algebra (MATH 221, MATH 354, or MATH 355) and (MATH 354 or MATH 355 (may be taken concurrently)).

Description: Prime numbers and factorization, modular arithmetic, Diophantine equations, quadratic reciprocity, and other topics such as cryptography or continued fractions.

Course URL: math.rice.edu

MATH 366. Geometry

Prerequisite(s):

Course Level: Undergraduate Upper-Level

Description: Topics chosen from Euclidean, spherical, hyperbolic, and projective geometry, with emphasis on the similarities and differences found in various geometries. Isometries and other transformations are studied and used throughout. The history of the development of geometric ideas is discussed. This course is strongly recommended for prospective high school teachers.

Course URL: math.rice.edu

MATH 368. Topics in Combinatorics

Prerequisite(s):

Course Level: Undergraduate Upper-Level

Description: Topics chosen from combinatorics and discrete mathematics. Topics that may be covered include graph theory, Ramsey theory, finite geometries, combinatorial enumeration, combinatorial games.

Course URL: math.rice.edu

MATH 370. Calculus on Manifolds

Prerequisite(s): (MATH 302 or MATH 321 or MATH 331) and (MATH 354 or MATH 355).

Description: Differentiation and integration on manifolds: calculus on R^n, exterior differentiation, differentiation forms, vector fields, Stokes' theorem.

Course URL: math.rice.edu

MATH 371. Lie Theory

Prerequisite(s): MATH 306 or MATH 356

Description: Study of classical groups as symmetries of Euclidean spaces. Geometry of complex numbers and quaternions, rotations and reflections of R^n, the orthogonal, unitary and symplectic groups. Tangent spaces to matrix groups, Lie algebras and the exponential map. If time permits: the structure of Lie algebras and the matrix logarithm.

Recommended Prerequisite(s): MATH 354 or MATH 355 (may be taken the same semester).

Course URL: math.rice.edu

MATH 373. Elliptic Curves

Prerequisite(s):

Course Level: Undergraduate Upper-Level

Description: Elliptic curves are central to modern number theory and instrumental in the proof of Fermat's Last Theorem. Topics will include: The addition law, solutions over the rational numbers, explicit computations, applications to factorization and cryptography; if time permits, infinite series attached to elliptic curves and the Birch-Swinnerton-Dyer conjecture. Recommended Prerequisite(s): 200 Level Math Course

Course URL: math.rice.edu

MATH 374. Introduction to Representation Theory

Prerequisite(s): MATH 306 or MATH 356

Description: First course in representation theory, with an emphasis on concrete examples, especially the symmetric group. Topics include representations of finite groups, characters, classification, symmetric functions, Young symmetrizers, and Schur-Weyl duality. Prior experience with proofs is necessary; some familiarity with linear or abstract algebra would be helpful, but can be acquired along the way.

Recommended Prerequisite(s): Linear Algebra (MATH 221, MATH 354, or MATH 355) and MATH 356.

Course URL: math.rice.edu
**MATH 376 - ALGEBRAIC GEOMETRY**
Short Title: ALGEBRAIC GEOMETRY  
Department: Mathematics  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Graduate level students may not enroll.  
Course Level: Undergraduate Upper-Level  
Prerequisite(s): (MATH 354 or MATH 355) and (MATH 306 or MATH 356)  
Description: An introduction to algebraic geometry, with an emphasis on algorithms. Topics include: polynomial rings and ideals, Groebner bases and elimination theory, affine varieties, Hilbert's Nullstellensatz, and the Algebra-Geometry correspondence. Projective varieties; Bezout's Theorem.

**MATH 381 - INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS**
Short Title: INTRO PARTIAL DIFF EQUATIONS  
Department: Mathematics  
Grade Mode: Standard Letter  
Course Type: Lecture  
Distribution Group: Distribution Group III  
Credit Hours: 3  
Restrictions: Graduate level students may not enroll.  
Course Level: Undergraduate Upper-Level  
Prerequisite(s): MATH 211.  
Description: Laplace transform: inverse transform, applications to constant coefficient differential equations. Boundary value problems: Fourier series, Bessel functions, Legendre polynomials. Recommended Prerequisite(s): MATH 211.

**MATH 382 - COMPUTATIONAL COMPLEX ANALYSIS**
Short Title: COMPUTATIONAL COMPLEX ANALYSIS  
Department: Mathematics  
Grade Mode: Standard Letter  
Course Type: Lecture  
Distribution Group: Distribution Group III  
Credit Hours: 3  
Restrictions: Graduate level students may not enroll.  
Course Level: Undergraduate Upper-Level  
Description: Study of the Cauchy integral theorem, Taylor series, residues, as well as the evaluation of integrals by means of residues, conformal mapping, and application to two-dimensional fluid flow. Graduate/Undergraduate Equivalency: MATH 427, MATH 517. Recommended Prerequisite(s): MATH 212 OR 221. Mutually Exclusive: Credit cannot be earned for MATH 382 and MATH 427/MATH 517.  
Course URL: math.rice.edu

**MATH 401 - DIFFERENTIAL GEOMETRY OF CURVES AND SURFACES**
Short Title: DIFF GEOM OF CURVES/SURFACES  
Department: Mathematics  
Grade Mode: Standard Letter  
Course Type: Lecture  
Distribution Group: Distribution Group III  
Credit Hours: 3  
Restrictions: Graduate level students may not enroll.  
Course Level: Undergraduate Upper-Level  
Prerequisite(s): MATH 222 or MATH 354 or MATH 302  
Description: Study of the differential geometry of curves and surfaces in R3. Includes an introduction to the concept of curvature and thorough treatment of the Gauss-Bonnet theorem.  
Course URL: math.rice.edu

**MATH 402 - DIFFERENTIAL GEOMETRY**
Short Title: DIFFERENTIAL GEOMETRY  
Department: Mathematics  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Graduate level students may not enroll.  
Course Level: Undergraduate Upper-Level  
Prerequisite(s): MATH 321 or MATH 331  
Description: Introduction to Riemannian geometry. Content varies from year to year. Graduate/Undergraduate Equivalency: MATH 500. Recommended Prerequisite(s): MATH 401 and MATH 321 or MATH 443. Mutually Exclusive: Credit cannot be earned for MATH 402 and MATH 500.  
Course URL: math.rice.edu

**MATH 410 - CALCULUS OF VARIATIONS**
Short Title: CALCULUS OF VARIATIONS  
Department: Mathematics  
Grade Mode: Standard Letter  
Course Type: Lecture  
Credit Hours: 3  
Restrictions: Graduate level students may not enroll.  
Course Level: Undergraduate Upper-Level  
Prerequisite(s): MATH 101 and MATH 102 and (MATH 211 or MATH 212 or MATH 221 or MATH 222)  
Description: Study of classical and modern theories about functions having some integral expression which is maximal, minimal, or critical. Geodesics, brachistochrone problem, minimal surfaces, and numerous applications to physics. Euler-Lagrange equations, 1st and 2nd variations, Hamilton's Principle.
MATH 423 - PARTIAL DIFFERENTIAL EQUATIONS I
Short Title: PARTIAL DIFFERENTIAL EQNS I
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level

MATH 424 - TOPICS IN PARTIAL DIFFERENTIAL EQUATIONS
Short Title: TOPICS IN PARTIAL DIFF EQNS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 423
Description: Continuation of MATH 423. Repeatable for Credit.
Course URL: math.rice.edu

MATH 425 - INTEGRATION THEORY
Short Title: INTEGRATION THEORY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 321 or MATH 331
Description: Lebesgue theory of measure and integration. Graduate/Undergraduate Equivalency: MATH 515. Mutually Exclusive: Credit cannot be earned for MATH 425 and MATH 515.
Course URL: math.rice.edu

MATH 426 - TOPICS IN REAL ANALYSIS
Short Title: TOPICS IN REAL ANALYSIS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 425
Description: Content varies from year to year. May include Fourier series, harmonic analysis, probability theory, advanced topics in measure theory, ergodic theory, and elliptic integrals. Graduate/Undergraduate Equivalency: MATH 516. Mutually Exclusive: Credit cannot be earned for MATH 426 and MATH 516. Repeatable for Credit.
MATH 443 - GENERAL TOPOLOGY
Short Title: GENERAL TOPOLOGY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 321 or MATH 331
Description: Study of basic point set topology. Includes a treatment of cardinality and well ordering, as well as metrization. Graduate/Undergraduate Equivalency: MATH 538. Mutually Exclusive: Credit cannot be earned for MATH 443 and MATH 538.
Course URL: math.rice.edu

MATH 444 - GEOMETRIC TOPOLOGY
Short Title: GEOMETRIC TOPOLOGY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 306 or MATH 356
Description: Introduction to algebraic methods in topology and differential topology. Elementary homotopy theory. Covering spaces. Graduate/Undergraduate Equivalency: MATH 539. Recommended Prerequisite(s): MATH 443. Mutually Exclusive: Credit cannot be earned for MATH 444 and MATH 539.
Course URL: math.rice.edu

MATH 445 - ALGEBRAIC TOPOLOGY
Short Title: ALGEBRAIC TOPOLOGY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 444
Description: Introduction to the theory of homology. Includes simplicial complexes, cell complexes and cellular homology and cohomology, as well as manifolds, and Poincare duality. Graduate/Undergraduate Equivalency: MATH 540. Mutually Exclusive: Credit cannot be earned for MATH 445 and MATH 540.

MATH 463 - ABSTRACT ALGEBRA II
Short Title: ABSTRACT ALGEBRA II
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 356

MATH 464 - ABSTRACT ALGEBRA III
Short Title: ABSTRACT ALGEBRA III
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 463
Description: Continuation of MATH 463. Tensor and exterior algebra, introductory commutative algebra, structure of modules, and elements of homological algebra. Additional advanced topics may include representations of finite groups and affine algebraic geometry. Graduate/Undergraduate Equivalency: MATH 564. Mutually Exclusive: Credit cannot be earned for MATH 464 and MATH 564.

MATH 465 - TOPICS IN ALGEBRA: INTRODUCTION TO ALGEBRAIC GEOMETRY
Short Title: TOPICS IN ALGEBRA
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Description: Varieties as solution sets of systems of polynomial equations, varieties in projective space, rational and regular functions, maps of varieties, local properties and singularities. Graduate/Undergraduate Equivalency: MATH 565. Mutually Exclusive: Credit cannot be earned for MATH 465 and MATH 565. Repeatable for Credit.

MATH 466 - TOPICS IN ALGEBRA II
Short Title: TOPICS IN ALGEBRA II
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Description: Content varies from year to year. Graduate/Undergraduate Equivalency: MATH 566. Mutually Exclusive: Credit cannot be earned for MATH 466 and MATH 566.

MATH 468 - POTPOURRI
Short Title: POTPOURRI
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Description: This course deals with miscellaneous special topics not covered in other courses. Repeatable for Credit.
MATH 498 - RESEARCH THEMES IN THE MATHEMATICAL SCIENCES
Short Title: RESEARCH THEMES IN MATH. SCI.
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 1-3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Description: A seminar course that will cover selected theme of general research in the mathematical sciences from the perspectives of mathematics, computational and applied mathematics and statistics. The course may be repeated multiple times for credit. Cross-list: CAAM 498, STAT 498. Graduate/Undergraduate Equivalency: MATH 698. Mutually Exclusive: Credit cannot be earned for MATH 498 and MATH 698. Repeatable for Credit.

MATH 499 - MATHEMATICAL SCIENCES VIGRE SEMINAR
Short Title: MATHEMATICAL SCIENCES
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 1-3
Restrictions: Graduate level students may not enroll.
Course Level: Undergraduate Upper-Level
Description: Repeatable for Credit.

MATH 500 - DIFFERENTIAL GEOMETRY
Short Title: DIFFERENTIAL GEOMETRY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Topic to be announced. Repeatable for Credit.

MATH 501 - TOPICS IN DIFFERENTIAL GEOMETRY
Short Title: TOPICS DIFFERENTIAL GEOMETRY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Topic to be announced. Repeatable for Credit.

MATH 502 - TOPICS IN DIFFERENTIAL GEOMETRY
Short Title: TOPICS DIFFERENTIAL GEOMETRY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Topic to be announced. Repeatable for Credit.

MATH 513 - PARTIAL DIFFERENTIAL EQUATIONS I
Short Title: PARTIAL DIFFERENTIAL EQNS I
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: First order of partial differential equations. The method of characteristics. Analysis of the solutions of the wave equation, heat equation and Laplace’s equation. Integral relations and Green’s functions. Potential theory, Dirichlet and Neumann problems. Asymptotic methods: the method of stationary phase, geometrical optics, regular and singular perturbation methods. Additional course work is required beyond the undergraduate course requirements. Cross-list: CAAM 523. Graduate/Undergraduate Equivalency: MATH 423. Recommended Prerequisite(s): MATH 321 AND MATH 322 Mutually Exclusive: Credit cannot be earned for MATH 513 and MATH 423.
MATH 515 - INTEGRATION THEORY
Short Title: INTEGRATION THEORY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Graduate/Undergraduate Equivalency: MATH 425. Mutually Exclusive: Credit cannot be earned for MATH 515 and MATH 425.

MATH 516 - TOPICS IN REAL ANALYSIS
Short Title: TOPICS IN REAL ANALYSIS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): MATH 425
Description: Graduate/Undergraduate Equivalency: MATH 426. Mutually Exclusive: Credit cannot be earned for MATH 516 and MATH 426. Repeatable for Credit.

MATH 517 - COMPLEX ANALYSIS
Short Title: COMPLEX ANALYSIS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): MATH 382, MATH 427
Description: Graduate/Undergraduate Equivalency: MATH 382/MATH 427. Mutually Exclusive: Credit cannot be earned for MATH 517 and MATH 382/MATH 427.

MATH 518 - TOPICS IN COMPLEX ANALYSIS
Short Title: TOPICS IN COMPLEX ANALYSIS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): MATH 382 or MATH 427
Description: Graduate/Undergraduate Equivalency: MATH 428. Mutually Exclusive: Credit cannot be earned for MATH 518 and MATH 428. Repeatable for Credit.

MATH 521 - ADVANCED TOPICS IN REAL ANALYSIS
Short Title: ADV TOPIC: REAL ANALYSIS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Topic to be announced. Repeatable for Credit.

MATH 522 - TOPICS IN ANALYSIS
Short Title: TOPICS IN ANALYSIS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Topic to be announced. Repeatable for Credit.

MATH 523 - FUNCTIONAL ANALYSIS
Short Title: FUNCTIONAL ANALYSIS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): MATH 382 or MATH 427
Description: Banach spaces: review of $L^p$ spaces, linear operators, dual space, Hahn-Banach theorem, weak topologies, Banach- Alaoglu theorem, compact and bounded operators, closed graph theorem; Hilbert spaces: self-adjoint and unitary operators (including spectral theorem), symmetric operators and self-adjoint extensions; if time allows, distributions and Sobolev spaces. Repeatable for Credit.

MATH 524 - TOPICS IN PARTIAL DIFFERENTIAL EQUATIONS
Short Title: TOPICS IN PDE
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Topic to be announced. Repeatable for Credit.

MATH 527 - ERGODIC THEORY AND TOPOLOGICAL DYNAMICS
Short Title: ERGODIC THRY&TOP DYNAMICS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Topic to be announced. Repeatable for Credit.

MATH 528 - ERGODIC THEORY AND TOPOLOGICAL DYNAMICS
Short Title: ERGODIC THRY&TOPOLOGICAL DYN
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Repeatable for Credit.

MATH 538 - GENERAL TOPOLOGY
Short Title: GENERAL TOPOLOGY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Graduate/Undergraduate Equivalency: MATH 443. Mutually Exclusive: Credit cannot be earned for MATH 538 and MATH 443.
MATH 539 - GEOMETRIC TOPOLOGY
Short Title: GEOMETRIC TOPOLOGY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): MATH 356 and MATH 443
Description: Graduate/Undergraduate Equivalency: MATH 444. Mutually Exclusive: Credit cannot be earned for MATH 539 and MATH 444.

MATH 540 - ALGEBRAIC TOPOLOGY
Short Title: ALGEBRAIC TOPOLOGY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): MATH 539
Description: Graduate/Undergraduate Equivalency: MATH 445. Mutually Exclusive: Credit cannot be earned for MATH 540 and MATH 445.

MATH 541 - TOPICS IN TOPOLOGY
Short Title: TOPICS IN TOPOLOGY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Topic to be announced. Repeatable for Credit.

MATH 542 - TOPICS IN ADVANCED TOPOLOGY
Short Title: TOPICS IN ADVANCED TOPOLOGY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Topic to be announced. Repeatable for Credit.

MATH 543 - TOPICS IN LOW-DIMENSIONAL TOPOLOGY
Short Title: TOPICS IN L-D TOPOLOGY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Repeatable for Credit.

MATH 544 - ABSTRACT ALGEBRA III
Short Title: ABSTRACT ALGEBRA III
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): MATH 563
Description: Graduate/Undergraduate Equivalency: MATH 464. Mutually Exclusive: Credit cannot be earned for MATH 544 and MATH 464.

MATH 545 - TOPICS IN ALGEBRA: INTRODUCTION TO ALGEBRAIC GEOMETRY
Short Title: TOPICS IN ALGEBRA
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Varieties as solution sets of systems of polynomial equations, varieties in projective space, rational and regular functions, maps of varieties, local properties and singularities. Graduate/Undergraduate Equivalency: MATH 465. Mutually Exclusive: Credit cannot be earned for MATH 545 and MATH 465. Repeatable for Credit.

MATH 546 - TOPICS IN ALGEBRA II
Short Title: TOPICS IN ALGEBRA II
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Mutually Exclusive: Credit cannot be earned for MATH 546 and MATH 466. Repeatable for Credit.

MATH 547 - TOPICS IN ALGEBRAIC GEOMETRY
Short Title: TOPICS IN ALGEBRAIC GEOMETRY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Repeatable for Credit.

MATH 548 - TOPICS IN LOW-DIMENSIONAL TOPOLOGY
Short Title: TOPICS IN L-D TOPOLOGY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 1-3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Repeatable for Credit.

MATH 549 - ABSTRACT ALGEBRA II
Short Title: ABSTRACT ALGEBRA II
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): MATH 356
Description: Mutually Exclusive: Credit cannot be earned for MATH 549 and MATH 463.
MATH 571 - MATHEMATICS OF APERIODIC ORDER
Short Title: MATHEMATICS OF APERIODIC ORDER
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Mathematical models of quasicrystals, whose discovery in the early 1980's led to a paradigm shift in materials science. Topics include: classical theory of ordered structures (i.e., lattices modeling crystals), Delone subsets and tilings of Euclidean space, aperiodically ordered structures generated by inflation or cut-and-project schemes. Graduate/Undergraduate Equivalency: MATH 471. Recommended Prerequisite(s): MATH 356 Mutually Exclusive: Credit cannot be earned for MATH 571 and MATH 471.

MATH 590 - CURRENT MATHEMATICS SEMINAR
Short Title: CURRENT MATHEMATICS SEMINAR
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Presentations of research in mathematics and related areas. Repeatable for Credit.

MATH 591 - GRADUATE TEACHING SEMINAR
Short Title: GRADUATE TEACHING SEMINAR
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Discussion on teaching issues and practice lectures by participants as preparation for classroom teaching of mathematics. Repeatable for Credit.

MATH 592 - MATHEMATICAL SCIENCES VIGRE SEMINAR
Short Title: MATHEMATICAL SCIENCES VIGRE SEMINAR
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: A seminar course that will cover selected theme of general research in the mathematical sciences from the perspectives of mathematics, computational and applied mathematics and statistics. The course may be repeated multiple times for credit. Cross-list: CAAM 698, STAT 698. Graduate/Undergraduate Equivalency: MATH 498. Mutually Exclusive: Credit cannot be earned for MATH 598 and MATH 498. Repeatable for Credit.

MATH 680 - MATHEMATICS COLLOQUIUM
Short Title: MATHEMATICS COLLOQUIUM
Department: Mathematics
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Lecture
Credit Hours: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Presentations of research topics in mathematics and related fields. Repeatable for Credit.

MATH 681 - TOPOLOGY SEMINAR
Short Title: TOPOLOGY SEMINAR
Department: Mathematics
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Seminar
Credit Hours: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Presentations of research in topology and related areas. Repeatable for Credit.
MATH 800 - GRADUATE THESIS AND RESEARCH
Short Title: GRADUATE THESIS AND RESEARCH
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 1-15
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Repeatable for Credit.

Description and Code Legend
Note: Internally, the university uses the following descriptions, codes, and abbreviations for this academic program. The following is a quick reference:

Course Catalog/Schedule
• Course offerings/subject code: MATH

Department Description and Code
• Mathematics: MATH

Undergraduate Degree Descriptions and Codes
• Bachelor of Arts degree: BA
• Bachelor of Science degree: BS

Undergraduate Major Description and Code
• Major in Mathematics (attached to both the BA and BS Degrees): MATH

Undergraduate Minor Description and Code
• Minor in Mathematics: MATM

Graduate Degree Descriptions and Codes
• Master of Arts degree: MA
• Doctor of Philosophy degree: PhD

Graduate Degree Program Description and Code
• Degree Program in Mathematics: MATH