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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
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. Pre-Calculus Diagnostic Test is required for registration. Mutually Exclusive: Cannot register for MATH 101 if student has credit for MATH 105/MATH 112.
Course URL: math.rice.edu (http://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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: Continuation of MATH 101. Includes further techniques of integration, as well as infinite sequences and series, Taylor polynomials and Taylor series, parametric equations, arc length, polar coordinates, complex numbers, and Fourier polynomials. Should not be taken if student already has credit for MATH 211, MATH 212, or MATH 221, without permission. Mutually Exclusive: Cannot register for MATH 102 if student has credit for MATH 106.
Course URL: math.rice.edu (http://math.rice.edu)

MATH 105 - AP/OTH CREDIT IN CALCULUS I
Short Title: AP/OTH CREDIT IN CALCULUS I
Department: Mathematics
Grade Mode: Transfer Courses
Course Type: Transfer
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: Provides transfer credit based on student performance on approved examinations in calculus, such as the AB Calculus Advanced Placement exam or the International Baccalaureate higher-level calculus exams. This credit counts toward the total credit hours required for graduation, and satisfies major requirements in lieu of MATH 101, but does not count for distribution. Mutually Exclusive: Cannot register for MATH 105 if student has credit for MATH 101/MATH 111/MATH 112.

MATH 106 - AP/OTH CREDIT IN CALCULUS II
Short Title: AP/OTH CREDIT IN CALCULUS II
Department: Mathematics
Grade Mode: Transfer Courses
Course Type: Transfer
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: Provides transfer credit based on student performance on approved examinations in calculus, such as the BC Calculus Advanced Placement exam or the International Baccalaureate higher-level calculus exams. This credit counts toward the total credit hours required for graduation, and satisfies major requirements in lieu of MATH 102, but does not count for distribution. Mutually Exclusive: Cannot register for MATH 106 if student has credit for MATH 102.

MATH 110 - MATH DISCUSSION SESSIONS
Short Title: MATH DISCUSSION SESSIONS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Laboratory
Credit Hour: 1
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Prerequisite(s): MATH 101 (may be taken concurrently) or MATH 111 (may be taken concurrently)
Description: This course is a discussion and practice section for students to review and reinforce concepts needed in single variable calculus. Students will work in small groups under the guidance of the instructor. Repeatable for Credit.

MATH 111 - CALCULUS: DIFFERENTIATION AND ITS APPLICATIONS
Short Title: CALCULUS: DIFFERENTIATION
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Corequisite: MATH 110
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. Pre-Calculus Diagnostic Test is required for registration. Mutually Exclusive: Cannot register for MATH 111 if student has credit for MATH 105.
Course URL: math.rice.edu (http://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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
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: Cannot register for MATH 112 if student has credit for MATH 101/MATH 105.
Course URL: math.rice.edu (http://math.rice.edu)

MATH 115 - THE ART OF MATHEMATICS
Short Title: THE ART OF MATH
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: Math 115 is intended primarily for students majoring in non-STEM fields seeking knowledge of the nature of mathematics as well as training in mathematical thinking and problem-solving. The goal of the course is to demonstrate that math is not necessarily about formulas, but is rather a process of thinking which is relevant to them on a daily basis. Instructor Permission Required.

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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
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. Mutually Exclusive: Cannot register for MATH 211 if student has credit for MATH 220.

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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
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: Cannot register for MATH 212 if student has credit for MATH 222/MATH 232.
Course URL: math.rice.edu (http://math.rice.edu)

MATH 215 - MATHEMATICS UNDERGRADUATE RESEARCH LABORATORY
Short Title: MATH UNDERGRAD LAB
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture/Laboratory
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: The main objective of this course is to offer students a research experience in mathematics by exploring research labs in science and engineering at Rice University. This Math lab is an inclusive and diverse research environment on mathematics for our undergraduate students. Instructor Permission Required. Repeatable for Credit.

MATH 220 - HONORS ORDINARY DIFFERENTIAL EQUATIONS
Short Title: HONORS ORD DIFFERENTIAL EQNS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: A rigorous introduction to the study of ordinary differential equations, including results about the existence, uniqueness and stability of solutions. Some concepts from multi-variable calculus and linear algebra will be introduced along the way. This course will introduce students to the understanding and writing of proofs. Mutually Exclusive: Cannot register for MATH 220 if student has credit for MATH 211.

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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: This course and MATH 222 include the material of MATH 212 and much more. Topology of Rn, 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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Prerequisite(s): MATH 221
Description: This course and MATH 221 include the material of MATH 212 and much more. Topology of Rn, calculus for functions of several variables, linear and multilinear algebra, theory of determinants, inner product spaces, integration on manifolds. A student may not receive credit for both MATH 222 and MATH 212, or MATH 222 and MATH 232. Mutually Exclusive: Cannot register for MATH 222 if student has credit for MATH 212/MATH 232.

MATH 232 - HONORS MULTIVARIABLE CALCULUS
Short Title: HONORS MULTIVARIABLE CALCULUS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Prerequisite(s): MATH 220 or MATH 354 or MATH 355 or MATH 221
Description: Calculus of several variables (partial derivatives and gradients, double and triple integrals, vector fields, line and surface integrals, Green's theorem, Stokes's theorem, Gauss's theorem). Content is similar to that of MATH 212, but MATH 232 will use linear algebra to extend results to R^n. There will also be an emphasis on rigorous mathematical arguments. Recommended Prerequisite(s): MATH 290 is recommended as a corequisite for students who have not taken MATH 220 or MATH 354. Mutually Exclusive: Cannot register for MATH 232 if student has credit for MATH 212/MATH 222.

MATH 238 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Laboratory, Lecture, Internship/Practicum, Seminar, Independent Study, Lecture/Laboratory
Credit Hours: 1-4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
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 280 - UNDERGRADUATE MATH TEACHING PRACTICUM
Short Title: UG MATH TEACHING PRACTICUM
Department: Mathematics
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Internship/Practicum
Credit Hours: 1-3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: In this course, undergraduates who have previously excelled in MATH courses will develop teaching skills while supporting faculty as teaching assistants (TAs) in a particular MATH course for the benefit of the students taking that particular course. This course is open only to undergraduates with special permission of the course instructor and can be repeated for credit. Instructor Permission Required. Repeatable for Credit.

MATH 290 - FOUNDATIONS OF MATHEMATICAL WRITING
Short Title: MATHEMATICAL WRITING SEMINAR
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hour: 1
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Lower-Level
Description: Half-semester course aimed at students concurrently taking their first mathematical proofs course. The course will cover foundational topics in mathematics such as logic, sets, relations, and functions, while providing students with detailed feedback on expressing mathematics in writing. Should not be taken if student already has credit for MATH 220, 221, 222, 302, or 354. Instructor Permission Required. Mutually Exclusive: Cannot register for MATH 290 if student has credit for COMP 181.

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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (MATH 221 or MATH 354 or MATH 355) and (MATH 220 or MATH 221 or MATH 222 or MATH 232 or MATH 302 or MATH 321 or MATH 331)
Description: Treatment of topics in undergraduate mathematics. Topics vary by year. May be repeated for credit with permission of department. Repeatable for Credit.
Course URL: math.rice.edu (http://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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 102 or MATH 106
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.
Course URL: math.rice.edu (http://math.rice.edu)

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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
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 (http://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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 302 or MATH 354 or MATH 220 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 many not receive credit for both MATH 306 and MATH 356. Recommended Prerequisite(s): MATH 354 or MATH 355 or MATH 221 Mutually Exclusive: Cannot register for MATH 306 if student has credit for MATH 356.
Course URL: math.rice.edu (http://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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 220 or 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: Cannot register for MATH 321 if student has credit for MATH 331.
Course URL: math.rice.edu (http://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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 321 or MATH 331
Description: Further study in real analysis, including analysis in higher dimensions. Possible additional topics include Hilbert spaces, Fourier series, Sturm-Liouville theory.
Course URL: math.rice.edu (http://math.rice.edu)

MATH 331 - HONORS ANALYSIS
Short Title: HONORS ANALYSIS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 220 or 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: Cannot register for MATH 331 if student has credit for MATH 321.
Course URL: math.rice.edu (http://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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
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): MATH 102 or MATH 106. Mutually Exclusive: Cannot register for MATH 354 if student has credit for MATH 355.

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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Systems of linear equations, matrices, vector spaces, linear transformations, determinants, inner products, eigenvalues and eigenvectors, and the Spectral Theorem for real symmetric matrices. Mutually Exclusive: Cannot register for MATH 355 if student has credit for 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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 302 or MATH 354 or MATH 220 or MATH 221
Description: An introduction to algebraic structures. Covers basic group theory (including subgroups and quotients, permutation and matrix groups, group actions) and basic ring theory (including ideals and quotients, polynomial rings, unique factorization). Recommended Prerequisite(s): MATH 354 or MATH 355 or MATH 221 Mutually Exclusive: Cannot register for MATH 356 if student has credit for MATH 306.
Course URL: math.rice.edu (http://math.rice.edu)

MATH 357 - 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 Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 356 and (MATH 354 or MATH 355 or MATH 221)
Description: Fields and field extensions, modules over rings, further topics in groups, rings, fields, and their applications.

MATH 365 - NUMBER THEORY
Short Title: NUMBER THEORY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 220 or MATH 221 or MATH 302 or MATH 354 or COMP 182
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 (http://math.rice.edu)

MATH 366 - GEOMETRY
Short Title: GEOMETRY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
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.

MATH 368 - TOPICS IN COMBINATORICS
Short Title: TOPICS IN COMBINATORICS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Distribution Group: Distribution Group III
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Study of combinatorics and discrete mathematics. Topics that may be covered include graph theory, Ramsey theory, finite geometries, combinatorial enumeration, combinatorial games.

MATH 370 - CALCULUS ON MANIFOLDS
Short Title: CALCULUS ON MANIFOLDS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (MATH 302 or MATH 321 or MATH 331) and (MATH 354 or MATH 355)
Description: Differentiation and integration on manifolds: calculus on Rn, exterior differentiation, differentiation forms, vector fields, Stokes' theorem.
Course URL: math.rice.edu (http://math.rice.edu)

MATH 371 - LIE THEORY
Short Title: LIE THEORY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 306 or MATH 356
Description: Study of classical groups as symmentries of Euclidean spaces. Geometry of complex numbers and quaternions, rotations and reflections of Rn, the orthogonal, unitary and sympletic 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 (http://math.rice.edu)

MATH 373 - ELLIPTIC CURVES
Short Title: ELLIPTIC CURVES
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 306 or MATH 356
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 (http://math.rice.edu)

MATH 374 - INTRODUCTION TO REPRESENTATION THEORY
Short Title: INTRO TO REPRESENTATION THEORY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
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 (http://math.rice.edu)

MATH 376 - ALGEBRAIC GEOMETRY
Short Title: ALGEBRAIC GEOMETRY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
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. Recommended Prerequisite(s): MATH 212 OR 221. Mutually Exclusive: Cannot register for MATH 382 if student has credit for MATH 427/MATH 517.
Course URL: math.rice.edu (http://math.rice.edu)

MATH 390 - UNDERGRADUATE COLLOQUIUM
Short Title: UNDERGRADUATE COLLOQUIUM
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hour: 1
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Lectures by undergraduate students on mathematical topics not usually covered in other courses. Presentation of one lecture and attendance at all sessions required. Distribution Credit for MATH 390 no longer eligible beginning Fall 2019. Repeatable for Credit.

MATH 401 - DIFFERENTIAL GEOMETRY OF CURVES AND SURFACES
Short Title: DIFF GEOM OF CURVES/SURFACES
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (MATH 222 or MATH 354 or MATH 355) and (MATH 321 or MATH 331)
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. Recommended Prerequisite(s): MATH 211 or MATH 220 or familiarity with ODEs
Course URL: math.rice.edu (http://math.rice.edu)

MATH 402 - DIFFERENTIAL GEOMETRY
Short Title: DIFFERENTIAL GEOMETRY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 444 or MATH 539
Description: MATH 402 is the undergraduate version of the graduate class MATH 500 (being generic for all related instances of dual enrollment classes). This is a course in smooth and Riemannian manifolds. Tensors, Riemannian metrics, differential forms. Lie derivatives. Distributions and foliations, including the Frobenius Theorem and an introduction to contact structures. Lie groups and the exponential map. Connections on Vector Bundles. Geodesics and completeness. Curvature. First and second variations of length and area. Jacobi Fields. Additional topics may vary from year to year. Graduate/Undergraduate Equivalency: MATH 500. Mutually Exclusive: Cannot register for MATH 402 if student has credit for MATH 500.

MATH 410 - CALCULUS OF VARIATIONS
Short Title: CALCULUS OF VARIATIONS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (MATH 101 or MATH 105) and (MATH 102 or MATH 106) 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 412 - PROBABILITY THEORY
Short Title: PROBABILITY THEORY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 321 or MATH 331
Description: A simultaneous introduction to probability theory and measure theory, from basic definitions to the central limit theorem. The selection of topics in measure theory is in the service of probability theory, and the course carefully examines interplay between the analytic and probabilistic notions.

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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
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. Cross-list: CMOR 405. Graduate/Undergraduate Equivalency: MATH 513. Recommended Prerequisite(s): MATH 321 AND MATH 322 Mutually Exclusive: Cannot register for MATH 423 if student has credit for MATH 513.

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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 423
Description: Continuation of MATH 423. Analysis of the solutions of second order differential equations. 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. Euler and Navier-Stokes equations. Graduate/Undergraduate Equivalency: MATH 514. Mutually Exclusive: Cannot register for MATH 424 if student has credit for MATH 514. Repeatable for Credit.
Course URL: math.rice.edu (http://math.rice.edu)

MATH 425 - INTEGRATION THEORY
Short Title: INTEGRATION THEORY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
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: Cannot register for MATH 425 if student has credit for MATH 515.
Course URL: math.rice.edu (http://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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
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: Cannot register for MATH 426 if student has credit for MATH 516. Repeatable for Credit.

MATH 427 - COMPLEX ANALYSIS
Short Title: COMPLEX ANALYSIS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 354 or MATH 222 or MATH 302
Description: Study of the Cauchy-Riemann equation, power series, Cauchy's integral formula, residue calculus, and conformal mappings. Emphasis on the theory. Graduate/Undergraduate Equivalency: MATH 517. Recommended Prerequisite(s): MATH 321 or MATH 331. Mutually Exclusive: Cannot register for MATH 427 if student has credit for MATH 382/MATH 517.
Course URL: math.rice.edu (http://math.rice.edu)

MATH 428 - 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 Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 382 or MATH 427
Description: Special topics include Riemann mapping theorem, Runge's Theorem, elliptic function theory, prime number theorem, Riemann surfaces, et al. Graduate/Undergraduate Equivalency: MATH 518. Mutually Exclusive: Cannot register for MATH 428 if student has credit for MATH 518. Repeatable for Credit.

MATH 433 - FUNCTIONAL ANALYSIS
Short Title: FUNCTIONAL ANALYSIS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (MATH 354 or MATH 221) and MATH 425 and MATH 443
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. Graduate/Undergraduate Equivalency: MATH 523. Mutually Exclusive: Cannot register for MATH 433 if student has credit for MATH 523.

MATH 435 - DYNAMICAL SYSTEMS
Short Title: DYNAMICAL SYSTEMS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Existence and uniqueness for solutions of ordinary differential equations and difference equations, linear systems, nonlinear systems, stability, periodic solutions, bifurcation theory. Theory and theoretical examples are complemented by computational, model driven examples from biological and physical sciences. Cross-list: CMOR 435. Recommended Prerequisite(s): (MATH 212 or MATH 221) and (CAAM 335 or MATH 355 or MATH 354) and (MATH 302 or MATH 321 or MATH 331)
Course URL: math.rice.edu (http://math.rice.edu)

MATH 443 - GENERAL TOPOLOGY
Short Title: GENERAL TOPOLOGY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
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: Cannot register for MATH 443 if student has credit for MATH 538.
Course URL: math.rice.edu (http://math.rice.edu)

MATH 444 - GEOMETRIC TOPOLOGY
Short Title: GEOMETRIC TOPOLOGY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 356 and MATH 443
Description: Introduction to algebraic methods in topology. Elementary homotopy theory. Covering spaces. Graduate/Undergraduate Equivalency: MATH 539. Mutually Exclusive: Cannot register for MATH 444 if student has credit for MATH 539.

MATH 445 - ALGEBRAIC TOPOLOGY
Short Title: ALGEBRAIC TOPOLOGY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
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: Cannot register for MATH 445 if student has credit for MATH 540.

MATH 448 - CONCRETE MATHEMATICS
Short Title: CONCRETE MATHEMATICS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (COMP 323 or COMP 382 or MATH 306 or MATH 323 or MATH 356 or MATH 357 or MATH 365 or MATH 368)
Description: Concrete mathematics is a blend of continuous and discrete mathematics. Major topics include sums, recurrences, integer functions, elementary number theory, binomial coefficients, generating functions, discrete probability and asymptotic methods. Cross-list: COMP 448.

MATH 451 - DIFFERENTIABLE MANIFOLDS
Short Title: DIFFERENTIABLE MANIFOLDS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (MATH 354 or MATH 355) and (MATH 321 or MATH 331) and MATH 443
Description: This is a course on differentiable manifolds. Topics include: Differential of a smooth map. Transversality. Implicit function theorem, submersions, and immersions. Tangent and Cotangent bundles. Vector fields, flows. Lie derivatives. Lie groups. Differential forms, Integration on manifolds, Stokes theorem. DeRham theory. Additional topics may include distributions and foliations, including the Frobenius Theorem. Graduate/Undergraduate Equivalency: MATH 551. Recommended Prerequisite(s): MATH 444 or MATH 463 or MATH 370 or MATH 401

MATH 452 - RIEMANNIAN GEOMETRY
Short Title: RIEMANNIAN GEOMETRY
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): (MATH 370 or MATH 401 or MATH 451) and (MATH 321 or MATH 331) and MATH 443
Description: This is a course on Riemannian manifolds. Topics will include: Tensors, Riemannian metrics. Connections. The exponential map. Geodesics and completeness. Curvature. First and second variations of length and area. Jacobi Fields. Additional topics may vary from year to year. Graduate/Undergraduate Equivalency: MATH 552. Recommended Prerequisite(s): MATH 444 Mutually Exclusive: Cannot register for MATH 452 if student has credit for MATH 552.

MATH 463 - ADVANCED ALGEBRA I
Short Title: ADVANCED ALGEBRA I
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 357
Description: This course will cover graduate level topics in group theory, ring theory, and module theory. Specific topics include the isomorphism theorems for groups, rings, and modules; group actions; solvable and nilpotent groups; Sylow's theorems; semi-direct products of groups; ideals; rings of fractions; various unique factorization domains; Hilbert's Basis Theorem; Gröbner Bases; tensor product of modules and universal property; modules over principal ideal domains; and canonical forms. The course will also include an introduction to category theory as time permits. Graduate/Undergraduate Equivalency: MATH 563. Mutually Exclusive: Cannot register for MATH 463 if student has credit for MATH 563.

MATH 464 - ADVANCED ALGEBRA II
Short Title: ADVANCED ALGEBRA II
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 463
Description: This course will cover topics in field theory, Galois theory, and advanced topics in commutative algebra and in multilinear algebra. Specific topics include various algebraic field extensions; fundamental theorem of Galois theory; solvable and radical extensions; transcendental extensions; tensor, symmetric, and exterior algebras; projective, injective, and flat modules; advanced ideal theory; localization; and chain conditions for rings and modules. The course will also include additional advanced topics, such as homological algebra, as time permits. Graduate/Undergraduate Equivalency: MATH 564. Mutually Exclusive: Cannot register for MATH 464 if student has credit for 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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 356 and MATH 357 (may be taken concurrently)
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: Cannot register for MATH 465 if student has credit for 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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 356 and MATH 357 (may be taken concurrently)
Description: Content varies from year to year. Graduate/Undergraduate Equivalency: MATH 566. Mutually Exclusive: Cannot register for MATH 466 if student has credit for MATH 566.

MATH 468 - POTPOURRI
Short Title: POTPOURRI
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: This course deals with miscellaneous special topics not covered in other courses. Repeatable for Credit.

MATH 471 - MATHEMATICS OF APERIODIC ORDER
Short Title: MATHEMATICS OF APERIODIC ORDER
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Prerequisite(s): MATH 321 or MATH 354 or MATH 355
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 571. Recommended Prerequisite(s): MATH 356. Mutually Exclusive: Cannot register for MATH 471 if student has credit for MATH 571.

MATH 477 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Internship/Practicum, Seminar, Lecture, Laboratory
Credit Hours: 1-4
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: Topics and credit hours may vary each semester. Contact department for current semester's topic(s). Repeatable for Credit.

MATH 479 - MATHEMATICS UNDERGRADUATE RESEARCH
Short Title: MATH UNDERGRADUATE RESEARCH
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Research
Credit Hours: 1-3
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: In depth investigation of a particular area of mathematics of mutual interest to the student and the faculty adviser. Instructor Permission Required. Repeatable for Credit.
Course URL: math.rice.edu (http://math.rice.edu)

MATH 490 - SUPERVISED READING
Short Title: SUPERVISED READING
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Independent Study
Credit Hours: 1-6
Restrictions: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
Course Level: Undergraduate Upper-Level
Description: 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: Enrollment is limited to Undergraduate, Undergraduate Professional or Visiting Undergraduate level students.
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
Prerequisite(s): MATH 444 or MATH 539
Description: A graduate course in smooth and Riemannian manifolds. Tensors, Riemannian metrics, differential forms. Lie derivatives. Distributions and foliations, including the Frobenius Theorem and an introduction to contact structures. Lie groups and the exponential map. Connections on Vector Bundles. Geodesics and completeness. Curvature. First and second variations of length and area. Jacobi Fields. Additional topics may vary from year to year. Graduate/Undergraduate Equivalency: MATH 402. Mutually Exclusive: Cannot register for MATH 500 if student has credit for MATH 402. 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: TOPIC 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: CMOR 505. Graduate/Undergraduate Equivalency: MATH 423. Recommended Prerequisite(s): MATH 321 AND MATH 322 Mutually Exclusive: Cannot register for MATH 513 if student has credit for MATH 423.

MATH 514 - 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: Enrollment is limited to Graduate level students.
Course Level: Graduate
Prerequisite(s): MATH 513 or MATH 423
Description: Continuation of MATH 513. Analysis of the solutions of second order differential equations. 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. Euler and Navier-Stokes equations. Graduate/Undergraduate Equivalency: MATH 424. Mutually Exclusive: Cannot register for MATH 514 if student has credit for MATH 424.
Course URL: math.rice.edu (http://math.rice.edu)

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: Cannot register for MATH 515 if student has credit for 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: Cannot register for MATH 516 if student has credit for 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
Description: Graduate/Undergraduate Equivalency: MATH 427. Mutually Exclusive: Cannot register for MATH 517 if student has credit for 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: Cannot register for MATH 518 if student has credit for 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
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. Graduate/Undergraduate Equivalency: MATH 433. Mutually Exclusive: Cannot register for MATH 523 if student has credit for MATH 433. 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: Cannot register for MATH 538 if student has credit for 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: Cannot register for MATH 539 if student has credit for 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: Cannot register for MATH 540 if student has credit for 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 - TOPOLOGY OF MANIFOLDS
Short Title: TOPOLOGY OF MANIFOLDS
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 444 or MATH 539) and (MATH 445 or MATH 540)
Description: A graduate course on the topology of fiber bundles, especially vector bundles and principal bundles, as well as their characteristic classes. It will cover differential forms as well as Stiefel-Whitney, Euler, Chern, and Pontryagin classes. If time allows, other topics may be included. The prerequisites for the class are the material from Math 444/539 and Math 445/540. In particular, the student should be familiar with smooth manifolds, the tangent spaces, homotopy groups, covering spaces, and homology groups.

MATH 551 - DIFFERENTIABLE MANIFOLDS
Short Title: DIFFERENTIABLE MANIFOLDS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: This is a course on differentiable manifolds. Topics include: Differential of a smooth map. Transversality. Implicit function theorem, submersions, and immersions. Tangent and Cotangent bundles. Vector fields, flows. Lie derivatives. Lie groups. Differential forms, Integration on manifolds, Stokes theorem. DeRham theory. Additional topics may include distributions and foliations, including the Frobenius Theorem. Graduate/Undergraduate Equivalency: MATH 451. Recommended Prerequisite(s): MATH 539

MATH 552 - RIEMANNIAN GEOMETRY
Short Title: RIEMANNIAN 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: This is a course on Riemannian manifolds. Topics will include: Tensors, Riemannian metrics. Connections. The exponential map. Geodesics and completeness. Curvature. First and second variations of length and area. Jacobi Fields. Additional topics may vary from year to year. Graduate/Undergraduate Equivalency: MATH 452. Recommended Prerequisite(s): MATH 451/551 or MATH 401/500 Mutually Exclusive: Cannot register for MATH 552 if student has credit for MATH 452.

MATH 563 - ADVANCED ALGEBRA I
Short Title: ADVANCED ALGEBRA 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: This course will cover graduate level topics in group theory, ring theory, and module theory. Specific topics include the isomorphism theorems for groups, rings, and modules; group actions; solvable and nilpotent groups; Sylow's theorems; semi-direct products of groups; ideals; rings of fractions; various unique factorization domains; Hilbert's Basis Theorem; Gröbner Bases; tensor product of modules and universal property; modules over principal ideal domains; and canonical forms. The course will also include an introduction to category theory as time permits. Graduate/Undergraduate Equivalency: MATH 463. Mutually Exclusive: Cannot register for MATH 563 if student has credit for MATH 463.

MATH 564 - ADVANCED ALGEBRA II
Short Title: ADVANCED 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 463 or MATH 563
Description: This course will cover graduate level topics in field theory, Galois theory, and advanced topics in commutative algebra and in multilinear algebra. Specific topics include various algebraic field extensions; fundamental theorem of Galois theory; solvable and radical extensions; transcendental extensions; tensor, symmetric, and exterior algebras; projective, injective, and flat modules; advanced ideal theory; localization; and chain conditions for rings and modules. The course will also additional advanced topics, such as homological algebra, as time permits. Graduate/Undergraduate Equivalency: MATH 464. Mutually Exclusive: Cannot register for MATH 564 if student has credit for MATH 464.

MATH 565 - 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: Cannot register for MATH 565 if student has credit for MATH 465. Repeatable for Credit.

MATH 566 - 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: . Graduate/Undergraduate Equivalency: MATH 466. Mutually Exclusive: Cannot register for MATH 566 if student has credit for MATH 466. Repeatable for Credit.

MATH 567 - 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: Possible topics include rational points on algebraic varieties, moduli spaces, deformation theory, and Hodge structures. Recommended Prerequisite(s): MATH 463 and MATH 464. Repeatable for Credit.

MATH 571 - MATHEMATICS OF APERIODIC ORDER
Short Title: MATHEMATICS OF APERIODIC ORDER
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Lecture
Credit Hours: 3
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: Cannot register for MATH 571 if student has credit for MATH 471.

MATH 590 - CURRENT MATHEMATICS SEMINAR
Short Title: CURRENT MATHEMATICS SEMINAR
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hour: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Lectures on topics of recent research in mathematics delivered by mathematics graduate students and faculty. Repeatable for Credit.

MATH 591 - GRADUATE TEACHING SEMINAR
Short Title: GRADUATE TEACHING SEMINAR
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hour: 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 677 - SPECIAL TOPICS
Short Title: SPECIAL TOPICS
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Internship/Practicum, Laboratory, Lecture, Seminar, Independent Study
Credit Hours: 1-4
Restrictions: Enrollment is limited to Graduate or Visiting Graduate level students.
Course Level: Graduate
Description: Topics and credit hours vary each semester. Contact department for current semester's topic(s). Repeatable for Credit.

MATH 680 - MATHEMATICS COLLOQUIUM
Short Title: MATHEMATICS COLLOQUIUM
Department: Mathematics
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Lecture
Credit Hour: 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 Hour: 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 682 - ALGEBRA SEMINAR
Short Title: ALGEBRA SEMINAR
Department: Mathematics
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Seminar
Credit Hour: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Presentations of research in algebraic geometry and related areas. Repeatable for Credit.

MATH 683 - GEOMETRY SEMINAR
Short Title: GEOMETRY SEMINAR
Department: Mathematics
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Seminar
Credit Hour: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Research in geometry and related areas will be presented by both external and internal speakers. The participation in this course will support the learning experience of students enrolled in the MATH PhD program at Rice who work with a faculty member whose primary research interests intersect geometry and related areas. Repeatable for Credit.

MATH 684 - ANALYSIS SEMINAR
Short Title: ANALYSIS SEMINAR
Department: Mathematics
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Seminar
Credit Hour: 1
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Presentations of research in analysis and related areas. Repeatable for Credit.

MATH 690 - SUPERVISED READING
Short Title: SUPERVISED READING
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Independent Study
Credit Hours: 1-6
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Repeatable for Credit.

MATH 699 - MATHEMATICAL SCIENCES VIGRE SEMINAR
Short Title: MATHEMATICAL SCIENCES
Department: Mathematics
Grade Mode: Standard Letter
Course Type: Seminar
Credit Hours: 1-9
Restrictions: Enrollment is limited to Graduate level students.
Course Level: Graduate
Description: Repeatable for Credit.

MATH 700 - SUMMER RESEARCH FOR PHD STUDENTS
Short Title: SUMMER RESEARCH
Department: Mathematics
Grade Mode: Satisfactory/Unsatisfactory
Course Type: Research
Credit Hours: 9
Restrictions: Enrollment is limited to Graduate level students. Enrollment limited to students in a Doctor of Philosophy degree. Enrollment limited to students in the Mathematics department.
Course Level: Graduate
Description: Summer research for MATH PhD students. Can be repeated for credit. 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.