## Mathematics (MATH)

### 100 Level Courses

**MATH 104: Trigonometry and Transcendental Functions.** 2 credits. Exponential and logarithmic functions, trigonometric functions, and analytic trigonometry. This course does not satisfy the university’s quantitative reasoning requirement. May not be taken for credit after receiving a C or better in MATH 105 or in any MATH course numbered 113 or higher. May not take MATH 105 for credit after receiving a C or better in MATH 104. Notes: May not be used as credit toward BA or BS in mathematical sciences. Offered by Mathematics. May not be repeated for credit.

**Registration Restrictions:**
**Required Prerequisite:** minimum score of 07 in 'Math Placement Algebra II'.

**Schedule Type:** Lecture

**MATH 105: Precalculus Mathematics.** 4 credits. Reviews mathematics skills essential to studying calculus. Topics include equations, inequalities, absolute values, graphs, functions, exponential and logarithmic functions, and trigonometry. Notes: Call Mathematical Sciences Department at 703-993-1460 for details. May not be used as credit toward BA or BS in mathematical sciences. This course does not satisfy the university’s quantitative reasoning requirement for the BA degree. May not be taken for credit after receiving grade of C or better in any MATH course numbered 113 or higher. Offered by Mathematics. May not be repeated for credit.

**Registration Restrictions:**
**Required Prerequisite:** minimum score of 13 in 'Math Placement Algebra II'.

**Schedule Type:** Lecture

**MATH 106: Quantitative Reasoning.** 3 credits. Quantitative skills for real world. Topics include critical thinking, modeling by functions, graphs, growth, scaling, probability, and statistics. Offered by Mathematics. May not be repeated for credit.

**Mason Core:** Quantitative Reasoning

**Schedule Type:** Lecture

**MATH 108: Introductory Calculus with Business Applications.** 3 credits. Functions, limits, derivative, and integral. Applications of differentiation and integration. Notes: Call Mathematical Sciences Department at 703-993-1460 for details. Students who have received credit for MATH 113 or 114 may not receive credit for this course. Offered by Mathematics. May not be repeated for credit.

**Mason Core:** Quantitative Reasoning

**Registration Restrictions:**
**Required Prerequisite:** minimum score of 13 in 'Math Placement Algebra II'.

**Schedule Type:** Lecture

**MATH 110: Introductory Probability.** 3 credits. Elementary set theory, probability, and statistics. Offered by Mathematics. May not be repeated for credit.

**Mason Core:** Quantitative Reasoning

**Schedule Type:** Lecture

**MATH 111: Linear Mathematical Modeling.** 3 credits. Matrix algebra, systems of linear equations, Markov chains, difference equations, and data fitting. Offered by Mathematics. May not be repeated for credit.

**Mason Core:** Quantitative Reasoning

**Schedule Type:** Lecture

**MATH 112: Discrete Mathematics for IT.** 3 credits. Introduces ideas of discrete mathematics including mathematical induction, sets, logic, graphs, trees, basic counting arguments, and discrete probability. Students who have received credit for MATH 125 may not receive credit for this course. Notes: Intended for IT students; does not count toward a major or minor in mathematics. Offered by Mathematics. May not be repeated for credit.

**Registration Restrictions:**
**Required Prerequisites:** minimum score of 13 in 'Math Placement Algebra II', MATH 105 C, 108 C or 113 C.
**C Requires minimum grade of C.**

**Schedule Type:** Lecture

**MATH 113: Analytic Geometry and Calculus I.** 4 credits. Functions, limits, the derivative, maximum and minimum problems, the integral, and transcendental functions. Offered by Mathematics. May not be repeated for credit. Equivalent to MATH 115, MATH 123, MATH 124.

**Mason Core:** Quantitative Reasoning

**Registration Restrictions:**
**Required Prerequisites:** (minimum score of 07 in 'Math Placement Transendentals', MATH 105 C or 104 C).
**C Requires minimum grade of C.**

**Schedule Type:** Lecture, Recitation


**Registration Restrictions:**
**Required Prerequisites:** (MATH 113 C or U113) or (MATH 123 C and 124 C).
**C Requires minimum grade of C.**

**Schedule Type:** Lecture, Recitation

**MATH 115: Analytic Geometry and Calculus I (Honors).** 4 credits. More challenging version of MATH 113. Functions, limits, the derivative, maximum and minimum problems, the integral, and transcendental functions. Offered by Mathematics. May not be repeated for credit. Equivalent to MATH 113.

**Mason Core:** Quantitative Reasoning

**Recommended Prerequisite:** Permission of instructor.

**Registration Restrictions:**
Required Prerequisite: (minimum score of 65 in 'Math Placement Transcendentals').

Schedule Type: Lecture, Recitation

MATH 105: Discrete Mathematics I. 3 credits.
Introduces ideas of discrete mathematics and combinatorial proof techniques including mathematical induction, sets, graphs, trees, recursion, and enumeration. Offered by Mathematics. May not be repeated for credit. Equivalent to MATH 106.

Schedule Type: Lecture

MATH 114: Calculus with Algebra/Trigonometry, Part A. 3 credits.
Math 113, with 114, is a two semester sequence for students with limited math background who desire careers in the sciences. In two semesters, students progress from algebra through the basic calculus covered in Math 113. Math 114 integrates the beginnings of calculus through the derivative with relevant precalculus algebra and trigonometry. Notes: Students who successfully complete Math 113-114 are considered the same as having successfully completed MATH 113 and can sign up for Math 114, Calculus II. Offered by Mathematics. May not be repeated for credit. Equivalent to MATH 115.

Schedule Type: Lecture

MATH 115: Calculus with Algebra/Trigonometry, Part B. 3 credits.
Math 114, with 115, is a two semester sequence for students with limited math background who desire careers in the sciences. In two semesters, students progress from algebra through the basic calculus covered in Math 113. Math 114 integrates the beginnings of calculus through the derivative with relevant precalculus algebra and trigonometry. Notes: Students who successfully complete Math 113-114 are considered the same as having successfully completed MATH 113 and can sign up for Math 114, Calculus II. Offered by Mathematics. May not be repeated for credit. Equivalent to MATH 116.

Schedule Type: Lecture

MATH 116: Analytic Geometry and Calculus II (Honors). 4 credits.
More challenging version of MATH 114. Methods of integration, conic sections, parametric equations, infinite series, and power series. Offered by Mathematics. May not be repeated for credit. Equivalent to MATH 117.

Schedule Type: Lecture, Recitation

MATH 203: Linear Algebra. 3 credits.
Systems of linear equations, linear independence, linear transformations, inverse of a matrix, determinants, vector spaces, eigenvalues, eigenvectors, and orthogonalization. Offered by Mathematics. May not be repeated for credit.

Schedule Type: Lecture

MATH 213: Analytic Geometry and Calculus III. 3 credits.
Partial differentiation, multiple integrals, line and surface integrals, and three-dimensional analytic geometry. Offered by Mathematics. May not be repeated for credit. Equivalent to MATH 214.

Schedule Type: Lecture, Recitation

MATH 214: Elementary Differential Equations. 3 credits.
First-order ODEs, higher-order ODEs, Laplace transforms, linear systems, nonlinear systems, numerical approximations, and modeling. Offered by Mathematics. May not be repeated for credit. Equivalent to MATH 215.

Schedule Type: Lecture

MATH 215: Analytic Geometry and Calculus III (Honors). 3 credits.
Vectors and vector-valued functions, partial differentiation, multiple integrals, line integrals, surface integrals, and transformation of coordinates. Offered by Mathematics. May not be repeated for credit. Equivalent to MATH 216.

Schedule Type: Lecture

MATH 216: Theory of Differential Equations. 3 credits.
First- and second-order equations, existence uniqueness of solutions, systems of differential equations, and phase plane analysis. Offered by Mathematics. May not be repeated for credit. Equivalent to MATH 217.

Schedule Type: Lecture

MATH 271: Mathematics for the Elementary School Teachers I. 3 credits.
Concepts and theories underlying elementary school mathematics including problem solving, patterns, sequences, set theory, numeration,
number sense, operations and properties of integers, whole, rational, irrational and real numbers, number theory, ratio, proportion, percent and mathematical systems. Notes: Does not count toward major in mathematics. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** Grade of C or better in 3 credits of college math.

**Schedule Type:** Lecture

**MATH 272:** *Mathematics for the Elementary School Teachers II*. 3 credits. Continuation of MATH 271. Concepts and theories underlying elementary school mathematics including functions, algebra, geometry, statistics, and probability. Notes: Intended for school educators; does not count toward major in mathematics. Offered by Mathematics. May not be repeated for credit.

**Registration Restrictions:**
**Required Prerequisite:** (MATH 271C).

*C* Requires minimum grade of C.

**Schedule Type:** Lecture

**MATH 290:** *Introduction to Advanced Mathematics*. 3 credits. Introduction to proofs and the language of mathematics. Topics include induction, equivalence relations, cardinality and basic properties of the real numbers. Designated as a writing intensive course for mathematics majors. Notes: Primarily intended for mathematics majors. Offered by Mathematics. May not be repeated for credit.

**Specialized Designation:** Scholarly Inquiry, Writing Intensive in the Major

**Registration Restrictions:**
**Required Prerequisites:** (MATH 114C, 114T or 116C).

*C* Requires minimum grade of C.

**Schedule Type:** Lecture

**300 Level Courses**

**MATH 301:** *Number Theory*. 3 credits.
Prime numbers, factorization, congruences, and Diophantine equations. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** Completion of 6 hours of MATH.

**Schedule Type:** Lecture

**MATH 302:** *Foundations of Geometry*. 3 credits.
Fundamental concepts of incidence. Axioms of Euclidean geometry and the resulting theory, and axioms and development of non-Euclidean and projective geometry. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** Completion of 6 hours of MATH.

**Schedule Type:** Lecture

**MATH 307:** *Mathematical Modeling*. 3 credits.
Focuses on the development and analysis of mathematical models that make qualitative and quantitative predictions. Students will address particular situations while learning general modeling strategies. Offered by Mathematics. May not be repeated for credit.

**Registration Restrictions:**
**Required Prerequisites:** (MATH 203C) and (MATH 214C or 216C).

*C* Requires minimum grade of C.

**Schedule Type:** Lecture

**MATH 312:** *Geometry*. 3 credits.
Two and three dimensional analytic geometry, complex geometry, projective geometry, conics and quadric surfaces, spherical geometry, quaternions, Euclidean and non-Euclidean geometry. This course meets the requirement for secondary school teacher certification. Offered by Mathematics. May not be repeated for credit.

**Registration Restrictions:**
**Required Prerequisites:** (MATH 114C or 116C).

*C* Requires minimum grade of C.

**Schedule Type:** Lecture

**MATH 313:** *Introduction to Applied Analysis*. 3 credits.
Vector differential calculus, vector integral calculus, and complex analysis. Offered by Mathematics. May not be repeated for credit.

**Registration Restrictions:**
**Required Prerequisites:** (MATH 213C, 213T or 215C).

*C* Requires minimum grade of C.

**Schedule Type:** Lecture

**MATH 314:** *Introduction to Applied Mathematics*. 3 credits.

**Registration Restrictions:**
**Required Prerequisites:** (MATH 214C, U214, 216C or U216).

*C* Requires minimum grade of C.

**Schedule Type:** Lecture

**MATH 315:** *Advanced Calculus I*. 3 credits.
Number system, functions, sequences, limits, continuity, differentiation, integration, transcendental functions, and infinite series. Offered by Mathematics. May not be repeated for credit.

**Registration Restrictions:**
**Required Prerequisites:** (MATH 213C or 215C) and MATH 290C.

*C* Requires minimum grade of C.

**Schedule Type:** Lecture

**MATH 316:** *Advanced Calculus II*. 3 credits.
Sequences of functions, Taylor series, vectors, functions of several variables, implicit functions, multiple integrals, and surface integrals. Offered by Mathematics. May not be repeated for credit.

**Registration Restrictions:**
**Required Prerequisites:** (MATH 215C, L315).

*C* Requires minimum grade of C.

**Schedule Type:** Lecture

**MATH 321:** *Abstract Algebra*. 3 credits.
Theory of groups, rings, fields. Offered by Mathematics. May not be repeated for credit.

**Registration Restrictions:**
**Required Prerequisites:** (MATH 213C or 215C) and (MATH 290C).
Schedule Type: Lecture

MATH 322: Advanced Linear Algebra. 3 credits. Abstract vector spaces, linear independence, bases, linear transformations, matrix algebra, inner product, and special topics. Offered by Mathematics. May not be repeated for credit.

Registration Restrictions: Required Prerequisites: (MATH 203C or U203) and (MATH 290C or U290).

MATH 325: Discrete Mathematics II. 3 credits. Advanced counting, binomial identities, generating functions, advanced recurrence, inclusion-exclusion, and network flows. Offered by Mathematics. May not be repeated for credit.

Registration Restrictions: Required Prerequisites: (MATH 125C or 125T).

Schedule Type: Lecture

MATH 351: Probability. 3 credits. Random variables, probability functions, special distributions, and limit theorems. Offered by Mathematics. May not be repeated for credit. Equivalent to STAT 344.

Registration Restrictions: Required Prerequisites: (MATH 213C, 215C or 215T).

Schedule Type: Lecture

MATH 352: Statistics. 3 credits. Estimation, decision theory, testing hypothesis, correlation, linear models, and design. Offered by Mathematics. May not be repeated for credit.

Registration Restrictions: Required Prerequisites: (MATH 351C or L351).

Schedule Type: Lecture

400 Level Courses

MATH 400: History of Math (Topic Varies). 3 credits. Explores internal controversies and dynamics of mathematics in larger intellectual and social settings. Topics vary but might include differential equations devised for mechanics and astronomy by Euler, Lagrange, and Laplace; foundation of mathematical analysis from Cauchy to Weierstrass; algebras of Galois and Boole; or creation of non-Euclidean geometry and Cantor's transfinite sets. Notes: Credits may not be used toward "upper division" math hours required of math majors. Offered by Mathematics. May not be repeated for credit.

MATH 401: Mathematics through 3D Printing. 3 credits. Incorporates new mathematics from a large variety of fields into the design and creation of 3D printed models, as well as the written and oral communication of these mathematical ideas. Topics vary but might include regular and quasiregular tilings, Platonic and Archimedean solids and their duality, orientable and non-orientable surfaces, fractals, chaotic attractors, Riemann surfaces, and data visualization. Offered by Mathematics. May not be repeated for credit.

Recommended Prerequisite: MATH 290 and at least 3 credits of Mathematics above MATH 300.

Schedule Type: Lecture

MATH 405: Honors Thesis in Mathematics I. 3 credits. A project, which is intended to result in a thesis, is to be chosen and completed under the guidance of a full-time faculty member. An oral presentation is required for MATH 405. Offered by Mathematics. May not be repeated for credit.

Specialized Designation: Research Associated

Recommended Prerequisite: MATH 315, three additional credits of MATH above the 300 level (excluding MATH 400) and admission to the Honors Program in Mathematics.

Schedule Type: Independent Study

MATH 411: Functions of a Complex Variable. 3 credits. Analytic functions, contour integration, residues, and applications to such topics as integral transforms, generalized functions, and boundary value problems. Offered by Mathematics. May not be repeated for credit.

Registration Restrictions: Required Prerequisite: (MATH 405C).

Schedule Type: Independent Study


Registration Restrictions: Required Prerequisites: (MATH 214C or 214T) or (MATH 216C or 216T).

Schedule Type: Lecture


Registration Restrictions: Required Prerequisites: (MATH 203C or 203T) and (MATH 214C or 214T) or (MATH 216C or 216T).

Schedule Type: Lecture
Required Prerequisites: (MATH 413C).
\( C \) Requires minimum grade of C.

Schedule Type: Lecture

MATH 414: Modern Applied Mathematics II. 3 credits.
Continuation of MATH 413, which involves synthesis of pure mathematics and computational mathematics. Fourier analysis and its role in applied mathematics developed (differential equations and approximations). Discrete aspects emphasized in computational models. Offered by Mathematics. May not be repeated for credit.

Registration Restrictions:
Required Prerequisite: (MATH 413C).
\( C \) Requires minimum grade of C.

Schedule Type: Lecture

MATH 431: Topology. 3 credits.
Metric spaces, topological spaces, compactness, and connectedness. Offered by Mathematics. May not be repeated for credit.

Registration Restrictions:
Required Prerequisite: (MATH 315C).
\( C \) Requires minimum grade of C.

Schedule Type: Lecture

MATH 441: Deterministic Operations Research. 3 credits.
Survey of deterministic methods for solving real-world decision problems. Programming model and simplex method of solution, duality and sensitivity analysis, transportation and assignment problems, shortest path and maximal flow problems, project networks including PERT and CPM, introduction to integer and nonlinear programming, dynamic programming, and game theory. Emphasizes modeling and problem solving. Offered by Mathematics. May not be repeated for credit. Equivalent to OR 441.

Registration Restrictions:
Required Prerequisites: (MATH 203C or 203T).
\( C \) Requires minimum grade of C.

Schedule Type: Lecture

MATH 442: Stochastic Operations Research. 3 credits.

Registration Restrictions:
Required Prerequisite: (MATH 351C).
\( C \) Requires minimum grade of C.

Schedule Type: Lecture

MATH 446: Numerical Analysis I. 3 credits.
Significant figures, round-off errors, iterative methods of solution of nonlinear equations of a single variable, solutions of linear systems, iterative techniques in matrix algebra, interpolation and polynomial approximation. Offered by Mathematics. May not be repeated for credit. Equivalent to OR 481.

Registration Restrictions:
Required Prerequisites: (MATH 203C or 203T) and (CS 112C or 112T).
\( C \) Requires minimum grade of C.

Schedule Type: Lecture

MATH 447: Numerical Analysis II. 3 credits.

Registration Restrictions:
Required Prerequisites: (MATH 214C, 214T, 216C or 216T) and (MATH 446C).
\( C \) Requires minimum grade of C.

Schedule Type: Lecture

MATH 453: Advanced Mathematical Statistics. 3 credits.
Maximum likelihood tests, sufficiency, most powerful tests, distributions of quadratic forms, topics from nonparametric statistics, Bayesian statistics and linear models. Offered by Mathematics. May not be repeated for credit.

Registration Restrictions:
Required Prerequisite: MATH 352C.
\( C \) Requires minimum grade of C.

Schedule Type: Lecture

MATH 478: Introduction to Partial Differential Equations with Numerical Methods. 3 credits.
Introduces basic facts about partial differential equations, including elliptic equations, parabolic equations and hyperbolic equations. Methods of solution, characteristics, initial/boundary-value problems, and numerical approximation techniques. Offered by Mathematics. May not be repeated for credit.

Registration Restrictions:
Required Prerequisites: (MATH 203C or 203T) and (MATH 214C or 214T) or (MATH 216C or 216T).
\( C \) Requires minimum grade of C.

Schedule Type: Lecture

MATH 491: Reading and Problems. 1-3 credits.
For mathematical sciences majors only. Independent study in math. Notes: Must be arranged with instructor before registering. Offered by Mathematics. May be repeated within the term.

Recommended Corequisite: For mathematical science majors only.

Schedule Type: Independent Study

MATH 493: Topics in Applicable Mathematics. 3 credits.
Topics that have been successfully used in applications of mathematics. Notes: Subject determined by instructor. Offered by Mathematics. May be repeated within the term for a maximum 12 credits.

Recommended Prerequisite: 6 credits of MATH at or above the 310 level.

Schedule Type: Lecture

MATH 494: Topics in Pure Mathematics. 3 credits.
Topics of pure math not covered in other courses. Topics might include Galois theory, cardinal and ordinal arithmetic, measure theory, mathematical logic, and differential geometry. Notes: Subject determined
by instructor. Offered by Mathematics. May be repeated within the term for a maximum 12 credits.

**Recommended Prerequisite:** 6 hours of MATH at or above the 310 level.

**Schedule Type:** Lecture

**MATH 495:** Undergraduate Seminar. 1 credit.
Offered by Mathematics. May be repeated within the degree for a maximum 3 credits.

**Schedule Type:** Seminar

### 500 Level Courses

**MATH 551:** Regression and Time Series. 3 credits.
Mathematics of regression, exponential smoothing, time series, and forecasting. Material included in this course constitutes Society of Actuaries Validation by Educational Experience (VEE) for applied statistics and corresponds to part of Casualty Actuary Society Exam 3. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** MATH 352, STAT 652, SOA exam P, or permission of instructor.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 554:** Financial Mathematics. 3 credits.
Simple and compound interest, annuities, present and future value, yield rates, capital budgeting, amortization schedules, mortgages, bonds. Material corresponds to the Society of Actuaries Exam: Financial Mathematics (FM). Not appropriate for graduate science and engineering majors not considering actuarial or financial career. Cannot be counted toward MS or PhD degree in mathematics. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** MATH 113.

**Recommended Corequisite:** MATH 114.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 555:** Actuarial Modeling I. 3 credits.
Two-semester sequence covering portions of the material corresponding to the Society of Actuaries Exam M, Casualty Actuary Society Exam 3, and Joint Board Exam EA1. The remaining material for these exams is covered in MATH 551 and 653. Topics include survival distribution and life tables, life insurance, life annuities, net premiums, net premium reserves, multiple life and multiple decrement models, pensions, insurance models including expense, and nonforfeiture benefits and cash values. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** MATH 554 and either MATH 351 or STAT 344.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 556:** Actuarial Modeling II. 3 credits.
Two-semester sequence covering portions of the material corresponding to the Society of Actuaries Exam M, Casualty Actuary Society Exam 3, and Joint Board Exam EA1. The remaining material for these exams is covered in MATH 551 and 653. Topics include survival distribution and life tables, life insurance, life annuities, net premiums, net premium reserves, multiple life and multiple decrement models, pensions, insurance models including expense, and nonforfeiture benefits and cash values. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** MATH 554 and either MATH 351 or STAT 344.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 557:** Financial Derivatives. 3 credits.

**Recommended Prerequisite:** MATH 554 and either MATH 351 or STAT 344.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

### 600 Level Courses

**MATH 600:** Special Topics in Mathematics. 1-6 credits.
Mathematical workshops, special courses, or other projects. Offered by Mathematics. May be repeated within the term for a maximum 12 credits.
**Mathematics (MATH)**

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Lecture

MATH 601: *Analysis I for Teachers.* 3 credits.
Develops continuous ideas of calculus with particular emphasis on concepts as opposed to computational aspects of calculus. Specific topics include decimal representation of real numbers, sequences, series, and limits; differentiation to find speed, slopes of curves, and tangents; integration to find volumes and distances and area under curves. Optimization problems including maximization of area and volume, and modeling of these concepts. Graphing techniques supported by theory of calculus and graphing utilities such as TI-83 calculator or computer software such as Maple. Notes: Background in mathematics desirable but not necessary. Some topics from college algebra will be reviewed in class, but thorough understanding of high school algebra and trigonometry expected. Offered by Mathematics. May not be repeated for credit.

**Recommended Corequisite:** Open only to inservice math teachers at the middle or secondary level, or by permission of instructor.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Lecture

MATH 602: *Analysis II for Teachers.* 3 credits.
Develops continuous ideas of calculus with particular emphasis on concepts as opposed to computational aspects of calculus. Specific topics include decimal representation of real numbers, sequences, series, and limits; differentiation to find speed, slopes of curves, and tangents; integration to find volumes and distances and area under curves. Optimization problems including maximization of area and volume, and modeling of these concepts. Graphing techniques supported by theory of calculus and graphing utilities such as TI-83 calculator or computer software such as Maple. Notes: Background in mathematics desirable but not necessary. Some topics from college algebra will be reviewed in class, but thorough understanding of high school algebra and trigonometry expected. Offered by Mathematics. May not be repeated for credit.

**Recommended Corequisite:** Open only to inservice math teachers at the middle or secondary level, or by permission of instructor.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Lecture

MATH 604: *Algebraic Structure for Teachers.* 3 credits.
Covers standard topics from Euclidean geometry, and includes discussion of non-Euclidean geometries. Emphasizes informal and explorative approach to geometry, and makes use of geometry sketchpad. Other topics include geometric constructions, and role of proof in geometry. Notes: Background in mathematics desirable but not necessary. Offered by Mathematics. May not be repeated for credit.

**Recommended Corequisite:** Open only to inservice math teachers at the middle or secondary level, or by permission of instructor.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Lecture

MATH 605: *Discrete/Finite Mathematics for Teachers.* 3 credits.
Thorough understanding of high school algebra assumed. Discusses finite mathematics in juxtaposition to continuous ideas of calculus. Topics may consist of elementary counting and combinatorics including recursion and difference equations and their analogy to calculus; thorough discussion of probability and central measures of statistics; and graph theory and its connection to geometry. Notes: Background in mathematics desirable but not necessary. Offered by Mathematics. May not be repeated for credit.

**Recommended Corequisite:** Open only to inservice math teachers at the middle or secondary level, or by permission of instructor.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Lecture

MATH 607: *Algebraic Structure for Teachers.* 3 credits.
Expands on customary operations on integers and rationals to discuss systems that mimic these operations. Emphasizes multiplicative and additive inverses and their corresponding identities as they occur in other systems. Topics might include permutation groups, rigid transformations, groups of symmetry of the plane and connection to geometry, and matrices treated as linear transformations and connections to solutions of systems of equations. Notes: Background in mathematics desirable but not necessary. Thorough understanding of high school algebra assumed. Offered by Mathematics. May not be repeated for credit.

**Recommended Corequisite:** Open only to inservice math teachers at the middle or secondary level, or by permission of instructor.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

**MATH 608: Problem Solving in Mathematics.** 3 credits.
Introduces variety of challenging mathematical problems appropriate for middle school student to analyze, and solving problems using mathematics learned in previous courses. Also asks students to search for such problems and orally present solutions. Notes: Background in mathematics or science desirable but not necessary. Assumes exposure to most of topics covered in MATH 601, 604, 605, and 607. Offered by Mathematics. May not be repeated for credit.

Recommended Corequisite: Open only to inservice math teachers at the middle or secondary level, or by Permission of Instructor.

Registration Restrictions: Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

**MATH 610: Number Systems and Number Theory for K-8 Teachers.** 3 credits.
This course covers the topics: ways of representing numbers, relationships between numbers, number systems, the meanings of operations and how they relate to one another, and computation within the number system as a foundation for algebra. It also includes episodes in history and development of the number system, and will examine the developmental sequence and learning trajectory as children learn this material. Offered by Mathematics. May not be repeated for credit.

Registration Restrictions: Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

**MATH 611: Geometry and Measurement for K-8 Teachers.** 3 credits.
The course explores the foundations of informal measurement and geometry in one, two, and three dimensions. The van Hiele model for geometric learning is used as a framework for how children build their understanding of length, area, volume, angles, and geometric relationships. Visualization, spatial reasoning, and geometric modeling are stressed. As appropriate, transformational geometry, congruence, similarity, and geometric constructions will be discussed. Offered by Mathematics. May not be repeated for credit.

Recommended Corequisite: Rational Numbers and Proportional Reasoning for K-8 Teachers.

Registration Restrictions: Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

**MATH 612: Probability and Statistics for K-8 Teachers.** 3 credits.
An introduction to probability, descriptive statistics, and data analysis. Topics studied will include the exploration of randomness, data representation, modeling. Descriptive statistics will include measures of central tendency, dispersion, distributions, and regression. The analysis of experiments requiring hypothesizing, experimental design and data gathering will also be discussed. Offered by Mathematics. May not be repeated for credit.

Recommended Corequisite: Open only to inservice math teachers at the middle or secondary level, or by Permission of Instructor.

Registration Restrictions: Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

**MATH 613: Algebra and Functions for K-8 Teachers.** 3 credits.
The course will examine representing and analyzing mathematical situations and structures using generalization and algebraic symbols and reasoning. Attention will be given to the transition from arithmetic to algebra, working with quantitative change, and the description of and prediction of change. Offered by Mathematics. May not be repeated for credit.

Registration Restrictions: Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

**MATH 614: Rational Numbers and Proportional Reasoning for K-8 Teachers.** 3 credits.
This course will cover the basic number strands in fractions and rational numbers, decimals and percents, and ratios and proportions in the school curriculum. Instruction will cover interpretations, computations, and estimation with a coordinated program of activities that develop both rational number concepts and skills and proportional reasoning. Offered by Mathematics. May not be repeated for credit.

Registration Restrictions: Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.
MATH 619: Topics in Mathematical Logic. 3 credits.
Special topics in foundations of mathematics not included in regular mathematics curriculum. May be repeated for credit. Offered by Mathematics. May be repeated within the term for a maximum 12 credits.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 621: Algebra I. 3 credits.
Groups, linear algebra, and matrix groups. Offered by Mathematics. May not be repeated for credit.

Recommended Prerequisite: Familiarity with basic properties of groups and rings or permission of instructor.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 624: Euclidean Geometry. 3 credits.
Euclidean space, geometry of k-dimensional planes, the affine structure of Euclidean space, rigid motions and similarities, paralleloptopes and volumes, convex polytopes, quadric surfaces, and additional topics by instructor's choice. Offered by Mathematics. May not be repeated for credit.

Recommended Prerequisite: MATH 315 and MATH 322, or equivalent.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 625: Numerical Linear Algebra. 3 credits.
Theory and development of numerical algorithms for solving variety of matrix problems: linear systems, least squares problems, eigenvalue problems, and singular value decomposition. Direct and iterative method, analysis of sensitivity to rounding errors, and applications. Offered by Mathematics. May not be repeated for credit. Equivalent to CSI 740.

Recommended Prerequisite: Computer literacy, including some programming experience.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 629: Topics in Algebra. 3 credits.
Special topics in pure and applied algebra not covered in regular algebra. May be repeated for credit when topic varies. Offered by Mathematics. May be repeated within the term for a maximum 12 credits.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 631: Topology I: Topology of Metric Spaces. 3 credits.
Covers definition and basic examples of metric spaces, open and closed sets, subspaces and finite products, sequences and convergence, compactness and separability, continuous functions, uniform continuity, metric space C(X) and uniform convergence, and homotopy. Offered by Mathematics. May not be repeated for credit.

Recommended Prerequisite: MATH 315 or equivalent.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 639: Topics in Geometry and Topology. 3 credits.
Special topics in geometry and topology not covered in regular geometry and topology sequence. May be repeated for credit when topic varies. Offered by Mathematics. May be repeated within the degree for a maximum 12 credits.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 641: Combinatorics and Graph Theory. 3 credits.
Covers enumerative combinatorics, including partially ordered sets; Moebius inversion and generating functions; and major topics in graph
theory such as graph coloring, Ramsey theory, and matching. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** MATH 321 or equivalent.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 644:** Convex and Discrete Geometry. 3 credits.
Basic properties of Euclidean space, convex sets and convex cones, convex hulls, extremal structure of convex sets, support and separation properties, polyhedra and polytopes, special classes of convex sets, Helly-type theorems, selected problems of discrete geometry. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** MATH 315 and MATH 322, or equivalent.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 649:** Topics in Combinatorics. 3 credits.
Special topics in combinatorics not covered in regular combinatorics sequence. May be repeated for credit. Offered by Mathematics. May be repeated within the term for a maximum 9 credits.

**Recommended Prerequisite:** MATH 315 and MATH 322, or equivalent.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 653:** Construction and Evaluation of Actuarial Models I. 3 credits.
Economics of insurance, individual risk models for short term, collective risk models for single period, collective risk models over an extended period, and applications of risk theory. Material included in this course corresponds to portions of the Society of Actuaries Exam M and Casualty Actuary Society Exam 3. The remaining material for these exams is covered in MATH 551, 555, and 556. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** MATH 351 or STAT 644 required. MATH 555 recommended but not required.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 654:** Construction and Evaluation of Actuarial Models II. 3 credits.
Nature and properties of survival and loss models, methods of estimates from complete and incomplete data, tabular and parametric models, and practical issues in survival model estimation. Material included in this course corresponds to most of the Society of Actuaries Exam C and Casualty Actuary Society Exam 4. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** MATH 556 or permission of instructor.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 655:** Pension Valuation. 3 credits.
Basic mathematics used in pension actuarial work without regard to pension law. Material included in this course corresponds to all of the Joint Board Exam EA-2A and portions of the Society of Actuaries Exam 8. This course cannot be counted toward the MS or PhD degree in mathematics. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** MATH 556, SOA Exam EA-1, or permission of instructor.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 661:** Complex Analysis I. 3 credits.
Topology of complex numbers, holomorphic functions, series, complex integration. Meromorphic, multivalued, and elliptic functions. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** MATH 351 or STAT 644 required. MATH 555 recommended but not required.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.
Schedule Type: Lecture

MATH 671: Fourier Analysis. 3 credits.
Study of fundamental ideas in Fourier analysis. Topics include orthonormal systems, Fourier series, continuous and discrete Fourier transform theory, generalized functions, and introduction to spectral analysis. Uses applications to physical sciences, linear systems theory, and signal processing to integrate topics. Offered by Mathematics. May not be repeated for credit.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 673: Dynamical Systems. 3 credits.
Contemporary topics in nonlinear dynamical systems illustrated in mathematical models from physics, ecology, and population dynamics. Traditional qualitative analysis of difference and differential equations provides background for understanding chaotic behavior when it occurs in these models. Topics include stability theory, fractals, Lyapunov exponents, and chaotic attractors. Offered by Mathematics. May not be repeated for credit. Equivalent to MATH 661.

Recommended Prerequisite: Elementary courses in linear algebra and differential equations.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 674: Stochastic Differential Equations. 3 credits.
Introduces stochastic calculus and differential equations. Includes Wiener process, Ito and Stratonovich integrals, Ito formula, martingales, diffusions, and applications, including financial applications. Simulations and numerical approximations of solutions. Offered by Mathematics. May not be repeated for credit.

Recommended Prerequisite: MATH 214 and 351.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 675: Linear Analysis. 3 credits.
Metric spaces, normed linear spaces, completeness, compactness, continuous (bounded) linear transformations, Banach spaces, Hilbert spaces, and orthogonal series. Offered by Mathematics. May not be repeated for credit.

Recommended Prerequisite: MATH 315 and MATH 322, or equivalent.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 677: Ordinary Differential Equations. 3 credits.
Qualitative and quantitative theory of ordinary differential equations. Phase portrait analysis of linear and nonlinear systems, including classification of stable and unstable equilibrium states and periodic orbits. Poincare-Bendixson theorem, Lyapunov stability and Lyapunov functions, and bifurcation theory. Optional topics include averaging and perturbation methods, numerical solution techniques, and chaos. Offered by Mathematics. May not be repeated for credit.

Recommended Prerequisite: MATH 214 or equivalent.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 678: Partial Differential Equations. 3 credits.
Physical examples, characteristics, boundary value problems, integral transforms, and other topics, such as variational, perturbation, and asymptotic methods. Offered by Mathematics. May not be repeated for credit.

Recommended Prerequisite: Elementary differential equations course.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 679: Topics in Analysis and Potential Theory. 3 credits.
Special topics not covered in regular analysis or potential theory sequence. May be repeated for credit when topic varies. Offered by Mathematics. May be repeated within the term for a maximum 12 credits.

Recommended Prerequisite: MATH 671.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.
Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 680: Industrial Mathematics.** 3 credits.
Takes examples from industry and goes through complete solution process: formulation of mathematical model of problem; solution, possibly by numerical approximation; and interpretation and presentation of results. Emphasizes working in groups, relating mathematics to concrete situations, and communication and presentation skills. Offered by Mathematics. May not be repeated for credit.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 683: Modern Optimization Theory.** 3 credits.
Introduces basic mathematical ideas and methods for solving linear and nonlinear programming problems, with emphasis on mathematical aspects of optimization theory. Reviews classical topics of linear programming, and covers recent developments in linear programming, including interior point method. Considers basic results in nonlinear programming, including very recent developments in this field. Offered by Mathematics. May not be repeated for credit.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 685: Numerical Analysis.** 3 credits.
Computational techniques for solving problems arising in science and engineering. Includes theoretical development as well as implementation, efficiency, and accuracy issues in using algorithms and interpreting results. Specific topics include linear and nonlinear systems of equations, polynomial interpolation, numerical integration, and introduction to numerical solution of differential equations. Offered by Mathematics. May not be repeated for credit. Equivalent to CSI 690, CSI 700, OR 682.

**Recommended Prerequisite:** Computer literacy, including some programming experience.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 686: Numerical Solutions of Differential Equations.** 3 credits.
Finite difference methods for initial value problems, two-point boundary value problems, Poisson equation, heat equation, and first-order partial differential equations. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** MATH 214 and MATH 446 or 685.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 687: Variational Methods.** 3 credits.
Weak formulation of partial differential equations, energy principles, Galerkin approximations, and finite element methods. Includes review and development of necessary analysis. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** MATH 446 or 685, and elementary differential equations course.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 689: Topics in Applied and Computational Mathematics.** 3 credits.
Special topics in applied and computational mathematics not covered in the regular applied and computational mathematics sequence. May be repeated for credit when topic varies. Offered by Mathematics. May be repeated within the term for a maximum 12 credits.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 697: Independent Reading and Research.** 1-6 credits.
In areas of importance, but with insufficient demand to justify a regular course, students may undertake a course of study under the supervision of a consenting faculty member. Written statement of the content of the course and a tentative reading list is normally submitted as part of the request for approval. Literature review, project report, or other written product is normally required. May be repeated for credit. Offered by Mathematics. May be repeated within the term.
Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Independent Study

700 Level Courses

MATH 721: Algebra II. 3 credits.
Rings, fields, and Galois theory. Offered by Mathematics. May not be repeated for credit.

Recommended Prerequisite: MATH 621.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 722: Algebraic Topology. 3 credits.
Covers simplices and simplicial complexes, cycles and boundaries, simplicial homology, homological algebra, homotopy and the fundamental group, cohomology. Offered by Mathematics. May not be repeated for credit.

Recommended Prerequisite: MATH 621 and MATH 631 or equivalent.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 723: Combinatorial Structures. 3 credits.
Studies structural properties of objects encountered in pure and applied combinatorics. Topics include partially ordered sets, codes, designs, matroids, buildings, symmetrical structures, permutation groups, and face lattices of polytopes. Offered by Mathematics. May not be repeated for credit.

Recommended Prerequisite: MATH 321 or equivalent.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 724: Commutative Algebra. 3 credits.
Study of commutative rings and their ideals, and of modules over commutative rings and their homological properties. More specific topics include Noetherian rings, primary decomposition, completions, graded rings and dimension theory with applications to algebraic geometry. Offered by Mathematics. May not be repeated for credit.

Recommended Prerequisite: MATH 621.

Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 732: Topology II: Set-Theoretic Topology. 3 credits.
Topics include review of basic set theory (including cardinal numbers, products of sets, the Axiom of Choice), definition of topological spaces, bases for topological spaces, forming new topological spaces by taking subspace, quotients, and products, separation properties (Hausdorff, regular, Tychonoff, and normal spaces) compactness, the Lindelof property, separability, connectedness, continuity and homeomorphism, manifolds. Offered by Mathematics. May not be repeated for credit.

Recommended Prerequisite: MATH 631 or equivalent.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 740: Differential Topology. 3 credits.
Differential forms, manifolds, smooth maps, vector fields, the Euler characteristic, integration on manifolds, and de Rham cohomology. Notes: MATH 740 will be an elective course acceptable (but not required) for the PhD Degree in the Mathematical Sciences offered by the Department of Mathematical Sciences. Offered by Mathematics. May not be repeated for credit.

Recommended Prerequisite: MATH 621 and MATH 631, or equivalent.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 762: Complex Analysis II. 3 credits.
Harmonic functions, generalizations of the maximum principle, entire and meromorphic functions, analytic continuation, and the Riemann mapping theorem. Offered by Mathematics. May not be repeated for credit.

Recommended Prerequisite: MATH 661.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

MATH 763: Functions of Several Complex Variables. 3 credits.
Covers the important results for analytic functions in several variables, including analyticity in several variables and the differences between the theory of one and the theory of several complex variables. Offered by Mathematics. May not be repeated for credit.

Recommended Prerequisite: MATH 661 and MATH 762 or an equivalent preparation in one complex variable.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.
Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 772: Wavelet Theory.** 3 credits.
Study of the theory and computational aspects of wavelets and the wavelet transform. Emphasizes computational aspects of wavelets, defining the Fast Wavelet Transform in one and two dimensions. Developing the appropriate numerical algorithms. Includes developing the theory of wavelet bases on the real line, discussing multiresolution analysis, splines, time-frequency localization, and wavelet packets. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** MATH 315 or equivalent.

**Registration Restrictions:**
Enrollment is limited to Graduate or Non-Degree level students. Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 776: Measure and Integration.** 3 credits.
Lebesgue measure and integration. Theory of Lp spaces with p between one and infinity on the real line. Theory of linear operators on Banach spaces, including the Hahn-Banach theorem, open mapping theorem, closed graph theorem and the uniform boundedness principle. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** MATH 675.

**Registration Restrictions:**
Enrollment is limited to Graduate or Non-Degree level students. Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 781: Advanced Methods in Applied Mathematics.** 3 credits.
Bifurcation theory and perturbation methods for solutions in ordinary and partial differential equations. This course will develop and apply these mathematical tools in current scientific fields, such as biology, materials science, or financial mathematics. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** MATH 677 or permission of instructor.

**Registration Restrictions:**
Enrollment is limited to Graduate or Non-Degree level students. Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 784: Nonlinear Functional Analysis.** 3 credits.
Techniques in nonlinear functional analysis with applications. Contraction mapping principle, Frechet and higher derivatives, the implicit function theorem, Lyapunov-Schmidt method, and bifurcation theory. Finite and infinite dimensional degree theory with applications in partial differential equations. Notes: Different backgrounds may be appropriate, but generally, a student is expected to be an upper level graduate student who has already taken Linear Analysis. Since the applications given in the course are for differential equations, some familiarity with differential equations is extremely useful. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** MATH 675 or permission of instructor.

**Registration Restrictions:**
Enrollment is limited to Graduate or Non-Degree level students. Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 790: Classical Potential Theory.** 3 credits.
Potential theory of Laplace's equation in Euclidean space. Harmonic functions, superharmonic functions, potentials, polar sets and capacity, the Dirichlet problem, the Martin boundary, boundary behavior of superharmonic functions using real variable techniques, and minimal fine limit techniques. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** MATH 675 and MATH 776.

**Registration Restrictions:**
Enrollment is limited to Graduate or Non-Degree level students. Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**MATH 795: Graduate Seminar.** 1 credit.
Mandatory for all PhD students. Weekly seminar graded on presentations and attendance. Faculty presentations on potential thesis topics and presentations by students. Offered by Mathematics. May be repeated within the degree for a maximum 9 credits.

**Recommended Prerequisite:** Enrolled in the PhD program in Mathematics.

**Registration Restrictions:**
Enrollment is limited to Graduate level students. Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Seminar

**MATH 799: MS Thesis.** 1-6 credits.
Original or compilatory work evaluated by committee of three faculty members. Offered by Mathematics. May be repeated within the degree.

**Registration Restrictions:**
Enrollment is limited to Graduate or Non-Degree level students. Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Thesis

**800 Level Courses**

**MATH 800: Studies for the Doctor of Philosophy in Education.** 1-6 credits.
Program of studies designed by student's discipline director and approved by student's doctoral committee, which brings the student to participate in current research of discipline director and results in paper reporting the original contributions of student. Enrollment may be repeated. Offered by Mathematics. May not be repeated for credit.

**Recommended Prerequisite:** Admission to the Ph.D. in Education program to study in mathematical sciences.

**Registration Restrictions:**
Enrollment is limited to Graduate level students.
Schedule Type: Independent Study

900 Level Courses

MATH 998: Doctoral Dissertation Proposal. 1-9 credits.
Work on research proposal that forms basis for doctoral dissertation.
May be repeated for credit. No more than 24 credit hours of 998 and 999 may be applied to doctoral degree requirements. Offered by Mathematics. May be repeated within the degree.

Recommended Prerequisite: Successful completion of qualifying exam.

Registration Restrictions:
Enrollment is limited to Graduate level students.

Schedule Type: Dissertation

MATH 999: Doctoral Dissertation. 1-12 credits.
Formal record of commitment to doctoral dissertation research under the direction of a faculty member. May be repeated for credit. No more than 24 credit hours of 998 and 999 may be applied to doctoral degree requirements. Offered by Mathematics. May be repeated within the degree.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy.

Enrollment is limited to Graduate level students.

Schedule Type: Dissertation