

MATHEMATICS • MATH

General education courses are marked with stars (★).

No student may receive more than nine semester hours of credit in mathematics courses numbered below 1550, with the exception of students who are pursuing the elementary education degree and following the 12-hour sequence specified in that curriculum. No student who has already received credit for a mathematics course numbered 1550 or above may be registered in a mathematics course numbered below 1550, unless given special permission by the Department of Mathematics.

0092 Preparation for College Mathematics II (3) Prereq.: MATH 0091 or placement by department. 3 hrs. lecture. For students not prepared to take MATH 1009, 1015, or 1021. Not for degree credit; 3 sem. hrs. will be added to the degree program of any student taking this course. No student who has received credit for a mathematics course numbered 1000 or above may register for this course. Linear equations and inequalities, polynomials and factoring, algebraic fractions, operations on radical expressions, rational exponents, quadratic equations, graphing.

1009 Mathematics for Prospective Elementary School Teachers I (3) V Prereq.: MATH 0092 or placement by department. Offered by correspondence only. Logic; counting numbers, integers, rational numbers, real numbers; emphasis on field properties; set nomenclature and some number theory; units of measurement.

1010 Mathematics for Prospective Elementary School Teachers II (3) V Prereq.: MATH 1009. Offered by correspondence only. Continuation of MATH 1009. Measurement, informal geometry, systems of equations, introduction to probability and statistics.

1015 Basic Mathematics and Applications (3) V Prereq.: MATH 0092 or placement by department. This course does not serve as a prerequisite for calculus. Credit will not be given for both this course and MATH 1021, 1022, or 1023. Offered by correspondence only. Basic mathematical skills of graphing, formulas for geometric measurement, systems of linear equations and inequalities, review of quadratic equations, logarithms and application to exponential growth and decay, triangle trigonometry and its application to geometry and measurements.

★ **1021 College Algebra (3) F,S,Su** Prereq.: MATH 0092 or placement by department. Credit will not be given for both this course and MATH 1015 or 1023.

Quadratic equations, systems of linear equations, inequalities, functions, graphs, exponential and logarithmic functions, complex numbers, theory of equations.

★ **1022 Plane Trigonometry (3) F,S,Su** Prereq.: MATH 1021 or placement by department. Credit will not be given for both this course and MATH 1015 or 1023. 3 hrs. lecture; 1 hr. lab. Trigonometric functions and identities, inverse trigonometric functions, graphs, solving triangles and equations, complex numbers, polar coordinates.

★ **1023 College Algebra and Trigonometry (5) F,S,Su** Prereq.: placement by department or grade of "A" in MATH 0092. Credit will not be given for both this course and MATH 1015, 1021, or 1022. For qualified students, a replacement for MATH 1021 and 1022 as preparation for calculus.

1025 Mathematics of Commerce (3) F,S Prereq.: MATH 1015 or 1021. Interest, discount, annuities, depreciation, and insurance.

★ **1029 Introduction to Contemporary Mathematics (3)** Prereq.: MATH 0092 or placement by department. Primarily for students in liberal arts and social sciences. Mathematical approaches to contemporary problems, handling of data, and optimization using basic concepts from algebra, geometry, and discrete mathematics.

★ **1100 The Nature of Mathematics (3) F,S,Su** Not for science, engineering, or mathematics majors. For students who desire an exposure to mathematics as part of a liberal education. An honors course, MATH 1101, is also available. Logic; the algebra of logic, computers, and number systems; networks and combinations; probability and statistics.

★ **1101 HONORS: The Nature of Mathematics (3) V** Prereq.: a grade of "A" in MATH 1021 or consent of department. Same as MATH 1100, with special honors emphasis for qualified students. Logic; the algebra of sets, logic, and networks; probability and statistics; game theory; infinities; famous impossibilities and unsolved problems.

1201 Number Sense and Open-Ended Problem Solving (3) F,S,Su Prereq.: MATH 1021. Primarily for students in the elementary education curriculum. Cardinality and integers; decimal representation and the number line; exploratory data analysis; number sense; open-ended problem solving strategies; written communication of mathematics.

1202 Geometry, Reasoning, and Measurement (3) F,S,Su Prereq.: MATH 1201. Primarily for students in the elementary education Holmes curriculum. Synthetic and coordinate geometry in two and three dimensions; spatial visualization and counting procedures; symmetries and tilings; history of geometry; written communication of mathematics.

★ **1431 Calculus with Business and Economic Applications (3) F,S,Su** Prereq.: MATH 1021 or equivalent. Credit will be given for only one of the following: MATH 1431, 1441, 1550. 3 hrs. lecture; 1 hr. lab. Differential and integral calculus of algebraic, logarithmic, and exponential functions; applications to business and economics, such as maximum-minimum problems, marginal analysis, and exponential growth models.

1435 Mathematics for Business Analysis (3) Prereq.: MATH 1431 or equivalent. Offered by correspondence only. Sets and counting; probability, including conditional probability, discrete and continuous random variables, variance, and normal distributions; matrices and echelon method for solving systems of equations; functions of several variables and partial derivatives.

★ **1441 Calculus with Application to Technology (3) F,S** Prereq.: MATH 1021 and 1022; or 1023; or consent of department. Credit will be given for only one of the following: MATH 1431, 1441, 1550. Differentiation and integration of algebraic and trigonometric functions; application to technology.

★ **1550 Analytic Geometry and Calculus I (5) F,S,Su** Prereq.: MATH 1022 or 1023 or consent of department. An honors course, MATH 1551, is also available. Credit will be given for only one of the following: MATH 1431, 1441, 1550. Analytic geometry, limits, derivatives, integrals.

★ **1551 HONORS: Analytic Geometry and Calculus I (5) F** Same as MATH 1550, with special honors emphasis for qualified students.

★ **1552 Analytic Geometry and Calculus II (4) F,S,Su** Prereq.: MATH 1550. An honors course, MATH 1553, is also available. Credit will not be given for both this course and either MATH 1553 or MATH 1554. Techniques of integration, parameter equations, polar coordinates, infinite series, vectors in low dimensions; introduction to differential equations and partial derivatives.

★ **1553 HONORS: Analytic Geometry and Calculus II (4) S** Same as MATH 1552 with special honors emphasis for qualified students. Credit will not be given for both this course and MATH 1554.

1554 Calculus II for Life Sciences (4) F,S Prereq.: MATH 1550. Credit will not be given for this course and either MATH 1552 or 1553. Does not satisfy prerequisite requirement for higher level Math courses. Designed for biological science majors. Techniques of integration, introduction to differential equations, stability of equilibrium points, elementary linear algebra, elements of multivariable calculus, systems of differential equations.

1635 Further Calculus for Quantitative Analysis (5) Prereq.: MATH 1435 or 1550. Credit will not be given for this course and either MATH 1552 or 2057. Selected topics in single-variable calculus, including related rates, Riemann sums, Newton's method, elementary differential equations, infinite sequences and series; functions of several variables, including partial derivatives, least squares regression, Lagrange multipliers, double integrals; vectors in two and three dimensions.

2010 Inquiry Approaches to Math and Science Teaching (1) See BIOL 2010.

2011 Inquiry-Based Math and Science Lesson Design (1) See BIOL 2011.

2020 Solving Discrete Problems (3) F,S Prereq.: MATH 1550. Logic, counting, discrete probability, graph theory, and number theory.

2025 Integral Transforms and Their Applications (3) F Prereq.: MATH 1552. Introduction to mathematical proofs and structures using selected topics from analysis; series of functions, Fourier series, Fourier integrals, and introduction to wavelets; applications in differential equations and signal processing.

2030 Discrete Dynamical Systems (3) S Prereq.: MATH 1552 or permission of instructor. Dynamical systems with discrete time and in one spatial dimension; hyperbolicity; quadratic maps; chaos; structural stability; bifurcation theory; and higher dimensional systems.

2040 Fundamentals of Mathematics (3) Prereq.: MATH 1550. Introduction to techniques of mathematical proofs; sets, logic, relations and functions, induction, cardinality, and properties of real numbers.

2057 Multidimensional Calculus (3) F,S,Su Prereq.: MATH 1552. An honors course, MATH 2058, is also available. Three-dimensional analytic geometry, partial derivatives, multiple integrals.

2058 HONORS: Multidimensional Calculus (3) F Same as MATH 2057, with special honors emphasis for qualified students.

2060 Technology Lab (1) F,S,Su Prereq.: credit or concurrent enrollment in MATH 2057. Students are encouraged to enroll in MATH 2057 and 2060 concurrently. Use of computers for investigating, solving, and documenting mathematical problems; numerical, symbolic, and graphical manipulation of mathematical constructs discussed in MATH 1550, 1552, and 2057.

2065 Elementary Differential Equations (3) F,S Prereq.: MATH 1552. Credit will be given for only one of the following: MATH 2065, 2070, 2090. Ordinary differential equations; emphasis on solving linear differential equations.

2070 Mathematical Methods in Engineering (4) F,S Prereq.: MATH 1552. Credit will be given for only one of the following: MATH 2065, 2070, 2090. Ordinary differential equations, Laplace transforms, linear algebra, and Fourier series; physical applications stressed.

2085 Linear Algebra (3) F,S,Su Prereq.: MATH 1552, 1635 or 2040, or equivalent. An honors course, MATH 2086, is also available. Credit will not be given for both this course and MATH 2090. Systems of linear equations, vector spaces, linear transformations, matrices, determinants.

2086 HONORS: Linear Algebra (3) V Same as MATH 2085, with special honors emphasis for qualified students.

2090 Elementary Differential Equations and Linear Algebra (4) F,S,Su Prereq.: MATH 1552. Credit will be given for only one of the following: MATH 2065, 2070, 2090. Credit will not be given for both this course and MATH 2085. Introduction to first order differential equations, linear differential equations with constant coefficients, and systems of differential equations; vector spaces, linear transformations, matrices, determinants, linear dependence, bases, systems of equations, eigenvalues, eigenvectors, Laplace transforms, and Fourier series.

2203 Measurement: Proportional and Algebraic Reasoning (3) F,S Prereq.: Professional Practice I Block, 12 sem. hrs. of mathematics including MATH 1201 and 1202, and concurrent enrollment in EDCI 3125 AND 3126. 2 hrs. lecture; 2 hrs. lab/field experience (as part of Professional Practice II Block); Mathematics content course designed to be integrated in Praxis II with the principles and structures of mathematical reasoning applied to the grades 1-6 classroom. Development of a connected, balanced view of mathematics; application of measurable attributes of objects and the units, systems, and processes of measurement; appropriate techniques, tools, and formulas of measurement; interrelationship of patterns, relations, and functions; applications of proportional and algebraic reasoning in mathematical situations and structures using contextual, numeric, graphic, and symbolic representations; written communication of mathematics.

3001 Mathematics Tutoring Experience (1) F,S Prereq.: MATH 1552, EDCI 2001 and concurrent enrollment in EDCI 3001. 3 hr. lab. Course provides a carefully supported, monitored, and evaluated mathematics tutoring experience in a local middle, or high school under the guidance of a mathematics faculty member and a mentoring mathematics teacher in the local school.

3002 Mathematics Classroom Presentations (1) F,S Prereq.: MATH 3001, EDCI 3001, and concurrent enrollment in EDCI 3002. Under the supervision of a mathematics faculty member and a mentoring mathematics teacher in a local school, students will prepare and deliver middle and/or high school mathematics lessons that incorporate appropriate use of technology.

3355 Probability (3) F,S Prereq.: MATH 2057. Suggested for preparation for actuarial exams. Introduction to probability, emphasizing concrete problems and applications; random variables, expectation, conditional probability, law of large numbers, central limit theorem, and stochastic processes.

3903 Methods of Problem Solving (1) F Prereq.: MATH 1552 and MATH 2070, 2085, or 2090. May be taken for a max. of 3 hrs. of credit when topics vary. Pass-fail grading. Instruction and practice in solving a wide variety of mathematical and logical problems, and participation in the Putnam competition.

3998 Undergraduate Major Seminar (1) V May be taken for a max. of 4 hrs. of credit. Pass-fail grading. Topics of current interest.

4003 Instructional Strategies in Mathematics (1) F,S Prereq.: MATH 3002, EDCI 3002, and concurrent enrollment in EDCI 4003. Instructional activities and strategies for mathematics that depart from the lecture style cooperative learning or open-ended exploration; students will design and conduct a mathematics lesson using such strategies.

4004 Mathematics Education Capstone Course (3) F,S Prereq.: MATH 4003, EDCI 4003, and concurrent enrollment in EDCI 4004. Student should be within two semesters of completion of requirements for a mathematics major. Same as MATH 4020 with special education emphasis for students in the secondary education area of concentration.

4005 Geometry (3) S Prereq.: MATH 2040. The foundation of geometry, including work in Euclidean and non-Euclidean geometries.

4020 Capstone Course (3) F,S Prereq.: Students should be within two semesters of completing the requirements for a mathematics major and must have completed a 4000-level mathematics course with a grade of "C" or better, or obtain permission of the department. Provides opportunities for students to consolidate their mathematical knowledge, and to obtain a perspective on the meaning and significance of that knowledge. Course work will emphasize communication skills, including reading, writing, and speaking mathematics.

4023 Applied Algebra (3) F,S,Su Prereq.: MATH 2085 or equivalent. Credit will not be given for both this course and MATH 4200. Finite algebraic structures relevant to computers: groups, graphs, groups and computer design, group codes, semigroups, finite-state machines.

4024 Mathematical Models (3) S Prereq.: MATH 1552 and credit or registration in MATH 2085; or equivalents. Construction, development, and study of mathematical models for real situations; basic examples, model construction, Markov chain models, models for linear optimization, selected case studies.

4025 Optimization Theory and Applications (3) S Prereq.: MATH 2057 and credit or registration in MATH 2085; or equivalent. Basic methods and techniques for solving optimization problems; n-dimensional geometry and convex sets; classical and search optimization of functions of one and several variables; linear, nonlinear, and integer programming.

4027 Differential Equations (3) S Prereq.: MATH 2057 and 2085. Ordinary differential equations, with attention to theory.

4031 Advanced Calculus I (3) F Completeness of the real line, Bolzano-Weierstrass theorem and Heine-Borel theorem; continuous functions including uniform convergence and completeness of $C[a,b]$; Riemann integration and the Darboux Criterion.

4032 Advanced Calculus II (3) S Derivative, including uniform convergence, the mean value theorem and Taylor's Theorem; absolute and uniform convergence of series, completeness of sequence spaces, dual spaces; real analytic functions; functions of bounded variation, the Stieltjes integral, and the dual of $C[a,b]$.

4035 Advanced Calculus of Several Variables (3) F Prereq.: MATH 2085 and 4031. Topology in n-dimensional space, differential calculus in n-dimensional space, inverse and implicit function theorems.

4036 Complex Variables (3) F,S Prereq.: MATH 2057. Analytic functions, integration, power series, residues, and conformal mapping.

4038 Mathematical Methods in Engineering (3) F,S,Su Prereq.: MATH 2065 or 2070 or 2090 and MATH 2057. Also offered as ME 4563. Vector analysis; solution of partial differential equations by the method of separation of variables; introduction to orthogonal functions including Bessel functions.

4039 Introduction to Topology (3) V Prereq.: MATH 4031 or equivalent. Examples and classification of two-dimensional manifolds, covering spaces, the Brouwer theorem, and other selected topics.

4050 Interest Theory (3) F Prereq.: MATH 3355. Measurement of interest (including accumulated and present value factors), annuities certain, yield rates, amortization schedules and sinking funds, and bonds and related securities.

4056 Mathematical Statistics (3) S Prereq.: MATH 3355. Suggested for preparation for actuarial exams. Experimental design, sampling methods, nonparametric methods, hypothesis testing, and regression.

4058 Elementary Stochastic Processes (3) S Prereq.: MATH 2085 and 3355. Markov chains, Poisson process, and Brownian motion.

4065 Numerical Analysis I (3) F Prereq.: MATH 2057. Basic programming ability in Fortran, Pascal, or C. Newton's method, Lagrange interpolation, least-squares approximation, orthogonal polynomials, numerical differentiation and integration, Gaussian elimination.

4066 Numerical Analysis II (3) S Prereq.: MATH 4065 and one of the following: MATH 2065, 2070, 2090, 4027. Numerical solutions of initial value problems and boundary value problems for ordinary and partial differential equations.

4153 Finite Dimensional Vector Spaces (3) S Prereq.: MATH 2057 or 2085. Vector spaces, linear transformations, determinants, eigenvalues and vectors, and topics such as inner product space and canonical forms.

4158 Foundations of Mathematics (3) V Prereq.: MATH 2057 or equivalent. Real number systems, sets, relations, product spaces, order, and cardinality.

4171 Theory of Graphs (3) Prereq.: MATH 2085 or consent of department. Fundamental concepts of undirected and directed graphs, trees, connectivity and traversability, planarity, colorability, network flows, matching theory, and applications.

4172 Combinatorics (3) F Prereq.: MATH 2085 or equivalent. Topics selected from permutations and combinations, generating functions, principle of inclusion and exclusion, configurations and designs, matching theory, existence problems, applications.

4181 Elementary Number Theory (3) F Prereq.: MATH 2057 or 2085. Divisibility, Euclidean algorithm, prime numbers, congruences, and topics such as Chinese remainder theorem and sums of integral squares.

4200 Abstract Algebra I (3) F Prereq.: MATH 2085 or equivalent. Credit will not be given for both this course and MATH 4023. Elementary properties of sets, relations, mappings, integers; groups, subgroups, normal subgroups, quotient groups, homomorphisms, automorphisms, and permutation groups; elementary properties of rings.

4201 Abstract Algebra II (3) S Prereq.: MATH 4200 or equivalent. Ideals in rings, factorization in polynomial rings; unique factorization and Euclidean domains, field extensions, splitting fields, finite fields, Galois theory.

4325 Fourier Transforms (3) V Prereq.: MATH 1552 and at least one from MATH 2057, 2065, 2070, 2085, 2090. For students majoring in mathematics, physics, and engineering. Fourier analysis on the real line, the integers, and finite cyclic groups; the fast Fourier transform; generalized functions; attention to modern applications and computational methods.

4340 Partial Differential Equations (3) V Prereq.: either MATH 2057, 2090, and knowledge of Laplace transforms; or MATH 2057, 2065, or 2070 and 2085. First-order partial differential equations and systems, canonical second-order linear equations, Green's functions, method of characteristics, properties of solutions, and applications.

4345 Special Functions (3) V Prereq.: either MATH 2057 and 2090; or MATH 2057, 2065 or 2070 and 2085. Sturm-Liouville problems, orthogonal functions (Bessel, Laguerre, Legendre, Hermite), orthogonal expansions including Fourier series, recurrence relations and generating functions, gamma and beta functions, Chebyshev polynomials, and other topics.

4470 Error-Correcting Codes (3) V Prereq.: MATH 2085 or 2090 or equivalent knowledge of linear algebra. Vector spaces over finite fields, basic properties of codes, examples of important codes and decoding schemes, bounds on sizes and rates of codes, the weight enumerator polynomial, perfect codes, and other topics.

4700 History of Mathematics (3) V Prereq.: MATH 2040, 2057, and 2085; students entering the course should have a firm sense of what constitutes a proof. This course will have substantial mathematical content; topics such as early Greek mathematics, from Euclid to Archimedes; algebra and number theory from Diophantus to the present; the calculus of Newton and Leibniz; the renewed emphasis on rigor and axiomatic foundations in the 19th and 20th centuries; interactions of mathematics with technology and the natural sciences; biographies of significant mathematicians.

4998 Senior Seminar for Mathematics Majors (3) S Prereq.: the student should be within two semesters of completion of requirements for a mathematics major; for undergraduate credit only; under guidance of professor teaching the course, student will undertake several independent reading projects and write expository papers; oral presentations will follow preparation of written papers.

4999 Selected Readings in Mathematics (1-3) Prereq.: consent of department. May be taken for a max. of 9 sem. hrs. credit.

6300 Topics in Mathematics for Secondary Teachers (1-3) V Prereq.: 6 sem. hrs. of mathematics at or above the level of 2040 or equivalent. May be taken for a max. of 6 sem. hrs. credit when topics vary. May be taken by M.N.S. students in mathematics with departmental approval. Areas of current interest to teachers of secondary school mathematics.

6301 Implementing the NCTM Standards I (3) May be taken for a max. of 9 sem. hrs. of credit when topics vary. Enrollment is restricted to participants in the teacher-training and grant-supported programs. Topics for mathematics teachers (K-5) to be selected from those in the Principles and Standards of School Mathematics of the National Council of Teachers of Mathematics.

6302 Implementing the NCTM Standards II (3) May be taken for a max. of 9 sem. hrs. of credit when topic vary. Enrollment is restricted to participants in the teacher-training and grant-supported programs. Topics for mathematics teachers (6-8) to be selected from those in the Principles and Standards of School Mathematics of the National Council of Teachers of Mathematics.

7001 Communicating Mathematics I (1) F Prereq.: consent of department. Practical training in the teaching of undergraduate mathematics; how to write mathematics for publication; other issues relating to mathematical exposition.

7002 Communicating Mathematics II (1) S Prereq.: consent of department. Practical training in the written and oral presentation of mathematical papers; the teaching of mathematics and the uses of technology in the mathematics classroom.

7200 Geometric and Abstract Algebra (3) Prereq.: MATH 2085 or equivalent. Linear algebra, rings, finite fields, groups, multilinear algebra, other topics.

7210, 7211 Algebra I, II (3,3) 7210 offered S; 7211 offered F Prereq.: MATH 7200 or equivalent. Groups: Sylow Theorems, finitely generated abelian groups; rings and modules: exact sequences, projective modules; fields: algebraic, transcendental, normal, separable field extensions; Galois theory, valuation theory, Noetherian and Dedekind domains, topics from commutative rings.

7280 Seminar in Commutative Algebra (1-3) V Prereq.: consent of department. May be repeated for credit with consent of department. Advanced topics such as commutative rings, homological algebra, algebraic curves, or algebraic geometry.

7290 Seminar in Algebra and Number Theory (1-3) V Prereq.: consent of department. May be repeated for credit with the consent of the department. Advanced topics such as algebraic number theory, algebraic semigroups, quadratic forms, or algebraic K-theory.

7311 Real Analysis I (3) Prereq.: MATH 4032 or equivalent. Axiom of choice, Lebesgue measure and integration, convergence theorems, bounded variation and absolute continuity, differentiation, Minkowski-Holder inequalities, Riesz-Fischer theorem.

7312 Real Analysis II (3) Prereq.: MATH 7311 or equivalent. Ascoli theorem, Stone-Weierstrass theorem, Hahn-Banach theorem, uniform boundedness theorem, Hilbert spaces, weak topologies, general measure and integration, Riesz representation theorem, other related topics.

7320 Ordinary Differential Equations (3) S Prereq.: MATH 2085 and 4031; or equivalent. Existence and uniqueness theorems, approximation methods, linear equations, linear systems, stability theory; other topics such as boundary value problems.

7325 Numerical Analysis and Applications (3) S Prereq.: MATH 4065 or equivalent. Finite difference methods; finite element methods; iterative methods; methods of parallel computing; applications to the sciences and engineering.

7330 Functional Analysis (3) V Prereq.: MATH 7312 or equivalent. Banach spaces and their generalizations; Baire category, Banach-Steinhaus, open mapping, closed graph, and Hahn-Banach theorems; duality in Banach spaces, weak topologies; other topics such as commutative Banach algebras, spectral theory, distributions, and Fourier transforms.

7350 Complex Analysis (3) V Prereq.: MATH 7311 or equivalent. Theory of holomorphic functions of one complex variable; path integrals, power series, singularities, mapping properties, normal families, other topics.

7360 Probability Theory (3) F Prereq.: MATH 7311 or equivalent. Probability spaces, random variables and expectations, independence, convergence concepts, laws of large numbers, convergence of series, law of iterated logarithm, characteristic functions, central limit theorem, limiting distributions, martingales.

7370 Lie Groups and Representation Theory (3) V Prereq.: MATH 7312, 7200, and 7510 or equivalent. Lie groups, Lie algebras, subgroups, homomorphisms, the exponential map. Also topics in finite and infinite dimensional representation theory.

7375 Wavelets (3) S Prereq.: MATH 7311 or equivalent. Fourier series; Fourier transform; windowed Fourier transform or short-time Fourier transform; the continuous wavelet transform; discrete wavelet transform; multiresolution analysis; construction of wavelets.

7380 Seminar in Functional Analysis (1-3) V Prereq.: consent of department. May be repeated for credit with consent of department. Advanced topics such as topological vector spaces, Banach algebras, operator theory, or nonlinear functional analysis.

7390 Seminar in Analysis (1-3) V Prereq.: consent of department. May be repeated for credit with consent of department. Advanced topics such as harmonic analysis, partial differential equations, Lie group representation theory, several complex variables, or probability theory.

7400 Combinatorial Theory (3) S Prereq.: MATH 7200 or equivalent. Problems of existence and enumeration in the study of arrangements of elements into sets; combinations and permutations; other topics such as generating functions, recurrence relations, inclusion-exclusion, Polya's theorem, graphs and digraphs, combinatorial designs, incidence matrices, partially ordered sets, matroids, finite geometries, Latin squares, difference sets, matching theory.

7490 Seminar in Combinatorics, Graph Theory, and Discrete Structures (1-3) V Prereq.: consent of department. May be repeated for credit with consent of department. Advanced topics such as combinatorics, graph theory, automata theory, or optimization.

7510 Topology I (3) Prereq.: MATH 2057 or equivalent. Basic notions of general topology, with emphasis on Euclidean and metric spaces, continuous and differentiable functions, inverse function theorem and its consequences.

7512 Topology II (3) *Prereq.: MATH 7510.* Theory of the fundamental group and covering spaces including the Seifert-Van Kampen theorem; universal covering space; classification of covering spaces; selected areas from algebraic or general topology.

7520 Algebraic Topology (3) S *Prereq.: MATH 7200 and 7510; or equivalent.* Basic concepts of homology, cohomology, and homotopy theory.

7550 Differential Geometry and Topology (3) F *Prereq.: MATH 7200 and 7510; or equivalent.* Manifolds, vector fields, vector bundles, transversality, Riemannian geometry, other topics.

7590 Seminar in Geometry and Algebraic Topology (1-3) V *Prereq.: consent of department. May be repeated for credit with consent of department.* Advanced topics such as advanced algebraic topology, transformation groups, surgery theory, sheaf theory, or fiber bundles.

7690 Seminar in Topological Algebra (1-3) V *Prereq.: consent of department. May be repeated for credit with consent of department.* Advanced topics such as topological groups, topological semigroups, or topological lattices.

7999 Selected Readings in Mathematics (1-3) *Prereq.: g consent of department. May be repeated for credit with consent of department.*

8000 Thesis Research (1-12 per sem.) "S"/"U" grading.

9000 Dissertation Research (1-12 per sem.) "S"/"U" grading.