MATHEMATICS

Students interested in specializing in mathematics and intending to do either graduate work in Mathematics or work in business or industry will be interested in this degree. The Mathematics Department Degree Program prepares students for employment in the private or public sector, graduate school, and scientific research. Studying mathematics naturally develops quantitative thinking and analytic problem solving, talents with universal application. Demand will always be high for individuals with these universal talents to solve society’s diverse and complex problems.

Eight concentrations and a No Concentration Option are available for a Bachelor of Arts and a Bachelor of Science.

Other Information

All coursework taken for the mathematics major or minor must be completed with a grade of C- or better.

Double Majors

If planned correctly, some disciplines, such as computer science and math 6-12 teaching endorsement, require few, if any, additional math courses beyond what is required for the major.

Writing in the Discipline

All students are required to take a writing in the discipline course within their major. For the math major, select one of the following:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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<tr>
<td>ENGL 3980</td>
<td>TECHNICAL WRITING ACROSS THE DISCIPLINES</td>
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<td>ENGL 3050</td>
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<td>CIST 3000</td>
<td>ADVANCED COMPOSITION FOR IS&amp;T</td>
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Student Groups

Math Club
Pi Mu Epsilon National Mathematics Honorary Society
Putnam Competition

Contact

Advisor/Academic Coordinator, Deb Challman
204 DSC
402.554.3841

Website ([http://www.unomaha.edu/college-of-arts-and-sciences/mathematics](http://www.unomaha.edu/college-of-arts-and-sciences/mathematics))

Bachelor of Arts and Bachelor of Science in Mathematics

The B.A. and B.S. Degrees with a major in Mathematical Sciences consists of 47 credits of required courses in Mathematics. Approved Statistics courses may also be included. Either degree option has eight possible concentrations and a No Concentration Option. The concentrations are defined by the required upper division courses.

Degrees Offered

- Mathematics, Bachelor of Arts ([http://catalog.unomaha.edu/undergraduate/college-arts-sciences/mathematics/mathematics-ba](http://catalog.unomaha.edu/undergraduate/college-arts-sciences/mathematics/mathematics-ba))
- Mathematics, Bachelor of Science ([http://catalog.unomaha.edu/undergraduate/college-arts-sciences/mathematics/mathematics-bs](http://catalog.unomaha.edu/undergraduate/college-arts-sciences/mathematics/mathematics-bs))

The Bachelor of Arts Degree requires foreign language through the intermediate level.

The Bachelor of Science Degree requires 18 credits in cognate courses outside the Department of Mathematics and approved by the Math Department Curriculum Committee as a cohesive group of courses, normally with at least 9 credits 3000 or 4000 level.

Minors Offered


MATH 1000 PRE-INTERMEDIATE ALGEBRA (2 credits)

An introductory level algebra course designed to prepare students to be successful in MATH 1310 (Intermediate Algebra). Topics include whole numbers, integers, fractions and mixed numbers, decimals, simplifying mathematical expressions, the properties of equality, solving linear equations in one variable, using linear equations to solve problems, ratios and proportions, graphing and the rectangular coordinate system. This course is worth two credit hours and will not satisfy the Math General Education requirement.

Prerequisite(s)/Corequisite(s): ACT Math sub score of 11-18, Math SAT at least 220 or Math SAT2016 at least 230 within the last 2 years; or Accuplacer score of 1 or COMPASS score of 1 or 2 within the last two years; or an F or better in MATH 1000 within the last 2 years

MATH 1010 PRE-INTERMEDIATE ALGEBRA PART II (1 credit)

This course is designed to prepare students who have passed MATH 1000, Pre-Intermediate Algebra, with a C- or better to be successful in MATH 1220, College Algebra for General Education. It will serve as a one credit bridge course and will be offered for a maximum of two years. Credit earned in MATH 1010 will not count towards the 120 hour degree requirement.

Prerequisite(s)/Corequisite(s): UNO’s MATH 1000 taken within the last two years with a grade of C- or better and department permission. The last semester MATH 1010 will be offered will be spring of 2020.

MATH 1120 INTRODUCTION TO MATHEMATICAL AND COMPUTATIONAL THINKING (3 credits)

This course embraces the visual arts to introduce students to the foundational elements of mathematical and computational thinking. Visual patterns form the basis for explorations in arithmetic and geometric sequences, from which algebraic functions and corresponding functions in computer programs are reasoned. (Cross-listed with STEM 1120).

Distribution: Math

MATH 1130 QUANTITATIVE LITERACY (3 credits)

Designed to equip students with the mathematical, statistical, and computational skills necessary to explore real-life situations. Students will learn and practice critical-thinking and problem-solving skills needed to use quantitative information to make responsible decisions in a variety of areas such as finance, health, and the environment.

Distribution: Math

MATH 1210 INTERMEDIATE ALGEBRA (3 credits)

This course is designed to prepare students to be successful in MATH 1220. Topics include simplifying mathematical expressions, the properties of equality, solving linear equations in one variable, using linear equations to solve problems, fractions, ratios and proportions, graphing and the rectangular coordinate system, relations and functions, systems of linear equations and inequalities in two variables, polynomial expressions and functions, factoring and solving polynomial equations. Credit earned in MATH 1210 will not count toward degree requirements.

Prerequisite(s)/Corequisite(s): ACT Math sub score of 18 or less, Math SAT at least 220 or Math SAT2016 at least 230 within the last 2 years; or Accuplacer score of 1 or 2 within the last 2 years; or MATH 1210 within the last 2 years.
MATH 1220 COLLEGE ALGEBRA (3 credits)
This course presents properties of real numbers, linear equations and graphing, systems of equations, linear inequalities, polynomials, algebraic fractions, exponents, logarithms, and an Introduction to Statistics. This course is designed to prepare students to be successful in MATH 1320 or MATH 1370. Students who have passed MATH 1310 with a C- or better should not take this course.
Prerequisite(s)/Corequisite(s): Within last two years: ACT Math at least 19, Math SAT at least 460, Math SAT2016 at least 500, Accuplacer score at least 3, MATH 1210 C- or better or MATH 1220 F or better. Students who have passed MATH 1310 with a C- or better should not take MATH 1220.
Distribution: Math

MATH 1320 PRE-CALCULUS ALGEBRA (3 credits)
An advanced algebra course that teaches the following topics: algebraic operations, functions, graphs, linear and quadratic equations and inequalities, polynomial and rational functions, systems of equations, binomial theorem, complex numbers, exponentials, logarithms, sequences, series, and combinatorics.
Prerequisite(s)/Corequisite(s): ACT Math at least 23, Math SAT at least 540, or Math SAT2016 at least 570 last 2 years; or Accuplacer score at least 4 last 2 years; or MATH 1220 or MATH 1310 each with C- or better last 2 years; or MATH 1320 last 2 years

MATH 1330 TRIGONOMETRY (3 credits)
This course introduces elements of plane trigonometry, including trigonometric and circular functions, inverse trigonometric functions, solutions of triangles, identities and conditional equations, vectors, and conic sections.
Prerequisite(s)/Corequisite(s): ACT Math at least 25, Math SAT at least 570, or Math SAT2016 at least 590 within last 2 years; or Accuplacer at least 5 within last 2 years; or MATH 1320 with at least C- within last 2 years; or MATH 1330 within last 2 years

MATH 1340 ALGEBRA AND TRIGONOMETRY FOR CALCULUS (5 credits)
A combined algebra and trigonometry course for science and engineering students planning to enroll in MATH 1950. Topics include: systems of equations, polynomials and rational functions, exponential and logarithmic functions, trigonometric functions and their inverses, trigonometric identities and applications, conic sections, and complex numbers. Credit for both MATH 1320/MATH 1324 and MATH 1340, or both MATH 1330 and MATH 1340 will not be given.
Prerequisite(s)/Corequisite(s): ACT Math at least 23, Math SAT at least 540, or Math SAT2016 at least 570 last 2 years; or Accuplacer at least 5 or COMPASS at least 4 last 2 years; or MATH 1310 or MATH 1220 with at least C- last 2 years; or MATH 1340 last 2 years

MATH 1370 APPLIED ALGEBRA AND OPTIMIZATION WITH DATA ANALYSIS (4 credits)
This is an applied algebra course with optimization, teaching the following topics with an emphasis on data analysis and application: algebraic, exponential, and logarithmic functions; derivatives and applications thereof; and statistics. The course will emphasize data analysis and applications of covered topics in order to demonstrate the relevance of mathematics to solving real-world problems.
Prerequisite(s)/Corequisite(s): ACT Math sub score at least 23, Math SAT at least 540, or Math SAT2016 at least 570 within last 2 years; or Accuplacer or COMPASS score at least 4 within last 2 years; or MATH 1310 or MATH 1220 with C- or better with in last 2 years

MATH 1530 INTRODUCTION TO APPLIED PROBABILITY AND STATISTICS (3 credits)
An elementary introduction to the basic concepts of probability, descriptive statistics, and statistical inference, including point estimation, confidence intervals, and hypotheses testing.
Prerequisite(s)/Corequisite(s): ACT Math sub score at least 19, Math SAT at least 460, or Math SAT2016 at least 500 within last 2 years; Accuplacer score at least 3 within last 2 years; or MATH 1210 each with C- or better within last 2 years
Distribution: Math

MATH 1930 CALCULUS FOR THE MANAGERIAL, LIFE, AND SOCIAL SCIENCES (3 credits)
Topics covered include functions, limits, derivatives, integrals, and applications. Trigonometry is not required. May not be used as a prerequisite for MATH 1960. Credit will not be granted for both MATH 1930 and 1950.
Prerequisite(s)/Corequisite(s): ACT Math sub score at least 25, Math SAT at least 570, or Math SAT2016 at least 590 within last 2 years; or Accuplacer or COMPASS score at least 6 within last 2 years; or MATH 1320 with at least C- within last 2 years; or MATH 1930 within last 2 years

MATH 1940 CALCULUS FOR BIOMEDICINE (5 credits)
Introductory calculus with an emphasis on dynamical systems analysis applied to biological systems. Topics include differential and integral calculus, elementary chaos theory, discrete modeling, neural networks, and elementary differential equations, population dynamics, and biochemical signal transduction.
Prerequisite(s)/Corequisite(s): ACT Math sub score at least 25, Math SAT at least 570, or Math SAT2016 at least 590 within last 2 years; or Accuplacer or COMPASS score at least 6 within last 2 years; or MATH 1320 with at least C- within last 2 years; or permission of instructor

MATH 1950 CALCULUS I (5 credits)
This is a course in plane analytic geometry emphasizing the study of functions, limits, derivatives and applications, and an introduction to integration.
Prerequisite(s)/Corequisite(s): ACT Math sub score at least 26, Math SAT at least 590 or Math SAT2016 at least 610 within last 2 years; or Accuplacer or COMPASS score of 7 within last 2 years; or MATH 1330 or MATH 1340 with C- or better within last 2 years

MATH 1960 CALCULUS II (5 credits)
This course introduces applications of integration, techniques of integration, infinite sequences and series, vectors in the plane, and polar functions. A mathematical software package is introduced, with required assignments.

MATH 1970 CALCULUS III (4 credits)
This course presents vector functions, parametric equations, solid analytic geometry, partial differentiation, multiple integration, and an introduction to vector calculus. A mathematical software package is introduced with required assignments.
Prerequisite(s)/Corequisite(s): MATH 1950 with a grade of C- or better or permission of instructor

MATH 2030 DISCRETE MATHEMATICS (3 credits)
A foundations course in discrete mathematics for applied disciplines, including computer science and computer engineering. Topics include: logic, sets, relations, functions, complexity functions and big congruences, induction and recursive definitions, elementary combinatorics, discrete probability, graphs and trees.
Prerequisite(s)/Corequisite(s): MATH 1950 or MATH 1930.
MATH 2040 FINITE DISCRETE MATHEMATICS FOR INFORMATION SCIENCE AND ENGINEERING (3 credits)
A foundations course in discrete mathematics for applied disciplines including information science and computer engineering. Topics include: logic, sets, relations, functions, complexity functions and big congruences, induction and recursive definitions, elementary combinatorics, discrete probability, graphs, trees, vectors, matrices, linear equations, eigenvalues, Markov chains, and linear programming. 
Prerequisite(s)/Corequisite(s): MATH 1950 or MATH 1930.

MATH 2050 APPLIED LINEAR ALGEBRA (3 credits)
This course presents Matrix algebra, simultaneous equations, vector spaces, with applications of linear algebra and computational considerations. Mathematical software is utilized, with required assignments. 
Prerequisite(s)/Corequisite(s): MATH 1950 with a grade of C- or better

MATH 2200 MATHEMATICAL COMPUTING I (3 credits)
This is a first course in mathematical computing. It covers the basic elements of scientific programming in both a computer algebra system and a high-level programming language. Explored are implementation issues, problem description, model building, method development, and solution assessment. 
Prerequisite(s)/Corequisite(s): MATH 1950

MATH 2230 INTRODUCTION TO ABSTRACT MATH (3 credits)
This course provides a transition from the calculus to more abstract mathematics. Topics include logic, sets and functions, an introduction to mathematical proof, mathematical induction, relations. Important prerequisite material for a number of more advanced mathematics courses is studied. Credit will not be given for both MATH 2030 (or MATH 2040) and MATH 2230. 
Prerequisite(s)/Corequisite(s): MATH 1960 or permission

MATH 2350 DIFFERENTIAL EQUATIONS (3 credits)
Topics include solutions of linear and first-order nonlinear differential equations with applications, higher-order linear differential equations with applications, power series solutions, and Laplace transform methods. 
Prerequisite(s)/Corequisite(s): MATH 1960 with a grade of C- or better

MATH 3100 APPLIED COMBINATORICS (3 credits)
Basic counting methods, generating functions, recurrence relations, principle of inclusion-exclusion, Polya's formula. Elements of graph theory, trees and searching network algorithms. (Cross-listed with MATH 8105, CSCI 3100, CSCI 8105). 
Prerequisite(s)/Corequisite(s): MATH 2030, MATH 2040, MATH 2230, or CSCI 2030 all with a C- or better. Mathematical logic; Set theory; Relations; Functions; Congruences; Inductive and recursive definitions; Discrete probability; sets, graphs, trees, & matrices

MATH 3200 MATHEMATICAL COMPUTING II (3 credits)
This course is a second course in mathematical computing. It covers the design and development of algorithms and more advanced elements of programming in a mathematical context. The computer algebra system Maple will be used. The programming assignments are primarily based on calculus concepts and are designed to reinforce and deepen the understanding of these concepts. 
Prerequisite(s)/Corequisite(s): CIST 1400 or MATH 2200, and MATH 1970 (the latter may be taken concurrently)

MATH 3230 INTRODUCTION TO ANALYSIS (3 credits)
Provides a theoretical foundation for the concepts of elementary calculus. Topics include real number system, topology of the real line, limits, functions of one variable, continuity, differentiation, integration. (Cross-listed with MATH 8235). 
Prerequisite(s)/Corequisite(s): MATH 1960 and MATH 2230

MATH 3300 NUMERICAL METHODS (3 credits)
This course involves solving nonlinear algebraic equations and systems of equations, interpolation and polynomial approximation, numerical differentiation and integration, numerical solutions to ordinary differential equations, analysis of algorithms and errors, and computational efficiency. (Cross-listed with MATH 8305, CSCI 3300, CSCI 8305). 
Prerequisite(s)/Corequisite(s): MATH 1960 with a C- or better or permission of instructor

MATH 3400 THEORY OF INTEREST (3 credits)
A study of the measurement of interest, annuities, amortization schedules and other miscellaneous topics. 
Prerequisite(s)/Corequisite(s): MATH 1970

MATH 3500 SELECTED TOPICS IN MATHEMATICS (1-6 credits)
This is a variable content course with selected topics in the mathematical sciences which may be of interest to students in other disciplines such as mathematics education, psychology and business. The course may be taken more than once for credit provided topics differ, with a maximum of nine hours. Mathematics majors may apply no more than three hours of MATH 3500 toward the minimum major requirements. (Cross-listed with MATH 8505). 
Prerequisite(s)/Corequisite(s): Permission of instructor.

MATH 3640 MODERN GEOMETRY (3 credits)
Axiomatic systems, finite geometries, modern foundations of Euclidean geometry, hyperbolic and other non-Euclidean geometrics, projective geometry. (Cross-listed with MATH 8645). 
Prerequisite(s)/Corequisite(s): MATH 2230 or MATH 2030, or equivalent mathematical maturity.

MATH 3650 HISTORY OF MATHEMATICS (3 credits)
An overview of the historical development of mathematical concepts and methods. Brief biographies of major mathematicians, descriptions of the cultural context of selected major advances and examples of the solution of problems using the knowledge and methods appropriate for each time period will be included. (Cross-listed with MATH 8855). 
Prerequisite(s)/Corequisite(s): Students who enroll in this course should have completed MATH 1970 and MATH 2230 in order to have the minimum amount of mathematical background needed to appreciate the mathematical content of the course.

MATH 4010 INTRODUCTION TO THE THEORY OF RECURSIVE FUNCTIONS (3 credits)
This is a proof-oriented course presenting the foundations of Recursion Theory. We present the definition and properties of the class of primitive recursive functions, study the formal models of computation, and investigate partially computable functions, universal programs. We prove Rice’s Theorem, the Recursion Theorem, develop the arithmetical hierarchy, demonstrate Post’s theorem. Introduction to the formal theories of computability and complexity is also given. (Cross-listed with CSCI 4010, CSCI 8016, MATH 8016). 
Prerequisite(s)/Corequisite(s): MATH 2230 with a C- or better or CSCI 3660 with a C- or better or instructor’s permission

MATH 4030 MODERN ALGEBRA (3 credits)
Algebra is the study of mathematical manipulations that preserve something (like equality - when solving equations). The areas in which Algebra finds application are quite diverse, from Ancient Greek Geometry through to Modern Information Protection and Security (error correcting codes, data compression, and cryptography). This course begins with topics that should be familiar (such as ruler-and-compass constructions, and modular arithmetic) and builds upon this foundation through polynomial rings up to finite fields and basic group theory. (Cross-listed with MATH 8036). 
Prerequisite(s)/Corequisite(s): MATH 2230 with a C- or better or MATH 2030 with a C- or better
MATH 4050  LINEAR ALGEBRA (3 credits)
The theory of vectors, vector spaces, inner product spaces, linear transformations, eigenvalues, canonical forms, complex vectors and matrices and orthogonality. Unlike MATH 2050, this course emphasizes the theoretical aspects of linear algebra. (Cross-listed with MATH 8056).
Prerequisite(s)/Corequisite(s): MATH 2050, MATH 2030 or MATH 2230 or equivalent; or permission

MATH 4110  ABSTRACT ALGEBRA I (3 credits)
An introduction to group theory. Various classes of group are studied: symmetric groups, abelian, cyclic, and permutation groups. Basic tools are developed and used: subgroups, normal subgroups, cosets, the Lagrange theorem, group homomorphisms, quotient groups, direct products, and group actions on a set. The course culminates with the Sylow theorems in finite group theory. The theory is illustrated with examples from geometry, linear algebra, number theory, crystallography, and combinatorics. (Cross-listed with MATH 8116).
Prerequisite(s)/Corequisite(s): MATH 4050/MATH 8056 with a C- or better or MATH 4560/MATH 8566 with a C- or better or permission of instructor

MATH 4120  ABSTRACT ALGEBRA II (3 credits)
An introduction to ring field theory. Various classes of commutative rings are considered including polynomial rings, and the Gaussian integers. Examples of fields include finite fields and various extensions of the rational numbers. Concepts such as that of an ideal, integral domain, characteristic and extension field are studied. The course culminates with an introduction to Galois theory. Applications include the resolution of two classical problems: the impossibility of angle-trisection and the general insolvability of polynomial equations of degree 5 or higher. (Cross-listed with MATH 8126).
Prerequisite(s)/Corequisite(s): MATH 4110/MATH 8116 with a C- or better or permission of instructor

MATH 4150  GRAPH THEORY & APPLICATIONS (3 credits)
Introduction to graph theory. Representations of graphs and graph isomorphism. Trees as a special case of graphs. Connectivity, covering, matching and coloring in graphs. Directed graphs and planar graphs. Applications of graph theory in several fields such as networks, social sciences, VLSI, chemistry and parallel processing. (Cross-listed with MATH 8156, CSCI 4150, CSCI 8156).
Prerequisite(s)/Corequisite(s): CSCI 2030 with a C- or better, or MATH 4560/MATH 8566 with a C- or better or permission of instructor

MATH 4230  MATHEMATICAL ANALYSIS I (3 credits)
Provides a theoretical foundation for the concepts of elementary calculus. Topics include ordered fields and the real number system, basic properties of complex numbers, metric space topology, sequences and series in Rk, limits and continuity in a metric space, monotonic functions. (Cross-listed with MATH 8236).
Prerequisite(s)/Corequisite(s): MATH 3200 and MATH 4300 each with a C- or better

MATH 4240  MATHEMATICAL ANALYSIS II (3 credits)
Provides a theoretical foundation for the concepts of elementary calculus. Topics include differentiation and Riemann-Stieljes Integration, sequences and series of functions, uniform convergence, power series, functions of several variables, Implicit Function Theorem. (Cross-listed with MATH 8246).
Prerequisite(s)/Corequisite(s): MATH 4230

MATH 4270  COMPLEX VARIABLES (3 credits)
Differentiation, integration and power series expansions of analytic functions, conformal mapping, residue calculation and applications. (Cross-listed with MATH 8276).
Prerequisite(s)/Corequisite(s): MATH 3230/MATH 8235 or equivalent.

MATH 4300  DETERMINISTIC OPERATIONS RESEARCH MODELS (3 credits)
This is a survey course of deterministic operations research models and algorithms. Topics include linear programming, network programming, and integer programming. (Cross-listed with CSCI 4300, CSCI 8306, MATH 8306).
Prerequisite(s)/Corequisite(s): MATH 2050 with a C- or better or permission of instructor.

MATH 4310  PROBABILISTIC OPERATIONS RESEARCH MODELS (3 credits)
This is a survey course of probabilistic operations research models and algorithms. Topics include Markov chains, queuing theory, inventory models, forecasting, and simulation. (Cross-listed with CSCI 4310, CSCI 8316, MATH 8316).
Prerequisite(s)/Corequisite(s): MATH 2050 and either MATH 4740 or MATH 8746 or STAT 3800 or STAT 8805 all with a C- or better or permission of instructor.

MATH 4320  COMPUTATIONAL OPERATIONS RESEARCH (3 credits)
Survey of computational methods used in the solution of operations research problems. Topics include scripting to guide optimization software, metaheuristics for optimization, and basic machine learning algorithms. (Cross-listed with MATH 8326).
Prerequisite(s)/Corequisite(s): MATH 3200 and MATH 4300 each with a grade of C- or better or permission of instructor.

MATH 4330  INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS (3 credits)
This course introduces the basic methods of PDEs guided by applications in physics and engineering. The main topics to be covered include The Linear First order PDEs, Transport equations, Characteristics, Classification of PDEs, Separation of variables, Heat conduction, vibrating membranes, boundary value problems, Maximum principle, Sturm-Liouville problems, Fourier series, Fourier integrals, Harmonic functions, Legendre polynomials, Distributions, Green’s functions.. (Cross-listed with MATH 8336).
Prerequisite(s)/Corequisite(s): MATH 1970 with a C- or better and MATH 2350 with a C- or better, or permission of instructor; MATH 2050 recommended, not required.

MATH 4350  ORDINARY DIFFERENTIAL EQUATIONS (3 credits)
Ordinary Differential Equations develops the theory of initial-, boundary-, and eigenvalue problems, existence theorems, real and complex linear systems of differential equations, and stability theory. There will be a strong emphasis on methods for finding solutions of initial and boundary value problems and analyzing properties of these solutions for various differential equations. (Cross-listed with MATH 8356).
Prerequisite(s)/Corequisite(s): MATH 2050 with a C- or better and MATH 2350 with a C- or better or instructor’s permission. It is recommended, but not required, that students take MATH 3230, which would require a C- or better.

MATH 4400  FINITE ELEMENT METHODS FOR SOLVING ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS (3 credits)
Prerequisite(s)/Corequisite(s): MATH 1970 with a C- or better, MATH 2050 with a C- or better, MATH 2350 with a C- or better, or instructor’s permission. MATH 3300/MATH 8305 and MATH 4330/ MATH8336 are recommended, but not required. Familiarity with MATLAB programming is assumed.
MATH 4450 INTRODUCTION TO MACHINE LEARNING AND DATA MINING (3 credits)
This is an introduction to machine learning and data mining which covers the following topics with an emphasis on mathematical and statistical analysis: linear and nonlinear regression models, model selection and regularization methods, resampling methods, classification models, tree-based models, and unsupervised learning topics. If time allows, text mining and deep learning will also be introduced in the course. Statistical software will be used. (Cross-listed with MATH 8456, STAT 4450, STAT 8456)
Prerequisite(s)/Corequisite(s): MATH 4740/8746 with a C- or better or STAT 3800/8805 with a C- or better or permission of instructor.

MATH 4560 NUMBER THEORY & CRYPTOGRAPHY (3 credits)
An overview of one of the many beautiful areas of mathematics and its modern application to secure communication. The course is ideal for any student who wants a taste of mathematics outside of, or in addition to, the calculus sequence. Topics to be covered include: prime numbers, congruences, perfect numbers, primitive roots, quadratic reciprocity, sums of squares, and Diophantine equations. Applications include error-correcting codes, symmetric and public key cryptography, secret sharing, and zero knowledge proofs. (Cross-listed with MATH 8566, CSCI 4560, CSCI 8566).
Prerequisite(s)/Corequisite(s): MATH 2230 with a C- or better or MATH 2030 with a C- or better or CSCI 2030 with a C- or better or permission of instructor.

MATH 4610 INTRODUCTION TO TOPOLOGY (3 credits)
This is a proof-oriented course presenting the foundations of topology. Metric spaces and general topological spaces are introduced. The course explores the properties of connectedness, compactness and completeness, and operations of Tychonoff product and hyperspace. (Cross-listed with MATH 8616).
Prerequisite(s)/Corequisite(s): MATH 3230 with a C- or better or permission of instructor.

MATH 4620 ITERATED FUNCTION SYSTEMS AND FRACTALS (3 credits)
This is a proof-oriented course presenting the foundations of fractal geometry. It introduces students to the beauty, magic, and applications of fractals and iterated function systems, with emphasis on the mathematics behind it all. Topics range from contractions on hyperspaces and their fixed points to fractal dimensions to Julia and Mandelbrot sets. (Cross-listed with MATH 8626).
Prerequisite(s)/Corequisite(s): MATH 4610 with a C- or better or permission of instructor.

MATH 4660 AUTOMATA, COMPUTABILITY, AND FORMAL LANGUAGES (3 credits)
This course presents a sampling of several important areas of theoretical computer science. Definition of formal models of computation and important properties of such models, including finite automata and Turing machines. Definition and important properties of formal grammars and their languages. Introduction to the formal theories of computability and complexity. (Cross-listed with CSCI 4660, CSCI 8666, MATH 8666)
Prerequisite(s)/Corequisite(s): MATH 2030. Recommended: CSCI 3320/ CSCI 8325.

MATH 4740 INTRODUCTION TO PROBABILITY AND STATISTICS I (3 credits)
A mathematical introduction to probability theory including the properties of probability; probability distributions; expected values and moments; specific discrete and continuous distributions; and transformations of random variables. (Cross-listed with MATH 8746).
Prerequisite(s)/Corequisite(s): MATH 1970 and either MATH 2230 or MATH 2030

MATH 4740 INTRODUCTION TO PROBABILITY AND STATISTICS II (3 credits)
Theory and methods of statistical inference including estimators, statistical hypotheses, multivariate estimation, chi-square tests, analysis of variance and statistical software. (Cross-listed with MATH 8746).
Prerequisite(s)/Corequisite(s): MATH 4740/MATH 8746

MATH 4760 TOPICS IN MODELING (3 credits)
Selection of such topics as formulation and analysis of various models involving Markov chains, Markov processes (including birth and death processes), queues, cellular automata, difference and differential equations, chaotic systems and fractal geometries. (Cross-listed with MATH 8766, CSCI 4760, CSCI 8766).
Prerequisite(s)/Corequisite(s): MATH 2350 and MATH 4740 or MATH 8746.

MATH 4980 SEMINAR (1-3 credits)
A seminar in mathematics.
Prerequisite(s)/Corequisite(s): At least one math course numbered 3000 or above (not including MATH 3500) and permission.

STAT 3000 STATISTICAL METHODS I (3 credits)
Distributions, introduction to measures of central value and dispersion, population and sample, the normal distribution, inference: single population, inference: two populations, introduction to analysis of variance. Statistical packages on the computer will also be utilized in the course. (Cross-listed with STAT 8005)
Prerequisite(s)/Corequisite(s): MATH 1310 or MATH 1220 or equivalent.

STAT 3010 STATISTICAL METHODS II (3 credits)
Regression and correlation, analysis of covariance, chi-square type statistics, more analysis of variance, questions of normality, introduction to non-parametric statistics. Statistical packages are used when appropriate. (Cross-listed with STAT 8015)
Prerequisite(s)/Corequisite(s): STAT 3000 or STAT 8005 or equivalent.

STAT 3800 APPLIED ENGINEERING PROBABILITY AND STATISTICS (3 credits)
An introduction to the application of probability and statistics to engineering problems. Topics include: probability and probability distributions, mathematical expectation, distribution of random variables, binomial, Poisson, hypergeometric, gamma, normal, and t-distributions, Central Limit Theorem, confidence intervals, hypothesis testing, linear regression, contingency tables. Credit for both MATH 4740 and STAT 3800 will not be given. (Cross-listed with STAT 8805)
Prerequisite(s)/Corequisite(s): MATH 1970

STAT 4410 INTRODUCTION TO DATA SCIENCE (3 credits)
Topics covered in this course include Data Technology, Methods of gathering and cleaning structured or unstructured data, Exploratory data analysis & Dynamic and interactive data visualization, Modeling data for prediction, forecasting or classification. (Cross-listed with STAT 8416)
Prerequisite(s)/Corequisite(s): MATH 4740 with at least C- or concurrent or STAT 3800 with at least C- or permission of instructor.
Students enrolling in this course should be comfortable with computer programming & have knowledge of data structures & preliminary statistical methods.
STAT 4420  EXPLORATORY DATA VISUALIZATION AND QUANTIFICATION (3 credits)
Topics covered in this course include Exploratory Data Visualization for
categorical/qualitative single/multivariate data, Grammar of Graphics,
Organizing Data for Visualization, Methods of Displaying Data that include
dynamic and interactive visualization, Visual Diagnostics of Statistical
Models and Visual Statistical Inference. Students planning to enroll in
this course should be comfortable with computer programming and have
knowledge of data structures and preliminary statistical methods. (Cross-
listed with STAT 8426)
Prerequisite(s)/Corequisite(s): MATH 4750 or MATH 8756 w/ a grade
of C- or better or STAT 3800 or STAT 8005 w/ a C- or better or another
introductory probability/statistics course w/ a C- or better, & CSCI 1620 or
equivalent with a grade of C- or better, or permission of instructor.

STAT 4430  LINEAR MODELS (3 credits)
This is an introduction to linear statistical models which will include: simple
linear regression models, multiple linear regression models, ANOVA models
including one way ANOVA, randomized block design, and other designs.
Also, logistic regression models, Poisson regression models, bootstrapping/
resampling models, survival analysis. Some necessary linear algebra and
mathematical statistics ideas will be covered in the course also. If time
allows, some mixed models and/or survival models. Much use of computer
software will be made. (Cross-listed with STAT 8436)
Prerequisite(s)/Corequisite(s): MATH 4750 or MATH 8756 w/ a C- or
better or STAT 3800 or STAT 8005 w/ a C- or better or instructor permission
based on students’ having taken a basic statistics course w/ a grade of C- or
better & having at least a basic knowledge of calculus.

STAT 4440  TIME SERIES ANALYSIS (3 credits)
The objective of this course is to learn and apply statistical methods for the
analysis of data that have been observed over time. Topics covered include:
Models for Stationary and Non-Stationary Time Series, Model Specification,
Parameter Estimation, Model Diagnostics, Forecasting, Seasonal Models,
Time Series Regression, and Spectral Analysis. Statistical software will be
used. (Cross-listed with STAT 8446)
Prerequisite(s)/Corequisite(s): MATH 4750 or MATH 8756 w/ a grade
of C- or better or STAT 3800 or STAT 8005 w/ a C- or better or another
introductory probability/statistics course w/ a C- or better, & CSCI 1620 or
equivalent with a grade of C- or better, or permission of instructor.

STAT 4450  INTRODUCTION TO MACHINE LEARNING AND DATA MINING (3 credits)
This is an introduction to machine learning and data mining which covers
the following topics with an emphasis on mathematical and statistical
analysis: linear and nonlinear regression models, model selection and
regularization methods, resampling methods, classification models, tree-
based models, and unsupervised learning topics. If time allows, text mining
and deep learning will also be introduced in the course. Statistical software
will be used. (Cross-listed with MATH 4450, MATH 8456, STAT 8456)
Prerequisite(s)/Corequisite(s): MATH 4740/8746 with a C- or better or
STAT 3800/8805 with a C- or better or permission of instructor.