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 Department of Mathematics and Statistical Sciences Degree Program prepares students for employment in the private or public sector, graduate school, and scientific research. Studying mathematics naturally develops quantitative thinking and analytical 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.

Seven 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.

At least one MATH or STAT course at the 3000 level or higher (excluding STAT 3000) must be taken at UNO to establish residency for the Mathematics major or minor.

Double Majors

If planned correctly, some disciplines, such as computer science and math 6-12 teaching endorsement, require few to no additional math courses beyond what is required for the major. Talk to your advisor about double majoring with Mathematics to expand your educational opportunities!

Student Groups

Math Club
Pi Mu Epsilon National Mathematics Honorary Society
Putnam Competition

Fast Track Program

Other Program Related Information

Fast Track Program

The Department of Mathematics and Statistical Sciences has developed a Fast Track program for highly qualified and motivated students providing the opportunity to complete a bachelor's degree and a master's degree in an accelerated time frame. With Fast Track, students may count up to 9 graduate hours toward the completion of their undergraduate program as well as the graduate degree program.

Program Specifics:

- This program is available for undergraduate students pursuing a BA/BS in Mathematics or pursuing a double-major with BA/BS in Mathematics as the primary or secondary major desiring to pursue a MA/MS/MAT in Mathematics.
- Students must have completed no less than 60 undergraduate hours
- Students must have a minimum undergraduate GPA of 3.0.
- Students must complete the Fast Track Approval form, obtain all signatures, and submit to the Office of Graduate Studies prior to first enrollment in a graduate course.
- Students will work with their undergraduate advisor to register for the graduate courses.
- A minimum cumulative GPA of 3.0 is required for graduate coursework to remain in good academic standing.
- Students remain undergraduates until they meet all the requirements for the undergraduate degree and are eligible for all rights and privileges granted undergraduate status including financial aid.
- Near the end of the undergraduate program, formal application to the graduate program is required. The application fee will be waived, the applicant will need to contact the Office of Graduate Studies for a fee waiver code.
  - Admission to Fast Track does NOT guarantee admission to the graduate program.
  - The admit term must be after the completion term of the undergraduate degree.

Contact

Advisor/Academic Coordinator, Emily Cook
204 DSC
402.554.3841

Website (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 Mathematics consists of 46 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/)
- Mathematics, Bachelor of Science (http://catalog.unomaha.edu/undergraduate/college-arts-sciences/mathematics/mathematics-bs/)

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:

Code	Title	Credits
CIST 3000	ADVANCED COMPOSITION FOR IS&T	3
ENGL 3050	WRITING FOR THE WORKPLACE	3
ENGL 3980	TECHNICAL WRITING ACROSS THE DISCIPLINES	3
PHIL 3000	PHILOSOPHY WRITING SEMINAR	3

The Bachelor of Arts Degree requires foreign language through the intermediate level (16 credits).

The Bachelor of Science Degree requires at least 15 hours of related Cognate coursework that must be approved by the Math Academic Advisor/Coordinator. Students can also choose a UNO Minor to satisfy their Cognate requirement; however, this Cognate minor cannot double-count as the Option 1 minor for the College of Arts & Sciences College Breadth Requirement. A Computer Science Minor cannot satisfy the Cognate requirement for Mathematics. No more than 6 credits of Cognate coursework may double-count within the general education requirements.

Minors Offered

- Mathematics Minor (http://catalog.unomaha.edu/undergraduate/college-arts-sciences/mathematics/math-minor/)

The Department Mathematics and Statistical Sciences 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, skills with universal application. Mathematics majors learn to make critical observations,

organize, analyze, and interpret data, and extract information and patterns. Demand will always be high for individuals with these universal skills to solve society's diverse and complex problems.

Mathematics majors often pursue careers as a:

- Cryptanalyst – developing encryption for cyber security for the Defense Department.
- Data scientist – analyzing data to make predictive decisions for a retailer.
- Operations research analyst – optimally determining which aircraft an airline should purchase.
- Teacher – teaching Math at the 7-12 level.
- Actuary – evaluating risk and helping companies make decisions.

When the Mathematics major is matched with complementary minors and thoughtful internships, new possibilities arise. A few examples are:

- Math + Biology = Biomathematician: modeling biological processes for a Biotech company.
- Math + Graphic Design = Animator: making realistic graphics for a movie.
- Math + Forensics = Forensics Analyst: solve crimes for the FBI.
- Math + Geology = Hydrologist: solving problems related to water quantity, quality, and availability for the U.S. Geological Survey.
- Math + English = Technical writer: writing documents for industries that need writers fluent with numbers and calculations.

MATH 1100 DATA LITERACY AND VISUALIZATION (3 credits)
Designed to help students become familiar with different types of data that are available in business, non-profit and governmental organizations. Students will learn basic data organization and manipulation as well as appropriate visualization techniques including charts, maps, and dashboards using cutting edge software tools. Students will apply this knowledge and skills to real-world data and develop skills in presentation of research results, strategic decision making and forecasting analysis. (Cross-listed with STAT 1100).
Distribution: Math

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.
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 1140 QUANTITATIVE REASONING FOR HEALTHCARE PROFESSIONALS (3 credits)
This course prepares students with the basic mathematical skills required for nursing programs. Topics include: fractions, decimals, percentages, ratios, conversions between measurement systems, dimensional analysis, formulating dosages and flow rates, interpreting drug orders, and nutritional analyses.
Distribution: Math

MATH 1210 INTERMEDIATE ALGEBRA (3 credits)
This course is designed to prepare students to be successful in MATH 1220, MATH 1300, and STAT 1530. 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.

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): Within the last two years: ALEKS score at least 3, ACT Math at least 19, SAT Math at least 460, SAT2016 Math at least 500, Accuplacer at least 3, MATH 1210 C- or better or MATH 1220. Students who passed MATH 1310 (C- or better) should not take MATH 1220.
Distribution: Math

MATH 1300 COLLEGE ALGEBRA WITH SUPPORT (4 credits)
This course teaches prerequisite material and all College Algebra (MATH 1320) content; it is intended for students who need additional mathematics support. This course will cover polynomial functions, exponential functions, logarithmic functions, and modeling of natural phenomena using these kinds of functions. Discussion of functions will center around four representations: algebraic, graphic, tabular, and verbal. Particular emphasis will be placed on development of covariational reasoning. Support sections will include arithmetic and algebra content necessary to engage with polynomial functions, exponential functions, and logarithmic functions at the College Algebra level, such as properties of real numbers, linear equations, graphing functions, factoring polynomials, and quadratic functions.
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): One of the following within the last two years: ALEKS score of at least 4, ACT Math at least 22, Math SAT at least 540, Math SAT2016 at least 570, Accuplacer score at least 4, MATH 1220 or MATH 1310 each with C- or better, or MATH 1320

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): One of the following within the last two years: ALEKS score at least 5, ACT Math at least 25, Math SAT at least 570, Math SAT2016 at least 590, Accuplacer at least 5, MATH 1320 or MATH 1300 with C- or better, or MATH 1330, or permission of instructor

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): One of the following within the last two years: ALEKS score of at least 4, ACT Math at least 23, Math SAT at least 540, Math SAT2016 at least 570, Accuplacer at least 5, MATH 1310 or MATH 1220 C- or better, or MATH 1340

MATH 1370 APPLIED ALGEBRA AND OPTIMIZATION WITH DATA ANALYSIS (3 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 data analysis. 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): One of the following within the last two years: ALEKS score 4+, ACT Math sub score 23+, SAT Math 540+, SAT2016 Math 570+, Accuplacer 4+, MATH 1220/MATH 1300/MATH 1320 with C- or better, or MATH 1370, or permission of instructor

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): One of the following within the last two years: ALEKS score 5+, ACT Math sub score 25+, Math SAT 570+, or Math SAT2016 590+, Accuplacer score 6+, MATH 1320 or MATH 1300 with C- or better, or MATH 1930, or permission of instructor

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): One of the following within the last two years: ALEKS score at least 5, ACT Math sub score at least 25, Math SAT at least 570, Math SAT2016 at least 590, Accuplacer score at least 6, MATH 1320/ MATH 1300 with C- or better; 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): One of the following within last two years: ALEKS score 6+, ACT Math 26+, Math SAT 590+, Math SAT2016 610+, Accuplacer 7+, MATH 1330/MATH 1340 C- or better; or permission of instructor. Prior enrollment in MATH 1950 cannot be used as prerequisite

MATH 1960 CALCULUS II (4 credits)
This course introduces applications of integration, techniques of integration, infinite sequences and series, parametric functions, and polar functions. A mathematical software package is introduced, with required assignments.
Prerequisite(s): MATH 1950 with a grade of C- or better or permission of instructor.

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): MATH 1960 with a grade of C- or better, or MATH 1970 with a grade of F or better, or permission of instructor.

MATH 2030 DISCRETE MATHEMATICS (3 credits)
A foundation course in discrete mathematics for applied disciplines including computer science, computer engineering, or biology. Topics include: logic, sets, functions, induction and recursive definitions, elementary combinatorics, discrete probability, elementary chaos theory, elementary cellular automata, graphs, trees, matrices.
Prerequisite(s): MATH 1950 or MATH 1940 or MATH 1930, with a grade of C- or better.

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): MATH 1940 or 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): 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.
Prerequisite(s): MATH 1960 or permission. Credit will not be given for both MATH 2030 and MATH 2230.

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): MATH 1960 with a grade of C- or better or permission of instructor.

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): 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 programming language Python will be used. The programming assignments are primarily based on data science and calculus concepts and are designed to reinforce and deepen the understanding of these concepts.
Prerequisite(s): CIST 1400 or MATH 2200, and MATH 1970 (the latter may be taken concurrently) all with a grade of C- or better.

MATH 3230 INTRODUCTION TO ANALYSIS (3 credits)
This course 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. (Cross-listed with MATH 8235).
Prerequisite(s): MATH 1960 and MATH 2230 each with a grade of C- or better.

MATH 3250 INTRODUCTION TO NUMERICAL METHODS (3 credits)
This course emphasizes the implementation of several numerical methods to problems that arise in science and engineering. It involves the application of the computer to solve mathematical problems using the following computational techniques: Taylor Series approximation, numerical differentiation, root-finding methods, interpolation, extrapolation, curve fitting, solution methods for matrix equations, numerical differentiation, numerical integration, and the solution of differential equations. (Cross-listed with MATH 8255).
Prerequisite(s): MATH 1960 with a C or better.

MATH 3400 THEORY OF INTEREST (3 credits)
A study of the measurement of interest, annuities, amortization schedules and other financial mathematics topics.
Prerequisite(s): MATH 1960 with a grade of C- or higher.

MATH 3640 MODERN GEOMETRY (3 credits)
This course will study the modern foundations of Euclidean and Non-Euclidian Geometry. Included will be a study of the principles of axiomatic systems. Euclidean Geometry will be investigated using Hilbert's axioms for Euclidean geometry (or another equivalent Euclidean geometry axiom set). Hyperbolic geometry will be encountered through the models of Klein and Poincare. Neutral geometry with Lambert and Saccheri quadrilaterals will be studied. Finite geometries and projective geometries will also be explored. (Cross-listed with MATH 8645).
Prerequisite(s): MATH 2230 with a grade of C- or better.

MATH 3850 HISTORY OF MATHEMATICS (3 credits)
An overview of the history of mathematics and famous mathematicians via studying and solving famous mathematical problems, exploring famous mathematical theorems, and studying the biographies of famous mathematicians. (Cross-listed with MATH 8855).
Prerequisite(s): MATH 1950 with a grade of C- or higher and one of either MATH 2230 or MTCH 2000 with a grade of C- or higher.

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 arithmetic 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): MATH 2230 or MATH 2030 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): MATH 2230 with a C- or better or MATH 2030 with a C- or better

MATH 4050 LINEAR ALGEBRA (3 credits)
Linear algebra is extensively utilized in the mathematical modeling of many natural phenomena. Many scientific and engineering disciplines, such as data science, chemical engineering and biology, make extensive use of the theory and techniques commonly present in basic to advanced linear algebra courses. The goal of this course is to help students to grasp a solid theoretical understanding of vectors, vector spaces, inner product spaces, linear transformations, eigenvalues, canonical forms, complex vectors, matrices, and orthogonality. By going through the materials in a mathematically rigorous way, students will develop deeper and more accurate intuitions of the basic concepts in linear algebra. Consequently, the applications of linear algebra will become much more transparent. (Cross-listed with MATH 8056).
Prerequisite(s): MATH 2050 with a grade of C- or better; MATH 2030 or MATH 2230 or equivalent with a grade of C- or better; 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): 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 and 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): 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): CSCI 2030 with a C- or better, or MATH 2030 with a C- or better, or MATH 2230 with a C- or better, or permission of instructor.

MATH 4200 NUMERICAL ANALYSIS (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 8206, CSCI 4200, CSCI 8206).
Prerequisite(s): MATH 1970 and MATH 2050 and MATH 2350 with a C- or better or permission of instructor.

MATH 4230 MATHEMATICAL ANALYSIS I (3 credits)
Provides a theoretical foundation for the concepts of classical calculus. Topics include ordered fields, the real and complex number system, basic metric space topology, numerical sequences and series, limits and continuity in metric spaces, monotonic functions, differentiation, (functions of several variables included). (Cross-listed with MATH 8236).
Prerequisite(s): MATH 3230/MATH 8235 with a grade of C- or better.

MATH 4240 MATHEMATICAL ANALYSIS II (3 credits)
Provides a theoretical foundation for the concepts of classical Calculus (vector calculus included). Topics include sequences and series of functions, uniform convergence, power series, Fourier series, multivariable real differential and integral calculus, the Implicit Function Theorem, integration of different forms, and the important formulas, connecting those integrals, due to: Green, Gauss, Riemann, and Ostrogradski. (Cross-listed with MATH 8246).
Prerequisite(s): MATH 4230/MATH 8236 with a grade of C- or better.

MATH 4270 COMPLEX ANALYSIS (3 credits)
This course is an introduction to the theory of functions of a complex variable, a fundamental area of mathematics with multiple applications to science and engineering. Topics include the field of complex numbers, complex differentiation, the complex contour integral and Cauchy's integral formula, Taylor expansions and analytic functions, conformal mapping and Riemann's conformal equivalence theorem, residue theory and Laurent series, harmonic functions, and applications. (Cross-listed with MATH 8276).
Prerequisite(s): MATH 3230/MATH 8235 with a grade of C- or better or permission of the instructor.

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): 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, queueing theory, inventory models, forecasting, and simulation. (Cross-listed with CSCI 4310, CSCI 8316, MATH 8316).
Prerequisite(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. Some topics may include scripting to guide optimization software, constraint programming, heuristics and metaheuristics for optimization, basic machine learning algorithms, and simulation. (Cross-listed with MATH 8326, CSCI 4320, CSCI 8326).
Prerequisite(s): MATH 3200 or CSCI 1620, 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): 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)
This course covers 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 ordinary differential equations. (Cross-listed with MATH 8356).
Prerequisite(s): MATH 1970 with a C- or better, MATH 2050 with a C- or better, and MATH 2350 with a C-, or better or instructor's permission.

MATH 4400 THE FINITE ELEMENT METHOD (3 credits)
Introduction to finite elements methods for solving ordinary and partial differential equations. Theoretical foundations of finite element methods for boundary value problems, approximation by piecewise polynomial functions, variation formulation of partial differential equations, basic error estimates. The Rayleigh-Ritz-Galerkin method, convergence of approximations, time-dependent problems, error analysis, discretization and computer implementation, applications to problems in elasticity, heat transfer, and fluid mechanics. (Cross-listed with MATH 8406).
Prerequisite(s): MATH 1970, MATH 2050 and MATH 2350 all with a C- or better or instructor permission. MATH 3300/MATH 8305 and MATH 4330/MATH 8336 recommended. Students should be able to use a programming language (ie MATLAB) to complete computational assignments

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): 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): 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): 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): 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): 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): MATH 1970 and either MATH 2230 or MATH 2030 all with a grade of C- or better or permission of instructor.

MATH 4750 INTRODUCTION TO PROBABILITY AND STATISTICS II (3 credits)
Theory and methods of statistical inference including sampling distributions, estimators, estimation, and statistical hypotheses. (Cross-listed with MATH 8756).
Prerequisite(s): MATH 4740/MATH 8746 with a grade of C- or better.

MATH 4760 TOPICS IN APPLIED MATHEMATICS (3 credits)
Selection of such topics such as dynamical systems and chaos, Boolean networks, modeling of discrete or continuous systems, matrix theory, difference equations, information theory, discrete events simulation and other approved by Upper Curriculum Committee. (Cross-listed with MATH 8766).
Prerequisite(s): MATH 3100/CSCI 3100 with a grade of C- or better, or permission of instructor.

MATH 4900 INDEPENDENT STUDIES (1-3 credits)
A variable credit course for the junior or senior who will benefit from independent reading assignments and research-type problems. As independent study courses are intended to enrich a student's regular academic program, they may not normally be taken as substitutes for scheduled classroom courses of the same nature. May be repeated for credit, up to six hours, under a different topic.
Prerequisite(s): Permission of the Upper Curriculum Committee of the Mathematics Department via submission of the Undergraduate Independent Study Form available on the Mathematics website.

MATH 4950 TOPICS IN THEORETICAL MATHEMATICS (3 credits)
This course introduces students to a specialized subject matter in the areas of theoretical mathematics not covered in existing courses. The course may be repeated for different topics up to a maximum of six credit hours. The specific topics will vary, depending upon when the course is offered. One example of a course is Axiomatic Set Theory. (Cross-listed with MATH 8956).
Prerequisite(s): Permission of Instructor.

MATH 4970 SEMINAR IN APPLIED MATHEMATICS (3 credits)
A seminar in Applied Mathematics, where the students would read and present research in applied math and write their exposition of those topics.
Prerequisite(s): MATH 3100/CSCI 3100 with a grade of C- or better, or permission of instructor.

MATH 4980 SEMINAR (3 credits)
A seminar in mathematics. This course introduces students to an important form of mathematical activity and culture, where a specialized mathematical subject matter (not covered in typical courses) is studied and discussed in a collaborative setting. The course may be repeated for different topics up to a maximum of six credit hours. The specific topics will vary, depending upon when the course is offered. One example of a seminar topic is Current Trends in Set Theory of the Reals.
Prerequisite(s): Permission of instructor.

STAT 1100 DATA LITERACY AND VISUALIZATION (3 credits)
Designed to help students become familiar with different types of data that are available in business, non-profit and governmental organizations. Students will learn basic data organization and manipulation as well as appropriate visualization techniques including charts, maps, and dashboards using cutting edge software tools. Students will apply this knowledge and skills to real-world data and develop skills in presentation of research results, strategic decision making and forecasting analysis. (Cross-listed with MATH 1100).
Distribution: Math

STAT 1530 ELEMENTARY 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): One of the following within the last two years: ALEKS score of at least 3, ACT Math sub score at least 19, Math SAT at least 460, Math SAT2016 at least 500, Accuplacer score at least 3, or MATH 1000 or MATH 1210 (each with a C- or better)
Distribution: Math

STAT 3000 STATISTICAL METHODS I (3 credits)
An introduction to descriptive statistics, measures of central value and dispersion, probability and distributions, population and sample, simple linear regression, statistical inference: point estimation, confidence intervals, hypotheses testing, two population comparison, goodness-of-fit tests, analysis of variance. Statistical software like Minitab or Excel will be utilized in the course. (Cross-listed with STAT 8005).
Prerequisite(s): MATH 1220 or MATH 1300 or MATH 1320 or equivalent with a grade of C- or better, or permission of instructor

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. If time allows, some linear regression and contingency tables. Credit for both MATH 4740 and STAT 3800 will not be given. (Cross-listed with STAT 8805)
Prerequisite(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): 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): STAT 3800 or STAT 8805 or MATH 4740 or MATH 8746 with a grade of C- or better or another introductory probability/statistics course with a grade of C- or better, and MATH 3200 or CSCI 1620 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): MATH 4750 or MATH 8756 w/ a C- or better or STAT 3800 or STAT 8805 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): MATH 4750 or MATH 8756 w/ a grade of C- or better or STAT 3800 or STAT 8805 w/ a C- or better or another introductory probability/statistics course w/ a 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): MATH 4740/8746 with a C- or better or STAT 3800/8805 with a C- or better or permission of instructor.