Mathematics and Statistics

General Information

Studying mathematics allows one to develop critical thinking and technical problem-solving skills widely applicable to many career paths. Consequently, a degree or minor in mathematics can be a boon to one's career opportunities in addition to being a worthwhile academic endeavor on its own.

Degrees and Areas of Concentration

The Department of Mathematics and Statistics offers numerous undergraduate degree programs, graduate degree programs, minors, and certificates.

Our undergraduate degrees include a Bachelor of Arts (B.A.) in Mathematics, a Bachelor of Science (B.S.) in Mathematics, a B.S. in Mathematics with an emphasis in Data Science, and a B.S. in Mathematics with an emphasis in Fiscal Mathematics. With the departments of Economics and Accounting, we offer an interdisciplinary B.S. in Actuarial Science. In cooperation with the College of Education, we offer the Bachelor of Secondary Education (B.S.Ed.) in Secondary Education with an emphasis in Mathematics and the B.A. or B.S. in Mathematics with master's level coursework for secondary teacher certification.

The department offers a minor in Mathematics, a minor in Statistics, an interdisciplinary Certificate in Actuarial Studies, and an interdisciplinary Certificate in Data Science.

At the graduate level, the department offers a Master of Arts (M.A.) degree in Mathematics with an emphasis in Mathematics or Data Science, a Doctor of Philosophy (Ph.D.) in Mathematical and Computational Sciences – with options in Mathematics, and Statistics.

Undergraduate Programs Overview

The program leading to the B.A. in Mathematics provides a broad grounding in different areas of mathematics, giving students a well-rounded education.

The programs leading to our various B.S. degrees allow students to develop a deep and substantial background in mathematics sufficient to produce graduates who can work in areas requiring applied mathematical techniques and tools. These B.S. degrees are structured to provide students the opportunity to explore their interests within the various degree programs.

The B.S. in Actuarial Science is designed to produce graduates who are well prepared for an entry-level career in the actuarial profession.

The B.S.Ed. in Secondary Education with an emphasis in mathematics introduces students to those branches of mathematics most relevant to the teaching of secondary school mathematics.

The Certificate in Data Science is designed to provide computing and statistical foundations for work with big data and data analytics.

The Certificate in Actuarial Studies is designed to help prepare students for entry-level employment in the actuarial profession.

Dual Program

The Department offers a dual Bachelor's and Master's degree program in mathematics for students with strong academic records. The dual degree program in mathematics is designed to provide an opportunity for strong undergraduate majors to start earning graduate work credit before actually completing their undergraduate degree, thus accelerating their education.
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Graduate Programs Overview

Students pursuing the M.A. degree in Mathematics may choose the traditional track of M.A. in either pure or applied mathematics or the track in data science.

The data science track of our M.A. degree is the only graduate program in data science available at UMSL, and it is designed for students preparing to work in industry as data scientists. These graduates will acquire a solid foundation in statistics and computational skills with emphasis on applications to data science.

The traditional track is ideal for students interested in honing their technical problem solving and critical thinking skills while simultaneously pursing the beauty inherent in a deeper understanding of mathematics. This degree is also well suited for those preparing to teach at the high school or junior college level. Those who concentrate on applied courses in the traditional track build a foundation for the application of mathematics in industry and the continuation of their education in the Ph.D. program in mathematical and computational sciences. Our graduates with the traditional track will have abilities in the basic areas of mathematics, and a breadth of knowledge in core subjects at the graduate level.

The Ph.D. program in Mathematical and Computational Sciences is designed to provide the highest level of academic study and research in mathematical and computational sciences. The goal is to produce highly qualified professionals for teaching and research positions in the academic world, as well as equivalent positions in industry and government. The demand for these professionals continues to exceed the current production and is expected to remain so for the foreseeable future.

Students may enroll in any of these graduate programs on a part-time basis, and with proper scheduling all can be completed in the evening.

Career Outlook

A degree in mathematics prepares well-motivated students for interesting careers. Our graduates find positions in industry, government, and education. The demand for individuals well trained in statistics, data science, and mathematics is greater than the available supply. In addition, a number of graduates in mathematics have elected careers in business, law and other related fields where they find logical and analytical skills valuable.

Graduates in mathematics from UMSL are located throughout the country, and they also have a strong local presence. They have careers in banking, health care, engineering and manufacturing, law, finance, public service, management, and actuarial management. Many are working in areas such as systems management, information systems and data management, scientific computing, cryptography, and scientific positions in the armed services. Others have careers in education, especially at secondary and higher levels.

Department Scholarships

The Department of Mathematics and Statistics offers many merit-based and need-based scholarships available to undergraduate department majors.

The Alumni Scholarship is awarded to outstanding undergraduate students and is open to all junior and senior department majors.

The Edward Z. Andalafte Memorial Scholarship is awarded to outstanding undergraduate department majors at the sophomore level or higher.

The Raymond and Thelma Balbes Scholarship in Mathematics is awarded to students at the sophomore level or higher who are pursuing a degree in mathematics, have an overall GPA of at least 3.0 and a GPA of at least 3.2 in mathematics and who have completed three semesters of calculus.

The Joseph M. and Mary A. Vogl Scholarship in Mathematics is a need based monetary award for undergraduate department majors.

Degrees

Mathematics BA (http://bulletin.umsl.edu/programs/mathematics-ba/)

Mathematics BS (http://bulletin.umsl.edu/programs/mathematics-bs/)

- Data Science Emphasis (http://bulletin.umsl.edu/programs/mathematics-bs-data-science-emphasis/)
- Fiscal Mathematics Emphasis (http://bulletin.umsl.edu/programs/mathematics-bs-fiscal-mathematics-emphasis/)

Mathematics BA or BS/MA Dual Degree Program (http://bulletin.umsl.edu/programs/mathematics-ba-or-bs-and-ma/)

Mathematics MA (http://bulletin.umsl.edu/programs/mathematics-ma/)

- Data Science Emphasis (http://bulletin.umsl.edu/programs/mathematics-ma-data-science-emphasis/)

Mathematical and Computational Science PhD

- Mathematics Emphasis (http://bulletin.umsl.edu/programs/mathematical-and-computational-science-phd-mathematics-emphasis/)
- Statistics Emphasis (http://bulletin.umsl.edu/programs/mathematical-and-computational-science-phd-statistics-emphasis/)

Minors

Mathematics Minor (http://bulletin.umsl.edu/programs/mathematics-minor/)

Statistics Minor (http://bulletin.umsl.edu/programs/statistics-minor/)

Affiliated Interdisciplinary Programs

Actuarial Science BS (http://bulletin.umsl.edu/programs/actuarial-science-bs/)

Actuarial Studies Undergraduate Certificate (http://bulletin.umsl.edu/programs/actuarial-studies-undergraduate-certificate/)

Data Science Undergraduate Certificate (http://bulletin.umsl.edu/programs/data-science-undergraduate-certificate/)

Courses

MATH 0005 Intermediate Algebra: 3 semester hours
Prerequisites: A satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course. Preparatory material for college level mathematics courses. Covers systems of linear equations and inequalities, polynomials, rational expressions, exponents, quadratic equations, graphing linear and quadratic functions. This course carries no credit towards any baccalaureate degree.

MATH 1020 Contemporary Mathematics (MOTR MATH 120): 3 semester hours
Prerequisites: A satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course. Presents methods of problem solving, centering on problems and questions which arise naturally in everyday life. May include aspects of algebra and geometry, the mathematics of finance, probability and statistics, exponential growth, and other topics chosen from traditional and contemporary mathematics which do not employ the calculus. Designed for students who do not plan to take calculus and may not be used as a prerequisite for other mathematics courses. Credit will not be granted for MATH 1020 if credit has been granted for MATH 1310, MATH 1800, MATH 1100, MATH 1102, or MATH 1105. Concurrent enrollment in MATH 1020 and any of these courses is not permitted. This course fulfills the University's general education mathematics proficiency requirement.

MATH 1021 Choice and Chance: 3 semester hours
Same as PHIL 1021. Prerequisites: A satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course. This course provides an introduction to inductive logic and the theory of probability in an organized and systematic way, so as to give students tools for more effective decision-making. We will introduce the probability calculus, basic concepts of utility theory, decision theory and different approaches to understanding probability. This course is designed to be accessible to students of all levels. This course fulfills the University's general education mathematics proficiency requirement.

MATH 1025 Geometry in the Real World: 3 semester hours
Prerequisites: A satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course. Presents topics in geometry designed to enrich the student's understanding of mathematics. Geometry as it applies to the physical world and such fields as art, music, nature, motion, architecture and city planning will be examined. This course is designed to be accessible to students of all levels. This course fulfills the University's general education mathematics proficiency requirement.

MATH 1026 The Music of Math: 3 semester hours
Prerequisites: A satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course. This course presents topics in mathematics as they relate to music. Fundamental concepts of music such as intervals, scales, chords, tuning will be explored by developing an understanding of their mathematical underpinnings. An ability to read music in treble and bass clef is strongly recommended. Satisfies the general education mathematics proficiency requirement.

MATH 1030 College Algebra (MOTR MATH 130): 3 semester hours
Prerequisites: A satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course, or approval of the department. This is a foundational course in math. Topics may include factoring, complex numbers, rational exponents, simplifying rational functions, functions and their graphs, transformations, inverse functions, solving linear and nonlinear equations and inequalities, polynomial functions, inverse functions, logarithms, exponentials, solutions to systems of linear and nonlinear equations, systems of inequalities, matrices, and rates of change. This course fulfills the University's general education mathematics proficiency requirement.

MATH 1035 Trigonometry: 2 semester hours
Prerequisite: MATH 1030 or MATH 1040, or concurrent registration in either of these two courses, or a satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course. A study of the trigonometric and inverse trigonometric functions with emphasis on trigonometric identities and equations.

MATH 1045 PreCalculus (MOTR MATH 150): 5 semester hours
Prerequisites: A satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course. This course covers topics including factoring, simplifying rational functions, functions and their graphs, solving linear and nonlinear equations, polynomial functions, inverse functions, the binomial theorem, logarithms, exponentials, solutions to systems of equations using matrices, solutions to nonlinear systems of equations, and sequences. Students will also study trigonometric and inverse trigonometric functions with emphasis on trigonometric identities and equations. This course is intended for students planning to take MATH 1800 and fulfills the University's general education mathematics proficiency requirement.

MATH 1100 Basic Calculus: 3 semester hours
Prerequisites: MATH 1030 or MATH 1040 or MATH 1045 or a satisfactory score on the UMSL ALEKS Placement Examination, obtained at most one year prior to enrollment in this course. This course introduces plane analytic geometry and basic differential and integral calculus with applications to various areas. No credit for Mathematics majors. Credit not granted for both MATH 1800 and MATH 1100.

MATH 1102 Finite Mathematics: 3 semester hours
Prerequisites: MATH 1030 or MATH 1040 or MATH 1045 or a satisfactory score on the UMSL ALEKS Math Placement Examination, obtained at most one year prior to enrollment in this course. This course introduces logic and set theory, partitions and counting problems, elementary probability theory, stochastic processes, Markov chains, vectors and matrices, linear programming, and game theory.

MATH 1105 Basic Probability and Statistics: 3 semester hours
Prerequisites: MATH 1030 or MATH 1040 or MATH 1045 or a satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course or consent of the department. This course is an introduction to probability and statistics. Topics may include the concept of probability and its properties, descriptive statistics, discrete and continuous random variables, expected value, distribution functions, the central limit theorem, random sampling, and sampling distributions. Credit will not be granted for more than one of MATH 1310, MATH 1320, and MATH 1105.

MATH 1150 Structure of Mathematical Systems I: 3 semester hours
Prerequisites: 45 hours of college credit and a satisfactory score on the UMSL Math Placement Examination, obtained at most one year prior to enrollment in this course OR successful completion of MATH 1030 no more than 2 years prior to enrollment in this course. This course examines topics including problem solving, patterns, sets, numeration systems, whole numbers and operations, positive rational numbers and operations, and an introduction to variables and equations, with an emphasis placed on using multiple techniques for each of the aforementioned topics.

MATH 1310 Elementary Statistical Methods: 3 semester hours
Prerequisites: MATH 1030 or MATH 1040 or MATH 1045 or a satisfactory score on the UMSL ALEKS Math Placement Examination, obtained at most one year prior to enrollment in this course. An introduction to the basic tools and elementary methods of statistics, such as testing of hypotheses, analysis of variance, method of least squares, and time series. A student may not receive credit for more than one of MATH 1310, MATH 1320, and MATH 1105.

MATH 1320 Introduction to Probability and Statistics: 3 semester hours
Prerequisites: MATH 1030 or MATH 1040 or MATH 1045 or consent of the department. The course will cover basic concepts and methods in probability and statistics. Topics include descriptive statistics, probabilities of events, random variables and their distributions, sampling distributions, estimation of population parameters, confidence intervals and hypothesis testing for population means and population proportions, chi-square tests. A student may not receive credit for more than one of MATH 1310, MATH 1320 and MATH 1105.

MATH 1800 Analytic Geometry and Calculus I: 5 semester hours
Prerequisites: MATH 1030 and MATH 1035, or MATH 1040 and MATH 1035, or MATH 1045, or a satisfactory score on the UMSL ALEKS Math Placement Examination, obtained at most one year prior to enrollment in this course, or approval of the department. This course provides an introduction to differential and integral calculus. Topics include limits, derivatives, related rates, Newton's method, the Mean-Value Theorem, Max-Min problems, the integral, the Fundamental Theorem of Integral Calculus, areas, volumes, and average values.

MATH 1900 Analytic Geometry and Calculus II: 5 semester hours
Prerequisite: MATH 1800. Topics include conic sections, rotation of axes, polar coordinates, exponential and logarithmic functions, inverse (trigonometric) functions, integration techniques, applications of the integral (including mass, moments, arc length, and hydrostatic pressure), parametric equations, infinite series, power and Taylor series.

MATH 2000 Analytic Geometry and Calculus III: 5 semester hours
Prerequisite: MATH 1900. Topics include vectors, cylindrical and spherical coordinates, vector-valued functions, arc length and curvature, functions of several variables, partial and directional derivatives, gradients, extrema, Lagrange multipliers, multiple integrals, change of variables, surface area, vector fields, Stokes' Theorem.

MATH 2010 Introduction to Inquiry Approaches to STEM Education (STEP I): 1 semester hour
Same as CHEM 2010, PHYSICS 2010, BIOL 2010, and SEC ED 2010. Prerequisites: Concurrent enrollment BIOL 1821, BIOL 1831, CHEM 1111, CHEM 1121, PHYSICS 2111, PHYSICS 2112, MATH 1800, or MATH 1900 or have a declared STEM major. Students who want to explore teaching careers become familiar with lesson plan development by writing, teaching and observing lessons in a local school class. Students build and practice inquiry-based lesson design skills and become familiar with and practice classroom management in the school setting. As a result of the STEP I experiences students should be able to decide whether to continue to explore teaching as a career and ultimately finishing the remainder of the WE TEACH MO curriculum leading to teacher certification. The classroom observations and teaching represent a major field component and requires at least one two hour block of free time during the school day once a week.

MATH 2011 Designing Inquiry-Based STEM Experiences (STEP II): 1 semester hour
Same as CHEM 2011, PHYSICS 2011, BIOL 2011, and SEC ED 2011. Prerequisites: BIOL 2010, CHEM 2010, PHYSICS 2010, MATH 2010, or SEC ED 2010. Students explore teaching careers, become familiar with STEM school setting through observing and discussing the school environment and by developing and teaching inquiry-based lessons.

MATH 2020 Introduction to Differential Equations: 3 semester hours
Prerequisite: MATH 2000. Topics will be chosen from: linear differential equations, equations with constant coefficients, laplace transforms, power series solutions, systems of ordinary differential equations.

MATH 2300 Introduction to Discrete Structures: 3 semester hours
Prerequisites: MATH 1100 or MATH 1800, and CMP SCI 1250. This course treats fundamental mathematical concepts in discrete structures useful for computer science. Topics include logic, sets, equivalence relations and partitions, functions, elementary number theory, cardinality, basic combinatorial methods, trees and graphs.

MATH 2450 Elementary Linear Algebra: 3 semester hours
Prerequisite: MATH 1100 or MATH 1900. An introduction to linear algebra. Topics will include complex numbers, geometric vectors in two and three dimensions and their linear transformations, the algebra of matrices, determinants, solutions of systems of equations, eigenvalues and eingenvectors.

MATH 2510 Structure of Mathematical Systems II: 3 semester hours
Prerequisites: MATH 1150. Topics include an introduction to probability, statistics, and displays of data; a study of elementary geometry, including points, lines, planes, angles, properties of triangles, properties of quadrilaterals, other 2- and 3-dimensional shapes; similarity; measurement and conversions; Pythagorean Theorem; perimeter; area; surface area, and volume. This course does not apply towards the elective requirements for any of the majors, minors or related areas in mathematics and statistics.

MATH 3000 Discrete Structures: 3 semester hours
Prerequisites: MATH 1800 or MATH 1100, and CMP SCI 1250 or equivalent. This course introduces fundamental concepts and important data structures in Discrete Mathematics and serves as an important foundation for subsequent courses in Computer Science. It provides a formal system on which mathematical reasoning is based, and various problem-solving strategies with emphasis on the algorithmic approach (both iterative and recursive). Topics include logic, sets, functions and relations; methods of proof, including mathematical induction; elements of number theory; order of growth and basic analysis of algorithms efficiency; recurrence relations; basic counting methods; graphs and trees. This course does not apply towards the elective requirements for any of the majors, minors or related areas in mathematics and statistics.

MATH 3250 Foundations of Mathematics: 3 semester hours
Prerequisites: MATH 1900 and CMP SCI 1250. The course will focus on developing an understanding of proofs and rigorous mathematical reasoning. Topics will include logic, sets, relations, functions, number theory, and counting methods.

MATH 3320 Applied Statistics: 3 semester hours
Prerequisites: MATH 1320. The course will cover topics including multiple regression, analysis of variance, generalized linear models, and applications of these methods. Using R for statistical analysis will be part of the course.

MATH 3520 Structure of Mathematical Systems III: 3 semester hours
Prerequisites: MATH 2510. Topics from MATH 1150 and MATH 2510 are continued. Other topics include integers and the real number system, relations and functions, coordinate system and linear equations, congruence, geometric constructions, geometric proofs, isometries, tessellations, and trigonometry. This course does not apply towards the elective requirements for any of the majors, minors or related areas in mathematics and statistics.

MATH 4005 Exploratory Data Analysis with R: 3 semester hours
Prerequisites: (MATH 1100 or MATH 1800) and (ANTHRO 3220 /SOC 3220 or BIOL 4122 or CRIMIN 2220 or ECON 3100 or MATH 1320 or POL SCI 3000 or PSYCH 2201). This course covers data analysis methods with R. It introduces the basic goals and techniques of the data science process, methods of characterizing and visualizing data and building predictive and inferential models. R will be introduced at the beginning of the class and then used throughout the rest of the class.

MATH 4010 Financial Mathematics I: 3 semester hours
Prerequisites: MATH 1900 or MATH 1100, and MATH 1320 or SCMA 3300 (or equivalents). This course introduces the theory of interest, annuities (certain), annuities with differing pay periods, amortization schedules, and sinking funds.

MATH 4020 Financial Mathematics II: 3 semester hours
Prerequisite: MATH 4010. This course introduces the premium-discount formula for bonds, bond amortization, term structure of interest rates, and pricing theory for options.

MATH 4030 Applied Mathematics I: 3 semester hours
Prerequisite: MATH 2020 and MATH 2450. Topics chosen from Fourier series, special functions, partial differential equations, and boundary value problems.

MATH 4060 Applied Differential Equations: 3 semester hours
Prerequisites: MATH 2020 and MATH 2450. The study of ordinary differential equations and partial differential equations is continued with applications in such areas as physics, engineering and biology.

MATH 4070 Introduction to Nonlinear Optimization: 3 semester hours
Prerequisites: MATH 1320, MATH 2000, MATH 2450 and (MATH 3000 or MATH 3250). This course will introduce the theory, methods, and applications of nonlinear optimization. It will cover convex functions, convex analysis, linear and quadratic programs, semidefinite programming and other optimization problems. Topics may include duality theory, algorithms of descent method, Newton's method and interior-point methods, and applications to signal processing, statistics and other fields will be covered. Credit cannot be earned for both MATH 4070 and MATH 5070.

MATH 4080 Introduction to Scientific Computation: 3 semester hours
Prerequisites: MATH 2000 and MATH 2450. This course will introduce fundamental algorithms in numerical linear algebra, matrix factorizations including SVD and QR, direct and iterative methods for solving linear systems, least squares problems and eigenvalue problems. Other topics covered will be chosen from numerical integration and differentiation, iterative methods for ODEs and PDEs, Discrete Fourier transform and FFT, spline smoothing and kernel smoothing. Credit cannot be earned for both MATH 4080 and MATH 5080.

MATH 4090 Introduction to High-dimensional Data Analysis: 3 semester hours
Prerequisites: MATH 1320, MATH 2000 and MATH 2450. This course introduces several advanced classical and modern techniques for modeling and analysis of high-dimensional datasets with low-dimensional structures. The topics covered in this course include principal component analysis, factor analysis, clustering-based methods, and sparse and low-rank recovery theory and algorithms. Credit cannot be earned for both MATH 4090 and MATH 5090.

MATH 4100 Real Analysis I: 3 semester hours
Prerequisites: MATH 3250, or CMP SCI 3130, or consent of instructor. This course provides an introduction to real analysis in one variable. Topics include the real number system, limits, continuity, differentiability, and sequences and series of functions.

MATH 4160 Complex Analysis I: 3 semester hours
Prerequisites: MATH 2000 or consent of the instructor. This course introduces complex numbers and their geometrical representation, point sets, analytic functions of a complex variable, complex integration, Taylor and Laurent series, residue theorem, and conformal mapping.

MATH 4200 Mathematical Statistics I: 3 semester hours
Prerequisites: MATH 1320 and MATH 2000. Introduction to the theory of probability and statistics using concepts and methods of calculus.

MATH 4210 Mathematical Statistics II: 3 semester hours
Prerequisites: MATH 4200. Continuation of MATH 4200. Sampling distributions, estimation theory, properties of estimators, hypothesis testing, NeymanPearson Theorem, likelihood ratio tests, introduction of analysis of variance and linear models. Basics of some nonparametric procedures.

MATH 4220 Bayesian Statistical Methods: 3 semester hours
Prerequisites: MATH 1320, MATH 2000 or MATH 1100; or consent of the instructor. This course introduces Bayesian methods in data analysis and the use of the R language and BUGS. The first half of the course covers inferential theorems and computation methods on fundamental Bayesian statistics, such as estimation, hypothesis testing, MCMC methods, model selection and hierarchical modeling. The second half of the course concentrates on particular models used in practice, such as Bayesian generalized linear models, Bayesian two-factor ANOVA, Bayesian logistic and probit models.

MATH 4225 Introduction to Statistical Computing: 3 semester hours
Prerequisites: MATH 1320, MATH 2000 and MATH 2450. This course will introduce fundamental algorithms in Monte Carlo methods: random variable generation, Monte Carlo integration, Monte Carlo optimization, Markov chain Monte Carlo, Metropolis-Hastings algorithm, Gibbs sampler, Langevin algorithms and Hamilton Monte Carlo, perfect, iterated and sequential importance sampling. Other topics covered may include particle systems, hidden Markov models, parallel and cloud computing. Credit cannot be earned for both MATH 4225 and MATH 5225.

MATH 4230 Numerical Analysis I: 3 semester hours
Prerequisites: MATH 2020, MATH 2450, and the ability to program in an upper-level language. Solutions of equations, interpolation and approximation numerical differentiation and integration, and numerical solutions of initial value problems in ordinary differential equations. Selected algorithms will be programmed for solution on computers.

MATH 4250 Introduction to Statistical Methods in Learning and Modeling: 3 semester hours
Prerequisites: MATH 1320, MATH 2000 and MATH 2450. This course will introduce basic statistical principles and methods for modeling, inference, prediction and classification. The topics will be chosen from linear regression, basis expansion methods, kernel smoothing methods, model regularization, model selection and assessment, and other nonparametric methods. Credit cannot be earned for both MATH 4250 and MATH 5250.

MATH 4260 Introduction to Stochastic Processes: 3 semester hours
Prerequisites: MATH 4200. Basic theory and applications of stochastic processes. Markov chains, recurrent and transient states, stationary distributions, ergodic theorem, renewal processes, discrete martigales and stationary processes.

MATH 4350 Theory of Numbers: 3 semester hours
Prerequisites: MATH 2450 and either MATH 3000 or MATH 3250; or consent of instructor. This course examines the properties of integers, multiplicative functions, congruences, primitive roots, and quadratic residues.

MATH 4390 Topics in Probability and Statistics: 3 semester hours
Prerequisites: Consent of instructor. A seminar on special topics in probability and statistics to be determined by the interests of the instructor. May be repeated for credit provided different topics are studied.

MATH 4400 Introduction to Abstract Algebra I: 3 semester hours
Prerequisites: MATH 2450 and either MATH 3250 or CMP SCI 3130; or consent of instructor. This course introduces groups, rings, and fields, with an emphasis on groups and rings.

MATH 4450 Linear Algebra: 3 semester hours
Prerequisites: MATH 2450 and either MATH 3250 or CMP SCI 3130; or consent of instructor. This course focuses on topics selected from vector spaces, bases, linear transformations, matrices, canonical forms, eigenvalues, hermitian and unitary matrices, inner product spaces, and quadratic forms.

MATH 4460 Introduction to Coding Theory: 3 semester hours
Prerequisites: MATH 2450 and either MATH 3000 or MATH 3250. This course is an introductory course in coding theory. Topics may include linear codes, generator and parity check matrices, dual codes, weight and distance, encoding and decoding, and the Sphere Packing Bound; various examples of codes like the Hamming codes, Golay codes, binary Reed-Muller codes, and the hexacode; Shannon's theorem for the binary symmetric channel, upper and lower bounds on the size of linear and nonlinear codes; constructions and properties of finite fields, basic theory of cyclic codes; concepts of idempotent generator, generator polynomial, zeros of a code, and defining sets, special families of BCH and Reed-Solomon cyclic codes as well as generalized Reed-Solomon codes. Credit cannot be granted for both MATH 4460 and MATH 5460.

MATH 4500 Special Readings: 1-10 semester hours
Prerequisites: 6 credit hours at the Math 4000 level and consent of the instructor. Advanced topics in Mathematics. May be repeated for credit if the topic differs.

MATH 4550 Combinatorics: 3 semester hours
Prerequisites: MATH 2450 and either MATH 3000 or MATH 3250; or consent of instructor. This course introduces advanced counting methods including the use of generating functions for the solution of recurrences and difference equations. Additional topics may include: graphs and trees, combinatorial designs, combinatorial games, error-correcting codes, and finite-state machines.

MATH 4580 Mathematical Logic: 3 semester hours
Prerequisites: MATH 2450 and one of MATH 3250, CMP SCI 3130, or PHIL 4460; or consent of instructor. This course focuses on a study of the logic of mathematics by the axiomatic method, with a development of the propositional calculus and restricted predicate calculus emphasizing its application to the foundations of mathematics.

MATH 4660 Foundations of Geometry: 3 semester hours
Prerequisites: MATH 2450 and either MATH 3250 or CMP SCI 3130; or consent of instructor. This course focuses on a development of portions of Euclidean geometry from a selected set of axioms, including a discussion of consistency, independence, categoricity, and completeness of the axioms.

MATH 4670 Introduction to Non-Euclidean Geometry: 3 semester hours
Prerequisites: MATH 2000, MATH 2450, and either MATH 3250 or CMP SCI 3130; or consent of instructor. This course focuses on a summary of the history of the non-Euclidean geometries and a study of hyperbolic plane geometry.

MATH 4800 Introduction to Topology: 3 semester hours
Prerequisites: MATH 2000 and either MATH 3250 or CMP SCI 3130; or consent of instructor. This course focuses on the study of topological spaces, including the concepts of limit, continuity, connectedness, compactness, etc. Special emphasis is placed on, and examples taken from, the space of real numbers.

MATH 4890 Topics in Mathematics: 3 semester hours
Prerequisite: Consent of instructor.

MATH 4995 Internship in Actuarial Science: 1-3 semester hours
Same as ECON 4995. Prerequisites: Junior standing and consent of program director. Supervised off-campus training in a private or public sector position in which the student applies the knowledge and skills learned in their actuarial science coursework. The internship is monitored by a faculty member and the student must provide a written report at the end of the project. This course may be repeated for a maximum of 6 credit hours.

MATH 5060 Computational Harmonic Analysis: 3 semester hours
Prerequisites: MATH 4030, MATH 4100 and MATH 4450. The course covers the basics of Fourier analysis and wavelet analysis. Topics include Fourier transforms and series, discrete Fourier transform, discrete cosine transform and their fast computational schemes, fast wavelet transform, and the lifting scheme. Additional topics include industrial standards for image compression and several aspects of signal processing.

MATH 5070 Nonlinear Optimization: 3 semester hours
Prerequisites: Graduate standing. This course will introduce the theory, methods, and applications of nonlinear optimization. It will cover convex functions, convex analysis, linear and quadratic programs, semidefinite programming and other optimization problems. Topics chosen from duality theory, algorithms of descent method, Newton’s method and interior-point methods, and applications to signal processing, statistics and other fields will be covered. Topics are identical to Math 4070 but material is covered at a greater depth and additional projects/assignments are required. Credit cannot be earned for both MATH 4070 and MATH 5070.

MATH 5080 Scientific Computation: 3 semester hours
Prerequisites: Graduate standing. This course will introduce fundamental algorithms in numerical linear algebra, matrix factorizations including SVD and QR, direct and iterative methods for solving linear systems, least squares problems and eigenvalue problems. Other topics covered will be chosen from numerical integration and differentiation, iterative methods for ODE's and PDE's, Discrete Fourier transform and FFT, spline smoothing and kernel smoothing. Topics are identical to MATH 4080 but material is covered at a greater depth and additional projects/assignments are required. Credit cannot be earned for both MATH 4080 and MATH 5080.

MATH 5090 High-dimensional Data Analysis: 3 semester hours
Prerequisites: Graduate standing. This course introduces several advanced classical and modern techniques for modeling and analysis of high-dimensional datasets with low-dimensional structures. The methods covered in this course include principal component analysis, factor analysis, clustering-based methods, and sparse and low-rank recovery theory and algorithms.Topics are identical to MATH 4090 but material is covered at a greater depth and additional projects/assignments are required. Credit cannot be earned for both MATH 4090 and MATH 5090.

MATH 5100 Real Analysis II: 3 semester hours
Prerequisites: MATH 4100. Introduction to measure and integration. Topics include the Riemann-Stieltjes integral, Lebesgue measure, measurable functions, the Lebesgue integral, Radon-Nikodym and Fubini theorems and the basics of Lp-spaces.

MATH 5140 Set Theory and Metric Spaces: 3 semester hours
Prerequisites: MATH 4100 or consent of instructor. Naive set theory, cardinal arithmetic, ordinal numbers, the axiom of choice and equivalents, metric spaces, convergence, continuity, compactness, contraction principals and applications. Construction of completions and examples like real numbers and p-adic numbers. Other topics could include the Stone-Weierstrass theorem and metrizability theorems.

MATH 5160 Complex Analysis II: 3 semester hours
Prerequisites: MATH 4160 and either MATH 4100 or MATH 4800. A second course in complex analysis, emphasizing the theory of analytic functions, and including various topics like the Riemann mapping theorem, normal families, analytic continuation, representations of analytic functions, and elliptic functions.

MATH 5225 Statistical Computing: 3 semester hours
Prerequisites: Graduate standing. This course will introduce fundamental algorithms in Monte Carlo methods: random variable generation, Monte Carlo integration, Monte Carlo optimization, Markov chain Monte Carlo, Metropolis-Hastings algorithm, Gibbs sampler, Langevin algorithms and Hamilton Monte Carlo, perfect, iterated and sequential importance sampling. Other topics covered may include particle systems, hidden Markov models, parallel and cloud computing. Topics are identical to Math 4085 but material is covered at a greater depth and additional projects/assignments are required. Credit cannot be earned for both MATH 4225 and MATH 5225.

MATH 5250 Statistical Methods in Learning and Modeling: 3 semester hours
Prerequisites: Graduate standing. This course will introduce basic statistical principles and methods for modeling, inference, prediction and classification. The topics will be chosen from linear regression, basis expansion methods, kernel smoothing methods, model regularization, other nonparametric methods, and model selection and assessment. Topics are identical to MATH 4250 but material is covered at a greater depth and additional projects/assignments are required. Credit cannot be earned for both MATH 4250 and MATH 5250.

MATH 5320 Topics in Statistics and its Applications: 3 semester hours
Prerequisites: MATH 4210 or consent of instructor. The course studies classical and recently developed statistical procedures selected from areas including multivariate analysis, linear and non-linear models, nonparametric methods, and statistical learning. Emphasis is on applications of the procedures.

MATH 5460 Coding Theory: 3 semester hours
Prerequisites: Graduate standing. This course is an introductory course in coding theory. Topics may include linear codes, generator and parity check matrices, dual codes, weight and distance, encoding and decoding, and the Sphere Packing Bound; various examples of codes like the Hamming codes, Golay codes, binary Reed--Muller codes, and the hexacode; Shannon’s theorem for the binary symmetric channel, upper and lower bounds on the size of linear and nonlinear codes; constructions and properties of finite fields, basic theory of cyclic codes; concepts of idempotent generator, generator polynomial, zeros of a code, and defining sets, special families of BCH and Reed--Solomon cyclic codes as well as generalized Reed–Solomon codes. Topics are identical to MATH 4460 but material is covered at a greater depth and additional projects/assignments are required. Credit cannot be granted for both MATH 4460 and MATH 5460.

MATH 5500 Directed Readings: 1-6 semester hours
Prerequisite: Consent of instructor. Independent readings at an advanced level.

MATH 5550 Topics in Advanced Math for the Teacher: 3 semester hours
Prerequisite: Consent of instructor. This course will look at various topics in Algebra, Analysis, and Geometry that will deepen a teacher's understanding of the Mathematics of the precollegiate curriculum. It can be taken more than once for credit.

MATH 5600 Topics in Computation: 3 semester hours
Prerequisite: Consent of instructor. The course will cover various advanced topics in computation, and can be taken more than once for credit. Examples of such topics are: computer graphics, computer architecture, theories of language, analysis of operating systems, numerical geometry and computer aided design, etc.

MATH 5700 Topics in Applied Mathematics: 3 semester hours
Prerequisite: Consent of instructor. The course will cover various advanced topics on applied mathematics, and can be taken more than once for credit. Examples of such topics are: fast transforms, digital filters, etc.

MATH 5710 Topics in Analysis: 3 semester hours
Prerequisites: MATH 5100 or consent of instructor. Topics selected from the areas of Fourier analysis, harmonic analysis, functional analysis, special functions, generalized functions, and partial differential equations. May be taken more than once for credit with consent of department.

MATH 5770 Advanced Topics in Nonlinear Optimization: 3 semester hours
Prerequisites: MATH 4070 or MATH 5070; or consent of the instructor. Topics chosen from theory and algorithms of Lagrange multipliers, algorithms for solving variational inequalities, forward-backward splitting algorithms and proximal alternating minimization algorithm for non-convex optimization problems.

MATH 5820 Topics in Algebra: 3 semester hours
Prerequisite: Consent of instructor. Topics selected from the theory of groups, rings, fields, algebras and other algebraic systems. May be taken more than once for credit with consent of department.

MATH 5890 Advanced Topics in Mathematics: 3 semester hours
Prerequisites: Consent of the instructor. The course will cover various advanced topics in mathematics, statistics, or data science. May be taken more than once if the topic differs.

MATH 6900 Masters Thesis: 1-6 semester hours
Prerequisite: Consent of instructor. Thesis work under the supervision of a faculty member. The course is designed for those students intending to present a thesis as part of their M.A. program. Students who do not write a thesis cannot apply MATH 6900 to a degree.

MATH 7990 Ph.D. Dissertation Research: 1-9 semester hours
Prerequisites: Completion of comprehensive examinations. May be taken for no more than nine hours.