Mathematics

Undergraduate Degrees

- Bachelor of Science in Mathematics (http://catalog.uta.edu/science/math/undergraduate/#bachelorstext/#bsmath)
- Bachelor of Science in Mathematics (Actuarial Science Option) (http://catalog.uta.edu/science/math/undergraduate/#bachelorstext/#bsactuarial)
- Bachelor of Science in Mathematics (Statistics Option) (http://catalog.uta.edu/science/math/undergraduate/#bachelorstext/#bsstatistics)
- Bachelor of Science in Mathematics (Applied Mathematics Option) (http://catalog.uta.edu/science/math/undergraduate/#bachelorstext/#bsindustrial)
- Bachelor of Science in Mathematics (Pure Mathematics Option) (http://catalog.uta.edu/science/math/undergraduate/#bachelorstext/#bspuremathematics)
- Bachelor of Science in Mathematics with Secondary Teaching Certification (http://catalog.uta.edu/science/math/undergraduate/#bachelorstext/#bateaching)
- Bachelor of Science in Mathematics (Data Science Option) (http://catalog.uta.edu/science/math/undergraduate/#bachelorstext/#bsdatascience)
- Bachelor of Arts in Mathematics (http://catalog.uta.edu/science/math/undergraduate/#bachelorstext/#bamath)
- Minor in Mathematics (http://catalog.uta.edu/science/math/undergraduate/#minortext)

Fast-Track Degrees

- Accelerated BS/MS: Bachelor of Science in Mathematics and Master of Science in Mathematics (http://catalog.uta.edu/science/math/undergraduate/#bachelorstext/#/#fasttrackBSmathMSmath)
- Accelerated BS/MS: Bachelor of Science in Mathematics and Master of Science in Biomedical Engineering (http://catalog.uta.edu/science/math/undergraduate/#bachelorstext/#fasttrackBSmathMSBioEng)

Graduate Degrees

- Mathematics (General Mathematics), M.S. (http://catalog.uta.edu/science/math/graduate/#masterstext/#msgeneralmath)
- Mathematics (General Statistics), M.S. (http://catalog.uta.edu/science/math/graduate/#masterstext/#msgeneralstatistics)
- Mathematics, M.A. (http://catalog.uta.edu/science/math/graduate/#masterstext/#mamath)
- Mathematics (General Mathematics), B.S. to Ph.D. (http://catalog.uta.edu/science/math/graduate/#doctoraltext/#bsphdgeneralmath)
- Mathematics (General Mathematics), Ph.D. (http://catalog.uta.edu/science/math/graduate/#doctoraltext/#phdgeneralmath)
- Mathematics (General Statistics), B.S. to Ph.D. (http://catalog.uta.edu/science/math/graduate/#doctoraltext/#bsphdgeneralstatistics)
- Mathematics (General Statistics), Ph.D. (http://catalog.uta.edu/science/math/graduate/#doctoraltext/#phdgeneralstatistics)
- Mathematics (Data Science), B.S. to Ph.D. (http://catalog.uta.edu/science/math/graduate/#doctoraltext/#bsphdgeneraldatascience)
- Mathematics (Data Science), Ph.D. (http://catalog.uta.edu/science/math/graduate/#doctoraltext/#phdgeneraldatascience)

Certificate

- Applied Statistics Certificate (http://catalog.uta.edu/science/math/graduate/#certificatetext)

COURSES

MATH 0302. FUNDAMENTALS OF ALGEBRA. 3 Hours.
This course is designed for students whose placement scores or life experience indicate that they may need additional preparation in order to take a college credit bearing mathematics course. Topics may include basic algebraic operations and expressions, linear equations and inequalities, polynomials, rational expressions, factoring, exponents and radicals, graphing, quadratic equations, and mathematical reasoning. Students will use mathematical software to master targeted areas and progress through a self-paced environment in order to achieve college readiness. Immediately following the successful completion of this foundational course, students should register for a credit bearing mathematics course accordingly to their degree plan. Credit in this course does not fulfill any degree requirement.

MATH 0311. FOUNDATIONS FOR CONTEMPORARY MATHEMATICS. 3 Hours.
This course is designed for students whose placement scores or life experience indicate that they may need additional preparation in order to take a college credit-bearing mathematics course. This course provides foundational preparation for MATH 1301. Topics include basic numeric and algebraic operations, expressions, linear and quadratic equations, solving techniques, graphing, mathematical logic and reasoning, as well as a brief introduction to probability and statistics. Students will use mathematical software to master targeted areas and progress through a modified self-paced environment in order to achieve college readiness. Immediately following the successful completion of this foundational course, students should register for a credit-bearing mathematics course according to their degree plan, specifically MATH 1301. Credit in this course does not fulfill any degree requirements.

MATH 0312. FOUNDATIONS FOR ALGEBRA. 3 Hours.
This course is designed for students whose placement scores or life experience indicate that they may need additional preparation in order to take a college credit-bearing mathematics course. This course provides foundational preparation for MATH 1302/1402 or MATH 1315. Topics include basic numeric and algebraic operations and expressions, linear equations and inequalities, polynomials, rational expressions, factoring, exponents and radicals, graphing, and quadratic equations. Students will use mathematical software to master targeted areas and progress through a modified self-paced environment in order to achieve college readiness. Immediately following the successful completion of this foundational course, students should register for a credit bearing mathematics course according to their degree plan, specifically MATH 1302, MATH 1402, or MATH 1315. Credit in this course does not fulfill any degree requirements.

MATH 1301. CONTEMPORARY MATHEMATICS. 3 Hours. (TCCN = MATH 1332)
This course covers material in a traditional algebra course together with real-world applications of mathematics. It develops problem-solving and critical thinking skills. Topics include the mathematics of dimensional analysis, mathematical logic, population growth, optimization, voting theory, number theory, graph theory, relations, functions, probability, statistics, and finance. The use of mathematical software and calculators is required. See course syllabus for details. Credit may be received for only one of MATH 1301, MATH 1302/1402, or MATH 1315.

MATH 1302. COLLEGE ALGEBRA. 3 Hours. (TCCN = MATH 1314)
This course is designed as preparation for higher level mathematics courses. Topics include the study of linear, quadratic, polynomial, rational, radical absolute value, logarithmic, and exponential functions, relations and inequalities; graphs, basic characteristics, and operations on functions; real and complex zeros of functions; graphing techniques; systems of equations and matrices. The use of mathematical software and calculators is required. See course syllabus for more details. Non-STEM (Science-Technology-Engineering-Mathematics) majors should enroll in MATH 1301, and Business majors should enroll in MATH 1315. Credit may be received for only one of MATH 1301, MATH 1302, MATH 1402 or MATH 1315. Students may not co-enroll in MATH 1302 and MATH 1402.

MATH 1303. TRIGONOMETRY. 3 Hours. (TCCN = MATH 1316)
Trigonometric functions, radian measure, solution of triangles, graphs of trigonometric functions, trigonometric identities and equations, and complex numbers. This course is not intended for Science majors. Prerequisite: C or better in MATH 1301, MATH 1302, MATH 1402, MATH 1308, MATH 1315, or a qualifying score on either Math Placement Test (MPT) or ALEKS PPL.

MATH 1308. ELEMENTARY STATISTICAL ANALYSIS. 3 Hours. (TCCN = MATH 1342)
Topics may include collection, analysis, presentation, and interpretation of data. Analysis includes descriptive statistics, probability, relationships between variables and graphs, elementary statistical models, hypothesis testing, inference, estimation, correlation, regression and confidence intervals. The use of mathematical software and calculators is required. See course syllabus for details.

MATH 1309. STATISTICAL LITERACY. 3 Hours. (TCCN = MATH 1342)
Topics may include collection, analysis, presentation, and interpretation of data. Analysis includes descriptive statistics, probability, relationships between variables and graphs, hypothesis testing, inference, estimation, correlation, regression, and confidence intervals. Special emphasis placed on statistical reasoning for everyday life, understanding statistical language and methods, and interpreting results. The use of mathematical software and calculators is required.

MATH 1313. LIBERAL ARTS HONORS MATHEMATICS. 3 Hours.
Topics include the development of the real number system, different orders of infinity, the idea of convergence and how this led to the development of calculus, the concept of a mathematical proof, the conceptual foundations of topology, networks, and knot theory, and modern applications of mathematics to the sciences.

MATH 1315. COLLEGE ALGEBRA FOR ECONOMICS & BUSINESS ANALYSIS. 3 Hours. (TCCN = MATH 1324)
This course covers material in a traditional algebra course with emphasis on business and financial application. The application of common algebraic functions including polynomial, exponential, logarithmic, and rational, to problems in business, economics, and the social sciences are addressed. Additional topics include systems of linear equations and inequalities, linear programming, mathematics of finance, elements of matrix algebra, logic and probability including expected value. Credit may be received for only one of MATH 1301, MATH 1302, MATH 1402, or MATH 1315.

MATH 1316. MATHEMATICS FOR ECONOMICS AND BUSINESS ANALYSIS. 3 Hours. (TCCN = MATH 1325)
This course is the basic study of limits and continuity, differentiation, optimization and graphing, and integration of elementary functions, with emphasis on mathematical tools and applications in business, economics, and social sciences. This course is not a substitute for MATH 1426 Calculus I. Prerequisite: C or better in MATH 1315 or MATH 1302 or MATH 1402, or a qualifying score on Math Placement Test (MPT) or ALEKS PPL, or student group.

MATH 1324. ALGEBRA AND TRIGONOMETRY. 3 Hours. (TCCN = MATH 2412)
A fast-paced summary study of the topics of MATH 1302 and MATH 1303. This course is not intended for calculus track students; those students should take MATH 1421. Credit cannot be received for MATH 1324 and MATH 1302/1402 or MATH 1303.

MATH 1325. ANALYTIC GEOMETRY. 3 Hours. (TCCN = MATH 1348)
Vectors, lines in two dimensions, circles, conics, transformation of coordinates, polar coordinates, parametric equations, and the solid analytic geometry of vectors, lines, planes, cylinders, spherical and cylindrical coordinates. Prerequisite:C or better in MATH 1301 or MATH 1302 or MATH 1402 or MATH 1315 or MATH 1324, or a qualifying score on Math Placement Test.

MATH 1327. ARCHITECTURAL CALCULUS WITH ANALYTIC GEOMETRY. 3 Hours.
Topics from Analytic Geometry and Calculus including conics, polar coordinates, parametric equations; concepts of limit, continuity, differentiation and integration; applications of these concepts. This course will not substitute for MATH 1426. Prerequisite: Major or intended major in Architecture or Interior Design and C or better in MATH 1303 or MATH 1421, or a qualifying score on either the Math Placement Test (MPT) or ALEKS PPL, or student group.

MATH 1330. ARITHMETICAL PROBLEM SOLVING. 3 Hours.
This is a course in small and large group problem solving, with emphasis on reasoning and writing. Topics include problem solving, sets, operations and relations, arithmetic, place value and bases, propositional logic, fractions, number theory, number systems and estimation. Prerequisite: C or better in MATH 1301 or MATH 1302 or MATH 1402, and enrollment as an education major.

MATH 1331. GEOMETRICAL INFERENCE AND REASONING. 3 Hours.
A discovery-oriented exploration of two-and three-dimensional geometry, with emphasis on reasoning and writing. Topics include constructions, polygons, tessellations, polyhedra, symmetry, rigid motions in the plane, measurement, and discovering theorems. Prerequisite: C or better in MATH 1330 and enrollment as an education major.

MATH 1332. FUNCTIONS, DATA, AND APPLICATIONS. 3 Hours.
An exploration of interpreting data, using cooperative groups, spreadsheets and mathematical models. Topics include graphs, applications to economics and natural sciences, function concepts, counting principles, and basic probability and statistics. Prerequisite: C or better in MATH 1330 and enrollment as an education major.

MATH 1402. COLLEGE ALGEBRA. 4 Hours. (TCCN = MATH 1414)
This course is designed as preparation for higher level mathematics courses. Integrated review materials will be used to master targeted areas as students proceed through the course. Topics include foundational numeric and algebraic operations in addition to the study of linear, quadratic, polynomial, rational, radical absolute value, logarithmic, and exponential functions, relations and inequalities; graphs, basic characteristics, and operations on functions; real and complex zeros of functions; graphing techniques; systems of equations and matrices. The use of mathematical software and calculators is required. See course syllabus for more details. Non-STEM (Science-Technology-Engineering-Mathematics) majors should enroll in MATH 1301, and Business majors should enroll in MATH 1315. Credit may be received for only one of MATH 1301, MATH 1302, MATH 1402, or MATH 1315. Students may not co-enroll in MATH 1302 and MATH 1402.

MATH 1421. PREPARATION FOR CALCULUS. 4 Hours.
This course integrates and builds upon concepts and skills from college algebra and trigonometry that are essential to success in calculus. Problem solving activities form the basis for the establishment of these mathematical connections. Prerequisite: C or better in MATH 1301 or MATH 1302 or or MATH 1402 MATH 1315, or a qualifying score on either the Math Placement Test (MPT) or ALEKS PPL, or student group.

MATH 1426. CALCULUS I. 4 Hours. (TCCN = MATH 2413)
Concepts of limit, continuity, differentiation and integration; applications of these concepts. Prerequisite: A qualifying score on the Math Placement Test (MPT) or ALEKS PPL is required to register for this course, or student group.

MATH 2326. CALCULUS III. 3 Hours. (TCCN = MATH 2315)
Vectors, dot product, cross product, planes, quadric surfaces, partial differentiation, multiple integrals (with applications), line integrals, Green's Theorem, surface integrals, Stokes' Theorem, divergence theorem. Prerequisite: C or better in MATH 2425 or HONR-SC 2425, or student group.

MATH 2330. FUNCTIONS AND MODELING. 3 Hours.
Students engage in explorations and lab activities designed to strengthen and expand their knowledge of the topics found in secondary mathematics. Students collect data and explore a variety of situations that can be modeled using linear, exponential, polynomial, and trigonometric functions. Activities are designed to have them take a second, deeper look at topics they should have been exposed to previously; illuminate the connections between secondary and college mathematics; illustrate good, as opposed to typically poor, sometimes counterproductive, uses of technology in teaching; illuminate the connections between various areas of mathematics; and engage them in serious (i.e., non-routine) problem solving, problem-based learning, and applications of mathematics. While there is some discussion of how the content relates to secondary mathematics instruction, the course primarily emphasizes mathematics content knowledge and content connections, as well as applications of the mathematics topics covered. This course is part of the UTeach program. Prerequisite: C or better in MATH 2425; C or better in SCIE 1201 or SCIE 1334 or concurrent enrollment.

MATH 2333. INTRODUCTION TO LINEAR ALGEBRA. 3 Hours.
Solving systems of linear equations by (reduced) row-echelon form and matrix inversion, matrix algebra, determinants, real n-dimensional space and its geometric structure, linear transformations, eigenvalues and eigenvectors, basis, dot product, quadratic forms, and applications in science and engineering. Prerequisite: C or better in MATH 2425.

MATH 2425. CALCULUS II. 4 Hours. (TCCN = MATH 2414)
Applications of integration, techniques of integration, parametric equations, polar coordinates, sequences, and series. Prerequisite: C or better in MATH 1426 or HONR-SC 1426, or student group.

MATH 3300. INTRODUCTION TO PROOFS. 3 Hours.
Techniques for constructing proofs for various propositions. The propositions chosen exhibit properties of functions, relations, sets, cardinality, and other ideas in mathematics. An axiomatic approach to some areas in mathematics. Oral presentations of proofs are required. Prerequisite: Math major or math intended major. C or better in MATH 2425 or HONR-SC 2425, or student group.

MATH 3301. FOUNDATIONS OF GEOMETRY. 3 Hours.
A development of the foundations of geometry. Prerequisite: C or better in MATH 2425 or HONR-SC 2425, or student group.

MATH 3302. MULTIVARIATE STATISTICAL METHODS. 3 Hours.
Topics in multivariate data analysis with applications in various areas of interest, including multiple regression, analysis of experimental designs, covariate adjustment, non-linear regression and the use of standard multivariate statistical packages. Offered as MATH 3302 and STATS 3302; credit will be granted in only one department. Prerequisite: C or better in MATH 3313 or STATS 3313 or MATH 3316 or STATS 3316 or MATH 3351 or BIOL 3351 or consent of the instructor.

MATH 3303. MATHEMATICAL GAME THEORY. 3 Hours.
Two-person zero-sum games, solving matrix games by linear programming, two-person non-zero sum games, noncooperative n-person games, Nash equilibrium points and refinements, cooperative n-person games, core, Shapley value, and other concepts of solution. Applications to cost allocation, fair division, and voting power. Prerequisite: C or better in MATH 3330 or MATH 3319, or consent of the instructor.

MATH 3304. LINEAR OPTIMIZATION APPLICATIONS. 3 Hours.
An introduction to basic methods of optimization with applications to optimal resource application, minimal cost allocation and interpersonal decision making in noncooperative and cooperative environments. Includes simplex method, duality, zero sum games, transportation and assignment. Prerequisite: C or better in MATH 3330 or MATH 3319.

MATH 3307. ELEMENTARY NUMBER THEORY. 3 Hours.
Various topics in elementary number theory. Divisibility, congruences, quadratic reciprocity, and multiplicative functions. Prerequisite: 2.0 or better in nine hours of college mathematics, or student group.

MATH 3313. INTRODUCTION TO PROBABILITY. 3 Hours.
Basic concepts in probability, random variables, probability distributions, functions of random variables, moment generating functions, central limit theorem and its role in statistics, joint probability functions and joint probability density functions, joint cumulative distribution functions, conditional and marginal probability distributions, covariance and correlation coefficients, transformation and order statistics. Offered as MATH 3313 and STATS 3313; credit will be granted in only one department. Prerequisite: C or better in MATH 2326, or student group.

MATH 3314. DISCRETE MATHEMATICS. 3 Hours.
An introduction into discrete structures. Propositional calculus, sets and operations, functions, induction, counting, relations and matrices, equivalences and partial orders, graphs and shortest path algorithms, trees and minimal spanning trees, tree traversal, elements of boolean algebra. Prerequisite: C or better in MATH 1426 or HONR-SC 1426, or student group.

MATH 3315. MATHEMATICAL MODELS. 3 Hours.
Methods for solving, by means of mathematics, problems which occur in other disciplines such as physics, engineering, biology, and economics. Basic mathematical tools are chosen from areas such as optimization, probability, differential equations, and computer-oriented mathematics. Problems arising in other disciplines or industrial applications are emphasized. Subject matter will depend on the instructor. Prerequisite: C or better in MATH 2326, or permission of instructor, or student group.

MATH 3316. STATISTICAL INFERENCE. 3 Hours.
A comprehensive study of basic data analysis, focused on reasoning process of statistical investigations from asking question and collecting data to analyzing data and drawing inferences. Topics include exploratory data analysis, sampling, sampling distribution, estimation, hypothesis tests, regression, and ANOVA, with an emphasis on applications of these techniques using statistical software. Offered as MATH 3316 and STATS 3316; credit will be granted in only one department. Prerequisite: C or better in 6 hours from the following: MATH 1302, MATH 1308, MATH 1322, MATH 1323, MATH 1330, MATH 1331, MATH 1332, MATH 1402, MATH 1421, MATH 1426, MATH 2425, MATH 2326, MATH 3300, MATH 3307, MATH 3314, MATH 3319, or MATH 3330; HONR-SC 1426, HONR-SC 2425, or student group.

MATH 3318. DIFFERENTIAL EQUATIONS. 3 Hours.
Ordinary differential equations with emphasis on the solutions and analysis of first and higher order differential equations drawn from fields of physics, chemistry, geometry, and engineering. Prerequisite: C or better in MATH 2326 or concurrent registration, or student group.

MATH 3319. DIFFERENTIAL EQUATIONS & LINEAR ALGEBRA. 3 Hours.
Introductory course with emphasis on solution techniques. Ordinary differential equations, vector spaces, linear transformations, matrix/vector algebra, eigenvectors, Laplace Transform, and systems of equations. Math majors will not receive credit for this course. Prerequisite: C or better in MATH 2326 or concurrent enrollment, or student group.

MATH 3321. ABSTRACT ALGEBRA I. 3 Hours.
Groups including Lagrange's Theorem, Cauchy's Theorem, the homomorphism theorems, and symmetric groups. Prerequisite: C or better in MATH 3300 and MATH 3330, or student group.

MATH 3330. INTRODUCTION TO LINEAR ALGEBRA AND VECTOR SPACES. 3 Hours.
Solving systems of linear equations by (reduced) row-echelon form and matrix inversion, matrix operations, linear transformations, projections, characterizing invertibility, determinants, bases, change of basis, real n-dimensional space and its geometric structure, subspaces, kernel and image of a linear transformation, application to abstract vector spaces of arbitrary dimension, dot product, orthogonality, Gram-Schmidt process, eigenvalues and eigenvectors, characteristic polynomial, diagonalization, symmetric matrices, and principal-axis theorem. Prerequisite: C or better in MATH 2425, or student group.

MATH 3335. ANALYSIS I. 3 Hours.
Real numbers, sequences, series, limits of functions, continuity. Prerequisite: Grade of C or better in both MATH 2326 and MATH 3300, or student group.

MATH 3345. NUMERICAL ANALYSIS AND COMPUTER APPLICATIONS. 3 Hours.
Numerical solutions of nonlinear equations, numerical integration and differentiation, polynomial interpolation, solutions of linear systems, and an introduction to spline functions. Prerequisite: C or better in MATH 2326, and C or better in one of MATH 3330 or MATH 3319, or student group.

MATH 3351. PROBABILITY AND RANDOM PROCESSES IN BIOLOGY. 3 Hours.
Introduction to random processes arising in biological modeling. Topics include introduction to probability, Poisson processes, birth-death processes, Markov chains, and Markov processes. Course taught as BIOL 3351 and MATH 3351; credit will be granted only once. Prerequisite: C or better in BIOL 3350 or MATH 3350 or consent of the instructor.

MATH 4093. UNDERGRADUATE RESEARCH. 0 Hours.
Undergraduate research experiences under supervision of faculty. Students are expected to disseminate research findings by poster or oral presentations in meetings or conferences. Students are also expected to participate in other activities as directed by the grant-funded Research Program Director.

MATH 4150. SEMINAR IN MATHEMATICAL BIOLOGY. 1 Hour.
Formulation and definition of interdisciplinary research problems in Mathematical Biology, the formulation and execution of strategies of solution, and the presentation of results. Research under faculty supervision and mentorship involving collaboration within a small group. Prerequisite: Consent of the instructor.

MATH 4180. ORAL COMMUNICATION OF MATHEMATICS. 1 Hour.
This course trains students in giving effective oral presentations of mathematics and topics involving mathematics. Students will give presentations to the class and evaluate the presentations of their classmates. Topics may be chosen from mathematics and science journals at a level suitable for undergraduates, from books and articles on the history and development of mathematics, or from previous course material.

MATH 4191. SPECIAL TOPICS IN MATHEMATICS. 1 Hour.
Special topics in mathematics are assigned to individuals or small groups. Faculty members closely supervise the projects and assign library reference material. Small groups will hold seminars at suitable intervals. May be repeated for credit. Prerequisite: senior standing and written permission of the instructor and department chair.

MATH 4291. SPECIAL TOPICS IN MATHEMATICS. 2 Hours.
Special topics in mathematics are assigned to individuals or small groups. Faculty members closely supervise the projects and assign library reference material. Small groups will hold seminars at suitable intervals. May be repeated for credit. Prerequisite: senior standing and written permission of the instructor & department chair.

MATH 4303. INTRODUCTION TO TOPOLOGY. 3 Hours.
A first course in topology from the axiomatic point of view. Prerequisite: C or better in MATH 3335.

MATH 4311. STOCHASTIC MODELS AND SIMULATION. 3 Hours.
A study of processes, whose outcomes are governed by chance, through a combination of lectures and computer lab sessions. Experiments include random number generation, coin tossing and other games of chance, random walks, Markov Chains, Poisson processes, birth-death processes, branching processes, and Brownian Motion. A foundation for modeling random phenomena in sciences, engineering and business. Prerequisite: C or better in MATH 2326 and knowledge of basic probability (MATH 3313/STATS 3313 or MATH 3351/BIOL 3351 or equivalent), or consent of instructor, or student group.

MATH 4312. ACTUARIAL RISK ANALYSIS. 3 Hours.
Fundamentals of actuarial science concerning risk theory based on probability. Topics include: utility theory, principles of premium calculations, collective and individual risk models, ruin theory, classical Lundberg's Model. Prerequisite: C or better in MATH 3313/STATS 3313.

MATH 4313. MATHEMATICAL STATISTICS. 3 Hours.
A continuation of MATH 3313. Random sampling and sampling distributions, estimation of unknown parameters and main properties of estimators, confidence intervals for unknown parameters, testing of hypotheses. Prerequisite: C or better in MATH 3313 or STATS 3313.

MATH 4314. ADVANCED DISCRETE MATHEMATICS. 3 Hours.
Finite automata, Turing machines, formal languages, graph theory, combinatorial optimization, complexity of algorithms, P versus NP, and decidable versus undecidable problems. Prerequisite: C or better in MATH 3314.

MATH 4320. ADVANCED DIFFERENTIAL EQUATIONS. 3 Hours.
The existence and properties of solution of differential equations. Prerequisite: C or better in MATH 3318 or MATH 3319.

MATH 4321. ABSTRACT ALGEBRA II. 3 Hours.
Rings and field theory, including polynomial rings and field extensions. Prerequisite: C or better in MATH 3321.

MATH 4322. INTRODUCTION TO COMPLEX VARIABLES. 3 Hours.
An introduction to the theory of functions of a complex variable and also an introduction to applications including uses of the residue theory, contour integration and conformal mapping. Prerequisite: C or better in MATH 2326, or student group.

MATH 4324. INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS. 3 Hours.
Methods of solutions of selected elliptic, parabolic, and hyperbolic partial differential equations with reference to physical applications. Prerequisite: C or better in MATH 3318 or MATH 3319.

MATH 4330. ADVANCED LINEAR ALGEBRA. 3 Hours.
Eigenvalues, eigenvectors, generalized eigenvectors, minimal/characteristic polynomial, Jordan normal/canonical form, companion matrix and rational canonical form, inner products, adjoint of a linear map, positive-definite operators and isometries, polar decomposition and singular-value decomposition, exponential of a matrix and applications to differential equations, least squares and curve fitting, bilinear and quadratic forms, dual spaces and transpose of a matrix, quotient spaces, multilinear maps, tensor products. Prerequisite: MATH 3330 or consent of instructor.

MATH 4334. ADVANCED MULTIVARIABLE CALCULUS. 3 Hours.
Topics include properties of limits of mappings, continuity of mappings, derivatives of mappings, and integrals of mappings from n-dimensional Euclidean space to m-dimensional Euclidean space. Prerequisite: C or better in MATH 3335, and MATH 3330.

MATH 4335. ANALYSIS II. 3 Hours.
Differentiation, integration, and selected topics in sequences and series of functions and metric spaces. Prerequisite: C or better in MATH 3335.

MATH 4345. NUMERICAL ANALYSIS & COMPUTER APPLICATIONS II. 3 Hours.
Numerical solutions for ordinary differential equations, boundary value problems, minimizations of multivariate functions, and methods of least squares. Prerequisite: C or better in MATH 3345.

MATH 4350. PRECALCULUS FOR MID-LEVEL MATHEMATICS TEACHERS. 3 Hours.
This course serves to bridge the gap between algebra and calculus for middle level teachers. It will develop a firm understanding of the concept of function, how to graphically represent various functions, analyze their behavior and create new functions from old. Functions will be used to model real-life situations. The course will focus on the essential elements of precalculus, as given by the TEKS. It will develop the foundations for functions and explore functions as a unifying theme. This includes transformations, inverses, and solving equations. These foundational ideas will be explored and applied to specific functions, including exponential, logarithmic, power, polynomial, rational, and trigonometric functions. There will be an emphasis on multiple representations of mathematical ideas: verbal, concrete, pictorial, tabular, symbolic and graphical. Throughout, the mathematical connections between precalculus and school mathematics will be highlighted. Prerequisite: C or better in MATH 1302/1402, MATH 1308, MATH 1330, MATH 1331 and MATH 1332. This course does not count toward a degree in mathematics.

MATH 4351. CALCULUS FOR MID-LEVEL MATHEMATICS TEACHERS. 3 Hours.
This course serves to introduce the basic concepts of calculus to middle level teachers. The primary goal is to help teachers develop a fundamental understanding of the key mathematical ideas in calculus in order to broaden their mathematical perspective and gain insight into the topics in the middle level curriculum which are related and foundational to its development. Participants will develop conceptual knowledge of the processes of differentiation and integration, and understanding of their applications and an understanding of the relationship between the two processes. Prerequisite: C or better in MATH 4350. This course does not count toward a degree in mathematics.

MATH 4381. MATHEMATICS RESEARCH. 3 Hours.
Formulation and definition of research problems, the formulation and execution of strategies of solution, and the presentation of results. Prerequisite: consent of instructor. Recommendation by other faculty encouraged.

MATH 4391. SPECIAL TOPICS IN MATHEMATICS. 3 Hours.
Special topics in mathematics are assigned to individuals or small groups. Faculty members closely supervise the projects and assign library reference material. Small groups will hold seminars at suitable intervals. May be repeated for credit. Prerequisite: senior standing and written permission of the instructor & department chair.

MATH 4392. ADVANCED TOPICS IN MATHEMATICS. 3 Hours.
Varies from semester to semester. New developments in mathematics, in-depth study of a topic not covered in other courses, or a special faculty expertise made available to undergraduates. May be repeated for credit as topic varies. Prerequisite: permission of instructor.

MATH 4393. HONORS THESIS/SENIOR PROJECT. 3 Hours.
Required of all students in the University Honors College. During the senior year the student must complete a thesis or a project under the direction of a faculty member in the math department. Prerequisite: enrollment in the University Honors College and written permission of the instructor and chair.

MATH 4394. UNDERGRADUATE RESEARCH EXPERIENCES. 3 Hours.
Research under faculty supervision and mentorship involving collaboration within a small group. The topic varies from semester to semester, is determined by the faculty teaching the course, and is announced in advance. The course promotes active learning based on inquiry, development of higher-order thinking skills, and meaningful scientific research. Prerequisite: consent of instructor.

MATH 5190. INTERNSHIP FOR MATHEMATICAL SCIENCES. 1 Hour.
Practical experiences in the mathematical sciences. May be repeated for credit when the content changes. Prerequisite: Successful completion of 18 graduate credit hours in the program of study and in good academic standing (i.e. graduate GPA 3.0/4.0 or higher).

MATH 5191. SEMINAR FOR TEACHING ASSISTANTS. 1 Hour.
This course is mandatory for all mathematics graduate teaching assistants. Students will be instructed on classroom procedures and effective teaching strategies and will be required to deliver teaching demonstrations under the supervision of mathematics faculty. The purpose is to enhance students' capacity to facilitate mathematics learning in a variety of settings. Admittance to this course is restricted to Math TAs.

MATH 5300. INTRODUCTION TO SCIENTIFIC COMPUTING. 3 Hours.
Introduction to scientific computing utilizing algorithmic languages and operating environment such as Fortran, MATLAB, C, and C++ and UNIX (LINUX) operating system. Prerequisite: consent of the instructor.

MATH 5302. FUNDAMENTALS OF MATHEMATICAL SCIENCES I. 3 Hours.
Matrices and operators, linear spaces, multivariable calculus, dynamical systems, applications. Prerequisites: MATH 3318 and MATH 3330 or consent of the instructor.

MATH 5303. FUNDAMENTALS OF MATHEMATICAL SCIENCES II. 3 Hours.
Wave propagation, potential theory, complex variables, transform techniques, perturbation techniques, diffusion, applications. Prerequisite: MATH 5302 or consent of the instructor.

MATH 5304. GENERAL TOPOLOGY. 3 Hours.
Introduction to fundamentals of general topology. Topics include product spaces, the Tychonoff theorem, Tietze's Extension theorem, and metrization theorems. Prerequisite: MATH 4304 or MATH 4335.

MATH 5305. STATISTICAL METHODS. 3 Hours.
Topics include descriptive statistics, numeracy, and report writing; basic principles of experimental design and analysis; regression analysis; data analysis using the SAS package. Prerequisite: consent of the instructor.

MATH 5307. MATHEMATICAL ANALYSIS I. 3 Hours.
Introduction to fundamentals of general topology. Topics include product spaces, the Tychonoff theorem, Tietze's Extension theorem, and metrization theorems. Prerequisite: MATH 4335 or consent of Graduate Advisor.

MATH 5308. MATHEMATICAL ANALYSIS II. 3 Hours.
Analysis in Rn, limits, continuity, Jacobian, extremum problems, multiple integrals, sequences and series of functions, Lebesgue integral. Prerequisite: MATH 5307 or consent of Graduate Advisor.

MATH 5310. MATHEMATICAL GAME THEORY. 3 Hours.
Two person null sum games. Bimatrix games and Nash equilibrium points. Noncooperative games, existence theorem. Cooperative games, core, Shapley value, the nucleolus. Cost allocation. Market games. Simple games and voting. Prerequisite: MATH 3330.

MATH 5311. APPLIED PROBABILITY AND STOCHASTIC PROCESSES. 3 Hours.
Topics include conditional expectations, law of large numbers and central limit theorem, stochastic processes, including Poisson, renewal, birth-death, and Brownian motion. Prerequisite: MATH 3313 or equivalent.

MATH 5312. MATHEMATICAL STATISTICS I. 3 Hours.
Random variables and their expectations, some special distributions, moment generating functions, transformations of bivariate random variables, sampling distribution of statistics, Central Limit Theorem, confidence intervals, maximum likelihood estimation, introduction to hypothesis testing, maximum likelihood tests. Prerequisite: MATH 3335 or consent of instructor.

MATH 5313. MATHEMATICAL STATISTICS II. 3 Hours.
Multivariate distributions, consistency and limiting distributions, Rao-Cramer lower bound and efficiency, sufficiency and completeness, most powerful tests, uniformly most powerful tests, likelihood ratio test, the sequential probability ratio test, minimax and classification procedures. Prerequisite: MATH 5312/STATS 5312.

MATH 5314. EXPERIMENTAL DESIGN. 3 Hours.
This course covers the classical theory and methods of experimental design, including randomization, blocking, one-way and factorial treatment structures, confounding, statistical models, analysis of variance tables and multiple comparisons procedures. Prerequisite: MATH 5305/STATS 5305 or MATH 5355/STATS 5355 or permission of instructor.

MATH 5315. GRAPH THEORY. 3 Hours.
Algorithms for problems on graphs. Trees, spanning trees, connectedness, fundamental circuits. Eulerian graphs and Hamiltonian graphs. Graphs and vector spaces, matrices of a graph. Covering and coloring. Flows. Prerequisite: MATH 3314.

MATH 5316. COMBINATORIAL OPTIMIZATION. 3 Hours.
Shortest paths. Minimum weight spanning trees and matroids. Matchings and optimal assignment. Connectivity. Flows in networks, applications. Prerequisite: MATH 3314.

MATH 5317. REAL ANALYSIS. 3 Hours.
Sigma-fields, measures, measurable functions, convergence in measure and almost everywhere, integration, Fatou's Lemma, Lebesgue-dominated convergence, signed measures, Radon-Nikodym Theorem, product measures, Fubini's Theorem. Prerequisite: Math 5307 or consent of the Graduate Advisor.

MATH 5318. FUNDAMENTALS OF STOCHASTIC ANALYSIS. 3 Hours.
General properties of stochastic processes, processes with independent increments, martingales, limit theorems including invariance principle, Markov processes, stochastic integral, stochastic differential. Prerequisite: Math 5317 or consent of the instructor.

MATH 5319. PROBABILITY THEORY. 3 Hours.
Probability spaces, random variables, filtrations, conditional expectations, martingales, strong law of large numbers, ergodic theorem, central limit theorem, Brownian motion and its properties. Prerequisite: MATH 5317.

MATH 5320. ORDINARY DIFFERENTIAL EQUATIONS. 3 Hours.
Fundamentals of the theory of systems of ordinary differential equations: existence, uniqueness, and continuous dependence of solutions on data; linear equations, stability theory and its applications, periodic and oscillatory solutions. Prerequisite: MATH 5307 and MATH 5333.

MATH 5321. APPLIED PARTIAL DIFFERENTIAL EQUATIONS. 3 Hours.
General first order equations. Basic linear theory for elliptic, hyperbolic, and parabolic second order equations, including existence and uniqueness for initial and boundary value problems. Prerequisites: MATH 5307 and MATH 5333.

MATH 5322. COMPLEX VARIABLES I. 3 Hours.
Fundamental theory of analytic functions, residues, conformal mapping and applications. Prerequisite: MATH 5307.

MATH 5325. ALGEBRAIC NUMBER THEORY. 3 Hours.
Field extensions, number fields and number rings, ramification theory, class groups, elliptic curves and their group structure, applications to Fermat's last theorem. Prerequisite: MATH 3321.

MATH 5326. ALGEBRAIC TOPOLOGY. 3 Hours.
Basics of topology, Fundamental groups, covering spaces, Van Kampen's Theorem, categories and functors, singular homology, relative homology, Mayer-Vietoris sequence, cohomology, cup products, the cohomology ring of a space, CW complexes. Prerequisites: MATH 3321, MATH 3335.

MATH 5327. FUNCTIONAL ANALYSIS I. 3 Hours.
Introduction to Hilbert and Banach spaces: Hahn-Banach, Banach-Steinhaus, and closed graph theorems. Riesz representation theorem and bounded linear operators in Hilbert space. Prerequisite: MATH 5317 or consent of the instructor.

MATH 5328. FUNCTIONAL ANALYSIS II. 3 Hours.
The theory of distributions and Sobolev spaces, with applications to differential equations. Compact operators and Fredholm theory. Spectral theory for unbounded operators. Prerequisite: MATH 5327.

MATH 5329. HOMOLOGICAL ALGEBRA. 3 Hours.
Projective and injective modules, projective and injective resolutions, Hom and tensor, the language of category theory, derived functors, Ext and Tor, complexes.

MATH 5330. ALGEBRAIC GEOMETRY. 3 Hours.
Theory of ideals in polynomial rings, Nullstellensatz, Hilbert's basis theorem, computation in polynomial rings, affine and projective varieties, singular and smooth points on varieties. Prerequisite: MATH 4321.

MATH 5331. ABSTRACT ALGEBRA I. 3 Hours.
Fundamental topics on groups, rings and modules that may include: abelian groups; dihedral groups; groups of permutations; normal subgroups; quotient groups; group actions; Lagrange's Theorem; Cayley's Theorem; Sylow's Theorems; factorization in commutative rings; localization in commutative rings; quotient rings; quotient modules; isomorphism theorems. Prerequisite: permission from instructor.

MATH 5332. ABSTRACT ALGEBRA II. 3 Hours.
Fundamental topics that may include: modules; chain conditions, noetherian rings and modules, artinian rings; Wedderburn's Theorem; localization with Ore conditions; Maschke's Theorem; special classes of rings such as regular algebras, Cohen-Macaulay rings, Gorenstein rings, universal enveloping algebras. Prerequisite: MATH 5331 or permission from instructor.

MATH 5333. LINEAR ALGEBRA AND MATRICES. 3 Hours.
Vector spaces, their sums, linear (in)dependence, bases, linear maps and their matrices, change of basis, inner-products, adjoints, diagonalization, eigenvectors and generalized eigenvectors, eigenvalues, Jordan form, characteristic and minimal polynomials, dual vector spaces, bilinear and quadratic forms. Prerequisite: MATH 3330 or consent of instructor.

MATH 5334. DIFFERENTIAL GEOMETRY. 3 Hours.
Introduction to the theory of curves and surfaces in three dimensional Euclidean space. Prerequisite: MATH 4334 or MATH 4335.

MATH 5336. CONCEPTS AND TECHNIQUES IN NUMBER THEORY. 3 Hours.
Topics include mathematical induction, fundamental theorem or arithmetic, inequalities, special sequences and sums, divisibility properties, greatest common divisor, division and Euclidean algorithm, properties of congruence and Diophantine equations.

MATH 5337. CONCEPTS AND TECHNIQUES IN CALCULUS. 3 Hours.
Topics studied include limits, continuity, differentiation, integration, numerical approximations, applications and Taylor series.

MATH 5338. NUMERICAL ANALYSIS I. 3 Hours.
Solution of equations including linear and nonlinear systems, interpolation and approximation, spline, numerical differentiation and quadrature. Prerequisite: MATH 2425 or consent of the instructor.

MATH 5339. NUMERICAL ANALYSIS II. 3 Hours.
Rigorous treatment of numerical aspects of linear algebra and numerical solution of ordinary differential equations, boundary value problems, introduction to numerical solution of partial differential equations. Prerequisite: MATH 5338 or consent of the instructor.

MATH 5340. DISCRETE MATHEMATICS FOR PROBLEM SOLVING. 3 Hours.
Topics may include functions, mathematical induction, principles of counting, combinatorics, sequences and recurrence relations, finite graph theory, and elementary game theory.

MATH 5341. MODERN GEOMETRY. 3 Hours.
Topics include Euclidean and non-Euclidean geometries with an emphasis on comparing intrinsic and extrinsic characteristics of geodesics and the resulting geometrical implications.

MATH 5342. CONCEPTS AND TECHNIQUES IN ALGEBRA. 3 Hours.
A study of algebra as described in the K-12 research literature and connections to algebraic structures. Topics include algebra as the study of functions and function relationships, algebra as the study of multiple representations with an emphasis on graphs, tables, and formulae, algebra as generalized arithmetic and quantitative reasoning, and algebra as a language.

MATH 5343. CONCEPTS AND TECHNIQUES IN PROBABILITY AND STATISTICS. 3 Hours.
Consideration of (1) exploring data: descriptive statistics of situations involving one and two variables; (2) anticipating patterns: probability and simulation; (3) design of experiments and planning a study; (4) statistical inference: confirming models. Use of a graphing calculator and other appropriate technology.

MATH 5344. MATHEMATICS-SPECIFIC TECHNOLOGIES. 3 Hours.
Focus on use of current mathematics-specific technologies for enhancing mathematical understanding and mathematics teaching. May include use of Geometer's Sketchpad, Fathom, graphing calculators and computer algebra systems.

MATH 5345. HISTORICAL APPROACH TO REAL ANALYSIS. 3 Hours.
A historical treatment of real analysis that explores motivations for the early definitions and theorems in analysis. Topics may include Fourier's introduction of trigonometric series and the issues it created for mathematicians of the early 19th century, Cauchy's efforts toward establishing a firm foundation for calculus, and Dirichlet's proof of the validity of the Fourier series expansion. Prerequisite: MATH 5337 or consent of the instructor.

MATH 5346. CONCEPTS AND TECHNIQUES IN PROBLEM SOLVING. 3 Hours.
A study of the application of various heuristics and general problem strategies in mathematics, with application to the teaching and learning of secondary school and college-level mathematics. Topics include analyzing, classifying, and modifying tasks, assessment of problem solving, and implementing problem solving in the classroom. Assignments require interaction in secondary school or college field settings.

MATH 5347. CONCEPTS AND TECHNIQUES IN MATHEMATICAL MODELING WITH APPLICATIONS. 3 Hours.
Topics studied include algebraic, graphical, geometrical and numerical techniques to model and solve applied problems.

MATH 5348. ADVANCED ALGEBRA IN SECONDARY SCHOOL MATHEMATICS. 3 Hours.
Major concepts of second-year algebra applied to the teaching and learning of secondary school mathematics. Topics include relations, algebraic, tabular, verbal and geometric representations of functions, transformations, including applications involving systems of equations and inequalities.

MATH 5350. APPLIED MATHEMATICS I. 3 Hours.
Development of models arising in the natural sciences and in engineering. Emphasis will be on the mathematical techniques and theory needed to analyze such models; these include aspects of the theory of differential and integral equations, boundary value problems, theory of distributions and transforms. Prerequisites: MATH 5307 and MATH 5333.

MATH 5351. APPLIED MATHEMATICS II. 3 Hours.
Continuation of MATH 5350; models arising in the physical sciences whose analysis includes such topics as the theory of operators in a Hilbert space, variational principles, branching theory, perturbation and stability analysis. Prerequisite: MATH 5350.

MATH 5352. CONCEPTS AND TECHNIQUES IN PRECALCULUS. 3 Hours.
Topics include functions (transcendental, inverse, parametric, polar, transformations), asymptotic behavior, conics, sequences, complex numbers.

MATH 5353. APPLIED LINEAR MODELS. 3 Hours.
The course covers, at an operational level, three topics: 1) the univariate linear model, including a self-contained review of the relevant distribution theory, basic inference methods, several parameterizations for experimental design and covariate-adjustment models and applications, and power calculation; 2) the multivariate linear model, including basic inference (e.g. the four forms of test criteria and simultaneous methods), applications to repeated measures experiments and power calculation; and 3) the univariate mixed model, including a discussion of the likelihood function and its maximization, approximate likelihood inference, and applications to complex experimental designs, missing data, unbalanced data, time series observations, variance component estimation, random effects estimation, power calculation and a comparison of the mixed model's capabilities relative to those of the classical multivariate model. Knowledge of the SAS package is required. Prerequisite: MATH 5358/STATS 5358 (Regression Analysis) or equivalent.

MATH 5354. CATEGORICAL DATA ANALYSIS. 3 Hours.
This course covers classical methods for analyzing categorical data from a variety of response/factor structures (univariate or multivariate responses, with or without multivariate factors), based on several different statistical rationales (weighted least squares, maximum likelihood and randomization-based). Included are logistic regression, multiple logit analysis, mean scores analysis, observer agreement analysis, association measures, methods for complex experimental designs with categorical responses and Poisson regression. The classical log-linear model for the association structure of multivariate responses is briefly reviewed. Randomization-based inference (e.g. Mantel-Haenzel) is discussed as well. The necessary distribution theory (multinomial, asymptotics of weighted least squares and maximum likelihood) are discussed at an operational level. Knowledge of the SAS package is required. Prerequisite: MATH 5358/STATS 5358 (Regression Analysis).

MATH 5355. STATISTICAL THEORY FOR RESEARCH WORKERS. 3 Hours.
Designed for graduate students not majoring in mathematics. Topics include basic probability theory, distributions of random variables, point estimation, interval estimation, testing hypotheses, regression, and an introduction to analysis of variance. Graduate credit not given to math majors. Prerequisite: calculus MATH 1426/MATH 2425/MATH 2326 or permission of instructor.

MATH 5356. APPLIED MULTIVARIATE STATISTICAL ANALYSIS. 3 Hours.
Statistical analysis for data collected in several variables, topics including sampling from multivariate normal distribution, Hotelling's T'2, multivariate analysis of variance, discriminant analysis, principal components, and factor analysis. Prerequisite: MATH 5312/STATS 5312 or consent of instructor.

MATH 5357. SAMPLE SURVEYS. 3 Hours.
A comprehensive account of sampling theory and methods, illustrations to show methodology and practice, simple random sampling, stratified random sample, ratio estimates, regression estimates, systematic sampling, cluster sampling, and nonsampling errors. Prerequisite: MATH 5312/STATS 5312 or consent of instructor.

MATH 5358. REGRESSION ANALYSIS. 3 Hours.
A comprehensive course including multiple linear regression, non-linear regression and logistic regression. Emphasis is on modeling, inference, diagnostics and application to real data sets. The course begins by developing a toolbox of methods via a sequence of guided homework assignments. It culminates with projects based on consulting-level data analysis problems involving stratification, covariate adjustment and messy data sets. Some knowledge of the SAS package is required. Prerequisites: MATH 5312/STATS 5312 or MATH 5305/STATS 5305 with a B or better or permission of the instructor.

MATH 5359. SURVIVAL ANALYSIS. 3 Hours.
This course covers analysis of lifetime data with applications in engineering and biomedical research. Topics may include survival function, hazard function, cumulative hazard function, parametric distributions to model lifetime data, censoring, Kaplan-Meier estimator, testing for survival times for two or more groups, Cox proportional hazards model (both fixed and time dependent covariate), parametric regression models, regression diagnostics, accelerated failure time models, sample size determination, extensive use of R statistical software. Prerequisites: MATH 5305/STATS 5305 or MATH 5312/STATS 5312 or permission of instructor.

MATH 5361. APPLIED CALCULUS OF VARIATION. 3 Hours.
Functionals, variation, extremization, Euler's equation, direct and indirect approximation methods; applications to mechanics and control theory. Prerequisite: MATH 5302.

MATH 5362. MATHEMATICS OF LINEAR PROGRAMMING. 3 Hours.
The simplex method and the revised simplex method. Linear algebra for polyhedra and polytopes. Duality theory. Sensitivity analysis. Applications to transportation problems, network flow problems, matrix-games and scheduling problems. Integer programming. Quadratic programming. Prerequisite: MATH 3330.

MATH 5363. OSCILLATIONS AND WAVES. 3 Hours.
Development of methods and results related to phenomena in nature that exhibit oscillatory motion; mathematical techniques include Fourier series, ordinary and partial differential equations, and the theory of almost periodic functions. Prerequisite: MATH 3318.

MATH 5364. INTRODUCTION TO MATHEMATICAL CONTROL THEORY. 3 Hours.
Systems in science, engineering, and economics and their mathematical description by means of functional equations (ordinary, partial, integral, delay-type). Basic properties of various classes of systems: observability, controllability, stability, and oscillating systems; optimal control problems and applications. Prerequisite: MATH 3318 or MATH 4320.

MATH 5365. BIOMATHEMATICS. 3 Hours.
Mathematical techniques used in modeling such as perturbation theory, dimensional analysis, Fourier analysis, and differential equations. Applications to morphogenetics, population dynamics, compartmental systems, and chemical kinetics.

MATH 5366. INTRODUCTION TO NEURAL AND COGNITIVE MODELING. 3 Hours.
Principles of neural network modeling; application of these principles to the simulation of cognitive processes in both brains and machines; models of associative learning, pattern recognition, and classification. Prerequisite: consent of instructor.

MATH 5370. PROBLEM SOLVING IN K-8 MATHEMATICS. 3 Hours.
A study of the nature and aspects of problem solving in mathematics, with application to the teaching and learning of K-8 mathematics. Topics include deconstructing and modifying tasks, assessment of problem solving, and the roles of representation, conjecture & proof, and technology in problem solving. Assignments require interaction in K-8 field settings. Prerequisite: graduate standing.

MATH 5371. APPLIED NUMERICAL LINEAR ALGEBRA. 3 Hours.
Numerical solutions of linear algebraic systems, least squares problems, and eigenvalue problems; LU and QR decompositions, Schur and Singular Value decompositions, Gaussian elimination, QR algorithm, and Krylov subspace iterations for large and sparse linear algebra problems. Prerequisites: MATH 3330 or consent of the instructor.

MATH 5372. OPTIMIZATION METHODS & NUMERICAL SOLUTIONS OF NONLINEAR EQUATIONS. 3 Hours.
Unconstrained and constrained optimization, solutions of nonlinear system of equations; Newton and quasi-Newton methods, secant methods and variations, nonlinear least squares problems. Prerequisite: consent of the instructor.

MATH 5373. NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS. 3 Hours.
Numerical methods for approximating solutions of initial value problems, boundary value problems, including linear multistep methods, Runge-Kutta methods, shooting methods. Prerequisite: MATH 5300, MATH 3319 or consent of instructor.

MATH 5374. NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS. 3 Hours.
Numerical methods for elliptic, parabolic, hyperbolic, mixed, and systems of partial differential equations; finite difference methods, finite element methods, spectral methods. Prerequisite: MATH 5373 or consent of instructor.

MATH 5375. CONSTRUCTING WHOLE NUMBER ANDOPERATIONS IN K-8 MATHEMATICS. 3 Hours.
A study of the interaction between the structure of place-value numeration systems and the nature of the four arithmetic operations. The development of traditional and alternative computational arithmetic algorithms from conceptual and concrete models for operations, viewed through the lens of alternative numeration systems and research on children's mathematical thinking. Assignments require interaction in K-8 field settings. Prerequisite: graduate standing.

MATH 5376. CONSTRUCTING RATIONAL NUMBERAND OPERATIONS IN K-8 MATH. 3 Hours.
The meanings and representations of rational numbers, and the development of computations on rational numbers from algorithms for whole numbers, including concrete models for operations on fractions and decimals. Discussion of research on the learning and teaching of operations on rational numbers. Also, divisibility tests and factoring. Assignments require interaction in K-8 field settings. Prerequisite: MATH 5375.

MATH 5377. ALGEBRAIC THINKING IN K-8 MATHEMATICS. 3 Hours.
A study of the practice of making and justifying generalizations in K-8 mathematics, including field properties of operations, modular arithmetic (with applications to odd/even), relations and equivalence relations, the introduction and use of variables and unknowns, and the influence of representations on the form of mathematical arguments. Assignments require interaction in K-8 field settings. Prerequisite: MATH 5375.

MATH 5378. GEOMETRY CONCEPTS IN K-8 MATHEMATICS. 3 Hours.
Major concepts of geometry applied to the teaching and learning of K-8 mathematics. Topics include dimension, development of definitions, meanings of angle, geometric comparison relations, notions of center, and non-Euclidean geometries. Assignments require interaction in K-8 field settings. Prerequisite: graduate standing.

MATH 5379. MEASUREMENT CONCEPTS IN K-8 MATHEMATICS. 3 Hours.
The development of measurement concepts as applied to the teaching and learning of K-8 mathematics. Topics include the development and properties of standard and nonstandard units, notions of size, decomposing space, relationships between boundaries and interiors, the algebra of units, measuring time, and notions of heaviness. Assignments require interaction in K-8 field settings. Prerequisite: graduate standing.

MATH 5380. SEMINAR. 3 Hours.
Current topics in mathematics, may be repeated for credit twice. Prerequisite: consent of instructor.

MATH 5391. SPECIAL TOPICS IN MATHEMATICS. 3 Hours.
Topics in mathematics assigned individual students or small groups. Faculty members closely supervise the students in their research and study. In areas where there are only three hours offered, the special topics may be used by students to continue their study in the same area. Graded P/F/R. Prerequisite: permission of instructor.

MATH 5392. SELECTED TOPICS IN MATHEMATICS. 3 Hours.
May vary from semester to semester depending upon need and interest of the students. May be repeated for credit. Prerequisite: permission of Graduate Advisor.

MATH 5395. SPECIAL PROJECT. 3 Hours.
Graded P/F/R. Prerequisite: permission of Graduate Advisor.

MATH 5398. THESIS. 3 Hours.
MATH 5398 Graded R/F only; MATH 5698 graded P/F/R. Prerequisite: permission of Graduate Advisor.

MATH 5399. RESEARCH IN MATHEMATICS. 3 Hours.
Faculty directed individual study and research. May be repeated for credit. Graded P/F/R/W only. Prerequisite: permission of instructor.

MATH 5698. THESIS. 6 Hours.
Graded P/F/R. Prerequisite: permission of Graduate Advisor.

MATH 5699. RESEARCH IN MATHEMATICS. 6 Hours.
Faculty directed individual study and research. May be repeated for credit. Graded P/F/R/W only. Prerequisite: permission of instructor.

MATH 5999. RESEARCH IN MATHEMATICS. 9 Hours.
Faculty directed individual study and research. May be repeated for credit. Graded P/F/R/W only. Prerequisite: permission of instructor.

MATH 6180. SEMINAR FOR PROFESSIONAL DEVELOPMENT OF PhD STUDENTS IN SPECIAL PROJECTS. 1 Hour.
This seminar class is for Ph.D. students enrolled in special University projects. Topics include a survey of new Math, Science, Technology and Engineering advancements, Ph.D. students professional development and mentoring. Prerequisite: Prior approval of Project Director.

MATH 6310. FOUNDATION OF DATA SCIENCES. 3 Hours.
Basic knowledge and computational methods in data sciences, select topics in norms, semidefinite matrix, nonnegative matrix, Cholesky decomposition, QR decompositions, linear system, least squares problem, eigenvalue and singular value decompositions, low rank approximation, nonnegative matrix factorization, introduction to simplex method, KKT conditions for optimizations, Krylov subspace methods, and applications. Prerequisite: MATH 3330 or consent of the instructor.

MATH 6311. OPTIMIZATION ON BIG DATA. 3 Hours.
Introduction to big data analysis; real world applications of data science; linear system solutions; linear programming; duality theory; convex sets; convex functions; optimality conditions; unconstrained optimization; constraint optimization; conjugate direction methods; alternating direction method of multipliers; classification/regression models and algorithms; dimensionality reduction for visualization; projects on real data. Prerequisite: MATH 3330 or consent of the instructor.

MATH 6312. DATA MINING. 3 Hours.
The course focuses on topics including but not limited to: linear methods in regression, linear methods in classification, model assessment and selection, regularized models, splines, generalized additive models, model averaging, ensemble learning, support vector machines, neural networks, probabilistic graphical models, cluster analysis, dimension reduction techniques, and multidimensional scaling. Prerequisite: MATH 5305/STATS 5305 or MATH 5312/STATS 5312 or permission of instructor. Basic programming skills are preferred.

MATH 6313. TOPICS IN PROBABILITY AND STATISTICS. 3 Hours.
May be repeated for credit when the content changes.

MATH 6353. GENERALIZED LINEAR MODELS. 3 Hours.
This course covers modern methods for analyzing Bernoulli, multinomial and count data. It begins with a development of generalized linear model theory, including the exponential family, link function and maximum likelihood. Second is a discussion of the case of models for independent observations. Next is a discussion of models for repeated measures, based on quasi-likelihood methods. These include models (such as Markov chains) for categorical time series. Next is a treatment of models with random effects. Finally is a discussion of methods for handling missing data. Knowledge of the SAS package is required. Prerequisites: MATH 5358/STATS 5358 (Regression Analysis) and preferably MATH 5313/STATS 5313. (Students without 5313 can still succeed but must deal with the slightly higher mathematical level of this course.).

MATH 6356. TIME SERIES ANALYSIS. 3 Hours.
This course covers classical methods of time series analysis, for both the time and frequency domains. For covariance stationary series, these include ARIMA modeling and spectral analysis. For nonstationary series, they include methods for detrending and filtering. Also included is a treatment of multivariate series, as well as a discussion of the Kalman filter state-space model. Knowledge of the SAS package is required. Prerequisites: MATH 5358/STATS 5358 (Regression Analysis) and MATH 5313/STATS 5313.

MATH 6357. NONPARAMETRIC STATISTICS. 3 Hours.
This is a survey of classical nonparametric methods for inference in standard observational settings (one-sample, two-sample, k-samples and the univariate linear model), and includes a development of U-statistics, rank statistics and their asymptotic distribution theory. The mathematical level is fairly high. Prerequisite: MATH 5313/STATS 5313.

MATH 6391. SPECIAL TOPICS IN MATHEMATICS. 3 Hours.
Faculty directed individual study and research. May be repeated for credit when the content changes.

MATH 6399. DISSERTATION. 3 Hours.
Prerequisite: admission to candidacy for the Doctor of Philosophy degree in mathematics.

MATH 6699. DISSERTATION. 6 Hours.
Prerequisite: admission to candidacy for the Doctor of Philosophy degree in mathematics.

MATH 6999. DISSERTATION. 9 Hours.
Prerequisite: admission to candidacy for the Doctor of Philosophy degree in mathematics.

MATH 7399. DOCTORAL DEGREE COMPLETION. 3 Hours.
This course may be taken during the semester in which a student expects to complete all requirements for the doctoral degree and graduate. Enrolling in this course meets minimum enrollment requirements for graduation, for holding fellowships awarded by The Office of Graduate Studies and for full-time GTA or GRA positions. Students should verify that enrollment in this course meets other applicable enrollment requirements. To remain eligible in their final semester of study for grants, loans or other forms of financial aid administered by the Financial Aid Office must enroll in a minimum of 5 hours as required by the Office of Financial Aid. Other funding sources may also require more than 3-hours of enrollment. Additional hours may also be required to meet to requirements set by immigration law or by the policies of the student's degree program. Students should contact the Financial Aid Office, other sources of funding, Office of International Education and/or their graduate advisor to verify enrollment requirements before registering for this course. This course may only be taken once and may not be repeated. Students who do not complete all graduation requirements while enrolled in this course must enroll in a minimum of 6 dissertation hours (6699 or 6999) in their graduation term. Graded P/F/R.

COURSES

MSCI 6399. DISSERTATION. 3 Hours.

MSCI 6699. DISSERTATION. 6 Hours.

MSCI 6999. DISSERTATION. 9 Hours.

MSCI 7399. DOCTORAL DEGREE COMPLETION. 3 Hours.
This course may be taken during the semester in which a student expects to complete all requirements for the doctoral degree and graduate. Enrolling in this course meets minimum enrollment requirements for graduation, for holding fellowships awarded by The Office of Graduate Studies and for full-time GTA or GRA positions. Students should verify that enrollment in this course meets other applicable enrollment requirements. To remain eligible in their final semester of study for grants, loans or other forms of financial aid administered by the Financial Aid Office must enroll in a minimum of 5 hours as required by the Office of Financial Aid. Other funding sources may also require more than 3-hours of enrollment. Additional hours may also be required to meet to requirements set by immigration law or by the policies of the student's degree program. Students should contact the Financial Aid Office, other sources of funding, Office of International Education and/or their graduate advisor to verify enrollment requirements before registering for this course. This course may only be taken once and may not be repeated. Students who do not complete all graduation requirements while enrolled in this course must enroll in a minimum of 6 dissertation hours (6699 or 6999) in their graduation term. Graded P/F/R.

COURSES

STATS 1308. ELEMENTARY STATISTICAL ANALYSIS. 3 Hours.
Topics may include collection, analysis, presentation, and interpretation of data. Analysis includes descriptive statistics, probability, relationships between variables and graphs, elementary statistical models, hypothesis testing, inference, estimation, correlation, regression and confidence intervals. The use of mathematical software and calculators is required. See course syllabus for details.

STATS 3302. MULTIVARIATE STATISTICAL METHODS. 3 Hours.
Topics in multivariate data analysis with applications in various areas of interest, including multiple regression, analysis of experimental designs, covariate adjustment, non-linear regression and the use of standard multivariate statistical packages. Offered as MATH 3302 and STATS 3302; credit will be granted in only one department. Prerequisite: C or better in MATH 3313 or STATS 3313 or MATH 3316 or STATS 3316 or MATH 3351 or BIOL 3351 or consent of the instructor.

STATS 3313. INTRODUCTION TO PROBABILITY. 3 Hours.
Basic concepts in probability, random variables, probability distributions, functions of random variables, moment generating functions, central limit theorem and its role in statistics, joint probability functions and joint probability density functions, joint cumulative distribution functions, conditional and marginal probability distributions, covariance and correlation coefficients, transformation and order statistics. Offered as MATH 3313 and STATS 3313; credit will be granted in only one department. Prerequisite: C or better in MATH 2326, or student group.

STATS 3316. STATISTICAL INFERENCE. 3 Hours.
A comprehensive study of basic data analysis, focused on reasoning process of statistical investigations from asking question and collecting data to analyzing data and drawing inferences. Topics include exploratory data analysis, sampling, sampling distribution, estimation, hypothesis tests, regression, and ANOVA, with an emphasis on applications of these techniques using statistical software. Offered as MATH 3316 and STATS 3316; credit will be granted in only one department. Prerequisite: C or better in 6 hours from the following: MATH 1302, MATH 1308, MATH 1322, MATH 1323, MATH 1330, MATH 1331, MATH 1332, MATH 1402, MATH 1421, MATH 1426, MATH 2425, MATH 2326, MATH 3300, MATH 3307, MATH 3314, MATH 3319, or MATH 3330; HONR-SC 1426, HONR-SC 2425, or student group.

STATS 4311. STOCHASTIC MODELS AND SIMULATION. 3 Hours.
A study of processes, whose outcomes are governed by chance, through a combination of lectures and computer lab sessions. Experiments include random number generation, coin tossing and other games of chance, random walks, Markov Chains, Poisson processes, birth-death processes, branching processes, and Brownian Motion. A foundation for modeling random phenomena in sciences, engineering and business. Prerequisite: C or better in MATH 2326 and knowledge of basic probability (MATH 3313/STATS 3313 or MATH 3351/BIOL 3351 or equivalent), or consent of instructor, or student group.

STATS 4313. MATHEMATICAL STATISTICS. 3 Hours.
A continuation of MATH 3313. Random sampling and sampling distributions, estimation of unknown parameters and main properties of estimators, confidence intervals for unknown parameters, testing of hypotheses. Prerequisite: C or better in MATH 3313 or STATS 3313.

STATS 5305. STATISTICAL METHODS. 3 Hours.
Topics include descriptive statistics, numeracy, and report writing; basic principles of experimental design and analysis; regression analysis; data analysis using the SAS package. Prerequisite: consent of the instructor.

STATS 5312. MATHEMATICAL STATISTICS I. 3 Hours.
Random variables and their expectations, some special distributions, moment generating functions, transformations of bivariate random variables, sampling distribution of statistics, Central Limit Theorem, confidence intervals, maximum likelihood estimation, introduction to hypothesis testing, maximum likelihood tests. Prerequisite: MATH 3335 or consent of instructor.

STATS 5313. MATHEMATICAL STATISTICS II. 3 Hours.
Multivariate distributions, consistency and limiting distributions, Rao-Cramer lower bound and efficiency, sufficiency and completeness, most powerful tests, uniformly most powerful tests, likelihood ratio test, the sequential probability ratio test, minimax and classification procedures. Prerequisite: MATH 5312/STATS 5312.

STATS 5314. EXPERIMENTAL DESIGN. 3 Hours.
This course covers the classical theory and methods of experimental design, including randomization, blocking, one-way and factorial treatment structures, confounding, statistical models, analysis of variance tables and multiple comparisons procedures. Prerequisite: MATH 5305/STATS 5305 or MATH 5355/STATS 5355 or permission of instructor.

STATS 5353. APPLIED LINEAR MODELS. 3 Hours.
The course covers, at an operational level, three topics: 1) the univariate linear model, including a self-contained review of the relevant distribution theory, basic inference methods, several parameterizations for experimental design and covariate-adjustment models and applications, and power calculation; 2) the multivariate linear model, including basic inference (e.g. the four forms of test criteria and simultaneous methods), applications to repeated measures experiments and power calculation; and 3) the univariate mixed model, including a discussion of the likelihood function and its maximization, approximate likelihood inference, and applications to complex experimental designs, missing data, unbalanced data, time series observations, variance component estimation, random effects estimation, power calculation and a comparison of the mixed model's capabilities relative to those of the classical multivariate model. Knowledge of the SAS package is required. Prerequisite: MATH 5358/STATS 5358 (Regression Analysis) or equivalent.

STATS 5354. CATEGORICAL DATA ANALYSIS. 3 Hours.
This course covers classical methods for analyzing categorical data from a variety of response/factor structures (univariate or multivariate responses, with or without multivariate factors), based on several different statistical rationales (weighted least squares, maximum likelihood and randomization-based). Included are logistic regression, multiple logit analysis, mean scores analysis, observer agreement analysis, association measures, methods for complex experimental designs with categorical responses and Poisson regression. The classical log-linear model for the association structure of multivariate responses is briefly reviewed. Randomization-based inference (e.g. Mantel-Haenzel) is discussed as well. The necessary distribution theory (multinomial, asymptotics of weighted least squares and maximum likelihood) are discussed at an operational level. Knowledge of the SAS package is required. Prerequisite: MATH 5358/STATS 5358 (Regression Analysis).

STATS 5355. STATISTICAL THEORY FOR RESEARCH WORKERS. 3 Hours.
Designed for graduate students not majoring in mathematics. Topics include basic probability theory, distributions of random variables, point estimation, interval estimation, testing hypotheses, regression, and an introduction to analysis of variance. Graduate credit not given to math majors. Prerequisite: calculus MATH 1426/MATH 2425/MATH 2326 or permission of instructor.

STATS 5356. APPLIED MULTIVARIATE STATISTICAL ANALYSIS. 3 Hours.
Statistical analysis for data collected in several variables, topics including sampling from multivariate normal distribution, Hotelling's T'2, multivariate analysis of variance, discriminant analysis, principal components, and factor analysis. Prerequisite: MATH 5312/STATS 5312 or consent of instructor.

STATS 5357. SAMPLE SURVEYS. 3 Hours.
A comprehensive account of sampling theory and methods, illustrations to show methodology and practice, simple random sampling, stratified random sample, ratio estimates, regression estimates, systematic sampling, cluster sampling, and nonsampling errors. Prerequisite: MATH 5312/STATS 5312 or consent of instructor.

STATS 5358. REGRESSION ANALYSIS. 3 Hours.
A comprehensive course including multiple linear regression, non-linear regression and logistic regression. Emphasis is on modeling, inference, diagnostics and application to real data sets. The course begins by developing a toolbox of methods via a sequence of guided homework assignments. It culminates with projects based on consulting-level data analysis problems involving stratification, covariate adjustment and messy data sets. Some knowledge of the SAS package is required. Prerequisites: MATH 5312/STATS 5312 or MATH 5305/STATS 5305 with a B or better or permission of the instructor.

STATS 5359. SURVIVAL ANALYSIS. 3 Hours.
This course covers analysis of lifetime data with applications in engineering and biomedical research. Topics may include survival function, hazard function, cumulative hazard function, parametric distributions to model lifetime data, censoring, Kaplan-Meier estimator, testing for survival times for two or more groups, Cox proportional hazards model (both fixed and time dependent covariate), parametric regression models, regression diagnostics, accelerated failure time models, sample size determination, extensive use of R statistical software. Prerequisites: MATH 5305/STATS 5305 or MATH 5312/STATS 5312 or permission of instructor.

STATS 6353. GENERALIZED LINEAR MODELS. 3 Hours.
This course covers modern methods for analyzing Bernoulli, multinomial and count data. It begins with a development of generalized linear model theory, including the exponential family, link function and maximum likelihood. Second is a discussion of the case of models for independent observations. Next is a discussion of models for repeated measures, based on quasi-likelihood methods. These include models (such as Markov chains) for categorical time series. Next is a treatment of models with random effects. Finally is a discussion of methods for handling missing data. Knowledge of the SAS package is required. Prerequisites: MATH 5358/STATS 5358 (Regression Analysis) and preferably MATH 5313/STATS 5313. (Students without 5313 can still succeed but must deal with the slightly higher mathematical level of this course.).

STATS 6356. TIME SERIES ANALYSIS. 3 Hours.
This course covers classical methods of time series analysis, for both the time and frequency domains. For covariance stationary series, these include ARIMA modeling and spectral analysis. For nonstationary series, they include methods for detrending and filtering. Also included is a treatment of multivariate series, as well as a discussion of the Kalman filter state-space model. Knowledge of the SAS package is required. Prerequisites: MATH 5358/STATS 5358 (Regression Analysis) and MATH 5313/STATS 5313.

STATS 6357. NONPARAMETRIC STATISTICS. 3 Hours.
This is a survey of classical nonparametric methods for inference in standard observational settings (one-sample, two-sample, k-samples and the univariate linear model), and includes a development of U-statistics, rank statistics and their asymptotic distribution theory. The mathematical level is fairly high. Prerequisite: MATH 5313/STATS 5313.