DEPARTMENT OF MATHEMATICS

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Programs of the Department

Students in the Department of Mathematics are encouraged to develop superior thinking and problem-solving skills in preparation for mathematics-based careers and continued study. Our mathematics programs prepare students for a range of careers in education, industry, and government. The mathematics major is also recommended for students planning for graduate or professional school.

The Department of Mathematics offers the following programs:

- Major in Mathematics
- Major in Mathematics Secondary Education Concentration
- Major in Mathematics Pure Mathematics Concentration
- Major in Mathematics Applied Mathematics Concentration
- Major in Mathematics Actuarial Science and Risk Management Concentration
- Minor in Mathematics

Major in Mathematics

The Mathematics Major prepares students to think critically and abstractly about topics in higher mathematics, including courses in both Algebra and Analysis, while allowing students to choose from additional courses from a wide range of topics.

Students who wish to focus their mathematical studies more narrowly may also choose from four concentrations:

- The Mathematics Secondary Education Concentration, offered in conjunction with Towson UTeach, is designed for students who wish to become certified to teach mathematics in secondary schools.
- The Pure Mathematics Concentration emphasizes abstract mathematics and provides a strong background in mathematical theory and prepares students for positions as researchers or analysts as well as for graduate study.
- The Actuarial Science and Risk Management Concentration, designated as a Center of Actuarial Excellence by the Society of Actuaries, provides students a solid background in mathematics along with specialized knowledge leading to career opportunities in the actuarial and financial professions.
- The Applied Mathematics Concentration provides a strong background in the foundations of applied mathematical methods and is designed for students who wish to apply mathematics to problems in business and industry.

The Bachelor of Arts degree may be earned by adding the intermediate level of a foreign language or its equivalent to the major course requirements.

Departmental Policies

Core Curriculum Requirements in Mathematics and Placement Test Information

Students should consult those portions of this catalog describing their major and minor programs to see whether specific mathematics courses are required or recommended.

For a comprehensive list of courses that satisfy the Core Curriculum requirement for Mathematics, please visit this webpage.

Students should enroll in the mathematics course which is most relevant to their program(s) of study and based on their results on the Mathematics Placement Test. The Mathematics Placement Test is used to place students into the most appropriate mathematics course. See the catalog policies on Placement Testing or the Mathematics Department Placement Testing Information for additional information and access to the assessment.

Course Prerequisites

The department strictly enforces prerequisites for all mathematics courses.

Policy on AP Mathematics Credit

For the general policy on Advanced Placement in Mathematics, please visit the Admissions Office's Advanced Placement Credit information site.

Courses/Units in Residence

Only courses approved by the Department of Mathematics may be applied to a major or minor program offered by the department. If students submit mathematics units that are more than five years old at the time of admission or readmission, the chair, after reviewing these records, may require that some courses be repeated or a new course be completed.

- Major in Mathematics
- Major in Mathematics - Pure Mathematics Concentration
- Major in Mathematics - Applied Mathematics Concentration
- Major in Mathematics - Actuarial Science and Risk Management Concentration
- Major in Mathematics - Mathematics Secondary Education Concentration
- Accelerated B.S./M.S. in Mathematics with Actuarial Science & Predictive Analytics
- Accelerated B.S./M.S. in Mathematics with Applied & Industrial Mathematics
- Minor in Mathematics

Faculty

Professors: Mostafa Aminzadeh, Sergiy Borodachov, Linda Cooper (Co-Director of Towson UTeach), Min Deng (Graduate Program Director), Xuezhang Hou, Gail Kaplan, Alexei Kolesnikov, R. Michael Krach, Angel Kumchev, Michael O'Leary (Chairperson), Moustapha Pemy, Felice Shore (Assistant Chair), Houshang Sohrab, Tatyana Sorokina (Graduate Program Director), Sandy Spitzer, Leonid Stern, Wei Sun, Ming Tomayko, Xiaoyin Wang, Maureen Yarnevich, Jay Zimmerman

Associate Professors: Diana Cheng (Graduate Program Director), Yunwei Cui, T Elizabeth Goode, Ge Han, Min Ji, Howard Kaplon, Todd Moyer, Mircea Voisei
Assistant Professors: Christopher Cornell, Kimberly Corum, Kristin Frank, Vincent Guingona, Melike Kara, Lindsey-Kay Lauderdale, Nathan McNew, Hervé Nganguia, Banghee So, Jian Tiang, Na Zhang

Lecturers: Mathew Gluck, Rachael Gross, Maureen Honeychurch, Ellen Johnson, Froma Lustman, Judith Mack, Stanley Max, Emily Morsberger, Christina Packard, Miriam Parnes, Kari Schumm, Rajeev Walia, Xinlong Weng, Nicole Winner

Clinical Assistant Professor: Opel Jones

Clinical Instructor: Erinn Tefel (Master Teacher (Towson UTech))

Courses

MATH 95 DEVELOPMENTAL MATHEMATICS (4)
A review of elementary and intermediate algebra including equations and inequalities, graphing linear equations, exponents and polynomials. Required for students whose required Math course sequence includes MATH 102 as a prerequisite, but whose placement test score is not adequate for placement in MATH 102. No credit toward graduation. Replacing DVMT 101. Graded S/U.

MATH 100 FOUNDATIONS OF MATHEMATICAL REASONING (3)
Designed to provide students the necessary mathematical knowledge and skills associated with quantitative literacy and which are needed for success in various Core courses other than those in an algebra-intensive pathway. The topics for this course are both mathematical and contextual: Numeracy; Proportional Reasoning; Algebraic Competence, Reasoning, and Modeling; Probabilistic Reasoning to Assess Risk; Quantitative reasoning in personal Finance; and Quantitative reasoning in civic life. 4 contact hours; 3 units. Prerequisite: not open to students completing MATH 105 or higher.

MATH 102 INTERMEDIATE ALGEBRA (3)
Intended primarily for students who will use algebraic skills in future mathematics courses. Topics include: factoring of polynomials, rational expressions and equations, graphs, relations and functions, radicals and exponents, and quadratic equations. Prerequisites: qualifying score on placement test or MATH 95 [DVMT 101] and consent of the department; not open to students completing MATH 115 or higher (except MATH 231 and MATH 237).

MATH 105 MATHEMATICAL IDEAS (3)
Basic concepts and ideas in mathematics are selected to explore the aesthetics and utility of mathematics. Topics are chosen from sets, counting methods, mathematical systems, basic rules of probability, statistics, logic, finance, geometry, numeration systems and modeling. Not counted toward or required for Early Childhood Education or Elementary Education majors. Not open to those who successfully completed MATH 103 or MATH 106. Prerequisite: Qualifying score on Math Placement exam or MATH 100. Core: Mathematics.

MATH 109 TRANSITION TO ALGEBRA FOR APPLICATIONS (3)
Intended primarily for students in business, economics, psychology and the social sciences. This course has 2 parts. Part 1 is DVMT 110 and Part 2 is MATH 111. Successful completion of Part 1 is required for entry into Part 2. Open only to students in the developmental math program. Not open to students who have completed DVMT 110 or MATH 111. Prerequisite: competency test score or DVMT 101. Core: Mathematics.

MATH 111 FINITE MATHEMATICS (3)
Intended primarily for students in business, economics, psychology, and the social sciences. Applications of finite mathematics: linear equations, matrices, linear programming using graphical and simplex methods, sets and counting, elementary probability, and difference equations. Not open to students who have successfully completed MATH 115 or MATH 119 or MATH 109. Prerequisite: Qualifying score on Math Placement exam or MATH 100. Core: Mathematics.

MATH 115 COLLEGE ALGEBRA (3)
Equations and the concept of function; linear, quadratic, higher-degree polynomial, exponential, logarithmic, and rational functions; complex numbers. Not open to those who have successfully completed MATH 119. Prerequisite: qualifying score on Math Placement exam or MATH 102. Core: Mathematics.

MATH 117 TRIGONOMETRY AND ADVANCED COLLEGE ALGEBRA (3)
The second semester in a two-semester precalculus sequence, with a primary focus on trigonometry. Angle measures; trigonometric functions and their graphs; trigonometric identities; inverse trigonometric functions and their graphs; algebraic and graphical solutions of trigonometric equations and basic trigonometric inequalities; solving triangles; linear systems in two and three variables with applications to partial fractions; conic sections. Students who successfully completed MATH 119 will not receive additional credit for MATH 117. Prerequisite: MATH 115.

MATH 119 PRE-CALCULUS (4)
An overview of functions and their graphs as well as algebraic techniques and trigonometry in preparation for Calculus I (MATH 273). Functions emphasized are polynomial, rational, exponential, logarithmic, and trigonometric. Prerequisite: qualifying score on Math Placement exam. Core: Mathematics.

MATH 204 MATHEMATICAL CONCEPTS AND STRUCTURES I (4)
Content knowledge for teaching elementary school mathematics. Problem solving, systems of numeration, development of number systems through rational numbers, arithmetic properties, operations, and algorithms, number theory, and the effective use of manipulative materials and educational technology. Prerequisite: qualifying score on Math Placement exam or MATH 100 or higher.

MATH 205 MATHEMATICAL CONCEPTS AND STRUCTURES II (4)
Content knowledge for teaching elementary school mathematics. Proportional reasoning, algebra, and statistics and data analysis with probability concepts through statistical investigations. Appropriate technology is integrated throughout. Prerequisite: MATH 204. Core: Mathematics.

MATH 211 CALCULUS FOR APPLICATIONS (3)
Intended primarily for students in biology, business, economics, psychology and the social sciences. Elements of differential and integral calculus from an intuitive standpoint with emphasis on the use of calculus in the above fields. Exponential and logarithmic functions, partial derivatives included. Not open to mathematics majors or minors. Prerequisite: qualifying score on the Math Placement Test or MATH 115 (recommended) or MATH 119. Core: Mathematics.
MATH 215 RATIONAL NUMBERS AND PROPORTIONAL REASONING FOR MIDDLE SCHOOL MATHEMATICS TEACHERS (4)
Will provide students with a thorough and rigorous treatment of concepts in rational number, ratio, and proportional reasoning – topics that form the foundation of the middle school mathematics curriculum. These topics will be investigated through a variety of models, representations, and contexts, as well as through solving non-routine problems. Prerequisites: MATH 119 or MATH 273 (MATH 273 may be taken concurrently) and department consent.

MATH 223 PEDAGOGICAL CONTENT KNOWLEDGE FOR MIDDLE SCHOOL MATHEMATICS (2)
Best practices for teaching in the middle grades; integrating effective elements of planning, instruction, questioning, and assessment. Content areas of focus include proportional reasoning, expressions and equations, functions. Prerequisites: SEMS 130 or both SEMS 110 and SEMS 120.

MATH 225 ALGEBRA AND NUMBER CONCEPTS FOR MIDDLE SCHOOL TEACHERS (4)
Will provide students with a thorough and rigorous treatment of the following topics in number theory and connections to algebra: factors and multiples; prime numbers and the Fundamental Theorem of Arithmetic; divisibility tests; integers; growing patterns; arithmetic and geometric sequences; functions (linear, quadratic, and exponential); expressions and equations; and additional connections between other branches of mathematics and algebra as time permits. These topics will be investigated through a variety of models, representations, and contexts, as well as through solving non-routine problems. Prerequisites: MATH 273 and department consent.

MATH 231 BASIC STATISTICS (3)
A non-calculus based introduction to statistics with emphasis on applications. Topics include categorical and quantitative data collection through sampling and experimental design, data description and displays, confidence intervals and hypothesis tests for one- and two-samples, and matched-pairs design; normal and t-distributions; correlation and simple linear regression. Emphasis on interpretations of results throughout. Substantial use of a computer package as a learning and computational tool. Prerequisite: qualifying score on Math Placement exam or MATH 100 (recommended) or MATH 102 or higher. Core: Mathematics.

MATH 233 HONORS BASIC STATISTICS (3)
A non-calculus based introduction to statistics with emphasis on applications. Topics include categorical and quantitative data collection through sampling and experimental design, data description and displays, confidence intervals and hypothesis tests for one- and two-samples, and matched-pairs design; normal and t-distributions; correlation and simple linear regression. Emphasis on interpretations of results throughout. Substantial use of a computer package as a learning and computational tool. Prerequisites: qualifying score on Math Placement exam, admission to Honors College and MATH 100, or MATH 102 or higher. Core: Mathematics.

MATH 236 PROBABILITY AND STATISTICS FOR MIDDLE SCHOOL TEACHER PREPARATION (1)
A supplement to Basic Statistics with content specific to the middle school mathematics curriculum. Topics include the display and analysis of data, conceptual meanings of measures of central tendency and variability, topics in probability, including theoretical approaches and experimental approaches via simulations. Graphing calculators and computer software are used extensively throughout the course. Prerequisite: MATH 231 (may be taken concurrently).

MATH 237 ELEMENTARY BIOSTATISTICS (4)
Elementary statistical concepts and their application to the biological and health sciences. Descriptive statistics, estimation techniques, hypothesis testing, analysis of enumerative data, one-way analysis of variance, and simple linear regression and correlation analysis. A statistical package such as MINITAB is introduced as a computational tool. Not open to students who have successfully completed MATH 231 or MATH 330 or to mathematics majors. Prerequisite: qualifying score on Math Placement exam or MATH 100 (recommended) or MATH 102 or higher (except MATH 204). Core: Mathematics.

MATH 251 ELEMENTS OF GEOMETRY (4)
Content knowledge for teaching elementary school mathematics. Geometric vocabulary, relationships, concepts and skills, including properties and classification of two- and three-dimensional shapes; transformations and symmetry; and measurement. Appropriate geometric tools and technology are integrated throughout. Prerequisite: MATH 204.

MATH 255 GEOMETRY FOR MIDDLE SCHOOL TEACHERS (4)
Content includes angle relationships, parallel lines, triangle congruence and similarity, quadrilaterals, circles, and area and perimeter of such figures. Also included is the pedagogy of using the van Hiele Model of Geometric Thought. Prerequisites: MATH 273 and department consent.

MATH 256 DISCRETE MATHEMATICS (3)
Sets, logic, induction, functions, relations, sequences, recursion, combinatorics, graphs and trees, matrices with an emphasis on applications in computer science. Prerequisite: COSC 236. Core: Mathematics.

MATH 257 INTRODUCTION TO ABSTRACT MATHEMATICS (4)
Sets, mappings, relations, logic, mathematical induction, properties of the integers, Fundamental Theorem of Arithmetic, polynomials, and elementary analytic concepts. Not open to those who successfully completed MATH 361 or MATH 463. Prerequisite: MATH 211 or MATH 273.

MATH 267 INTRODUCTION TO ABSTRACT MATHEMATICS (4)
Sets, mappings, relations, logic, mathematical induction, properties of the integers, Fundamental Theorem of Arithmetic, polynomials, and elementary analytic concepts. Not open to those who successfully completed MATH 361 or MATH 463. Prerequisites: MATH 273 and MATH 265 or consent of the instructor.

MATH 273 CALCULUS I (4)
Functions, limits, and continuity; differentiation of algebraic and trigonometric functions; mean value theorem; differentials; introduction to integration; applications. Four lecture hours and one laboratory hour per week. Prerequisite: qualifying score on Math Placement exam or MATH 117 or MATH 119. Core: Mathematics.
MATH 274 CALCULUS II (4)
Differentiation and integration of exponential, logarithmic, and inverse trigonometric functions; techniques of integration and applications; indeterminate forms; improper integrals; sequences and series of numbers; power series. Prerequisite: MATH 273. Core: Mathematics.

MATH 275 CALCULUS III (4)
Vectors in two and three dimensions, differential and integral calculus of functions of several variables. Four lecture hours and one laboratory hours per week. Prerequisite: MATH 274.

MATH 280 INDEPENDENT STUDY (1-4)
Supervised original work in mathematics. May be repeated for up to eight units. Prerequisite: consent of instructor.

MATH 283 HONORS CALCULUS I (4)
Functions, limits, and continuity; differentiation of algebraic and trigonometric functions; mean value theorem; differentials; introduction to integration; applications. Honors College course. Prerequisites: admission to Honors College and MATH 117 or MATH 119 or adequate score on placement test. Core: Mathematics.

MATH 284 HONORS CALCULUS II (4)
Differentiation and integration of exponential, logarithmic, and inverse trigonometric functions; techniques of integration and applications; indeterminate forms; improper integrals; sequences and series of numbers; power series. Students who have successfully completed the non-honors version of this course will not receive additional credit for this course. Prerequisites: Admission to Honors College and MATH 273 or Honors Calculus I. Topics will be covered in more depth and detail than in Calculus II. Several extended projects on related material will be given. Core: Mathematics.

MATH 293 HONORS SEMINAR IN MATHEMATICS (3)
A problem solving seminar designed for students who have shown talent in mathematics but have not yet been exposed to advanced mathematics courses. Techniques of problem solving and the solution of challenging problems involving elementary mathematics, such as probability, number theory, graph theory, and counting. Qualified students will usually take this course during their freshman or sophomore year. Students who have successfully completed the non-honors version of this course will not receive additional credit for this course. Prerequisite: Admission to Honors College and special permit only by Departmental Honors Committee. Core: Mathematics.

MATH 301 HISTORY OF MATHEMATICS (3)
Development of mathematics emphasizing mathematical concepts and contributions and individuals and societies. Major credit only toward Secondary Education concentration. Prerequisites: MATH 263 or MATH 265, and MATH 274.

MATH 305 CHANCE (3)
Role of chance in a variety of contemporary scientific, social, and ethical issues. No credit toward a mathematics major. Prerequisites: One college level mathematics course and one college level science course; junior standing or by permission.

MATH 310 FUNCTIONS AND MODELING FOR SECONDARY SCHOOL TEACHERS (3)
Engagement in explorations of mathematics to broaden and deepen content knowledge, emphasizing concepts needed to teach secondary mathematics at various levels. Investigations into mathematical topics including regressions in modeling; functions, rates, and patterns; and functions in other systems, with an emphasis on written communication about mathematical ideas and models. Prerequisites: ENGL 102 or ENGL 190 or equivalent; MATH 273, MATH 274, and MATH 265; either SEMS 230 or SCED 305 (may be taken concurrently); MATH 267 is recommended. Core: Advanced Writing Seminar.

MATH 312 THEORY OF INTEREST (4)
Covers the mathematical theory and applications of key financial management concepts and procedures including money growth, force of interest, annuities, perpetuities, amortization, stocks, bonds, yield approximation approaches, term structure of interest rates, swaps, determinants of interest, duration, convexity, and asset matching. Prerequisite: MATH 274.

MATH 314 INTRODUCTION TO CRYPTOGRAPHY (3)
A broad introduction to cryptography and its mathematical foundations: Elementary number theory; classical and modern symmetric key cryptosystems; public key cryptography; primality tests, factoring algorithms; hash functions and digital signatures. Selected further topics may include security protocols, digital cash, elliptic curve cryptography, or quantum cryptography. Prerequisites: COSC 236; either MATH 263 or MATH 267; and either MATH 330 or MATH 331 (may be taken concurrently).

MATH 315 APPLIED COMBINATORICS (4)
General counting methods, pigeonhole principle, inclusion-exclusion principle, generating functions, recurrence relations, summation techniques, partitions, permutations and pattern avoidance, Polya's enumeration, asymptotics, select topics from graph theory. Prerequisites: MATH 274; MATH 263 or MATH 267.

MATH 320 TEACHING ADVANCED PLACEMENT CALCULUS FOR PRESERVICE TEACHERS (3)
Integration of mathematical knowledge and pedagogical techniques to successfully teach Advanced Placement Calculus at the secondary level. Prerequisites: MATH 273 and MATH 274.

MATH 321 TEACHING MATHEMATICS IN EARLY CHILDHOOD EDUCATION (3)
Analysis of pedagogical methods and materials in early childhood mathematics instruction and assessment. Mathematics topics include, but are not limited to, those taught in grades PreK - 3. Prerequisites: MATH 204, MATH 205, and MATH 251, or their equivalents.

MATH 322 TEACHING MATHEMATICS IN ELEMENTARY SCHOOL (3)
Analysis of pedagogical methods and materials in elementary school mathematics instruction and assessment. Mathematics topics include, but are not limited to, those taught in grades 1 - 6. Corequisite: MATH 324. Prerequisites: MATH 204, MATH 205, and MATH 251, or their equivalents.
MATH 324 SUPERVISED OBSERVATION/PARTICIPATION IN ELEMENTARY SCHOOL MATHEMATICS (2)
Application of pedagogy and methodology for developing and conducting classroom activities in mathematical concepts and skills during a weekly field experience at a local elementary school. Graded S/U. Corequisite: MATH 323.

MATH 325 MATHEMATICAL PROBLEM SOLVING FOR MIDDLE SCHOOL TEACHERS (3)
A problem solving seminar designed for students who have not yet been exposed to advanced mathematics courses. Problems solving strategies will be applied to a variety of challenging problems, related to topics from middle and high school mathematics curricula. An important focus of the course is oral and written justifications of solutions. No credit toward a Mathematics major or minor. Prerequisites: MATH 273 and one from MATH 215, MATH 225, MATH 235, or MATH 255; department consent required.

MATH 330 INTRODUCTION TO STATISTICAL METHODS (4)
An introductory course for students with mathematics and computing backgrounds emphasizing statistical ideas and techniques. Descriptive statistics, probability, estimation and sampling, hypothesis testing, regression and correlation, and analysis of variance. A statistical package such as MINITAB is introduced as a computational tool. Prerequisite: MATH 274.

MATH 331 PROBABILITY (4)
Probability in sample spaces, discrete and continuous random variables, distribution theory. Chebyshev's Theorem, Central Limit Theorem, expected values and moments. Prerequisite: MATH 275 (may be taken concurrently).

MATH 332 MATHEMATICAL STATISTICS (3)
Sample theory and distributions, point estimation, confidence intervals, tests of hypothesis, and theory of statistical inference. Prerequisite: Math 331 (MATH 531).

MATH 337 APPLIED REGRESSION AND TIME SERIES PREDICTIVE MODELING (4)
Simple and multiple regression, least squares estimates, hypothesis testing, confidence intervals and prediction intervals, model building methods and diagnostic checking. Non-seasonal time series models: autoregressive, moving-average and/or autoregressive integrated moving-average models, parameter estimation and forecasting. Minitab or a similar software is used for real data analysis. Prerequisites: MATH 265 or equivalent and MATH 332/ MATH 532 or equivalent.

MATH 339 BIOSTATISTICS II (3)
Probability and random variables, estimation and hypothesis testing, nonparametric methods, categorical data analysis, multiple regression, analysis of variance, and design techniques for epidemiological study. Minitab or a similar software will be used for data analysis. Prerequisites: MATH 237 Elementary Biostatistics or equivalent and MATH 273 Calculus I or equivalent.

MATH 353 EUCLIDEAN AND NON-EUCLIDEAN GEOMETRIES (3)
Review of synthetic Euclidean geometry, non Euclidean geometries, finite geometries and systems of axioms, classical theorems and elementary transformations. Prerequisites: MATH 265, MATH 273, and one of the following: MATH 251, MATH 263, or MATH 267.

MATH 369 INTRODUCTION TO ABSTRACT ALGEBRA (4)
Elementary number theory; congruences, groups up to and including the isomorphism theorems, commutative rings, polynomials, unique factorization, irreducibility, finite fields. Prerequisites: MATH 265, MATH 267, and MATH 274.

MATH 372 REAL ANALYSIS I (4)
An introduction to the real numbers and the analytic properties of real-valued sequences and functions. The set of real numbers; sequences and series; continuous functions and uniform continuity; differentiation; Riemann integration. Prerequisites: MATH 267 and MATH 275.

MATH 374 DIFFERENTIAL EQUATIONS (3)
Theory and application of linear ordinary differential equations: homogeneous and nonhomogeneous linear equations, initial and boundary value problems, exact equations, variation of parameters, Euler equations; solutions of non-linear ordinary differential equations of the first order and second order; power series solutions; system of linear equations. Prerequisite: MATH 274.

MATH 377 MATHEMATICAL MODELS (3)
Developing appropriate mathematical models and techniques to solve mathematical problems in sociology, psychology, economics, management science, and ecology. Prerequisites: MATH 265, MATH 274, COSC 236 and at least junior standing.

MATH 378 EXPERIMENTAL MATHEMATICS (3)
A course-based introduction to undergraduate research and mathematical exploration through computational experimentation. Programming, computational methods, algorithms, and software environments used by research mathematicians. Students will apply these tools to explore patterns and make conjectures and explore the role of computation in formal mathematical proofs. Possible topics include: combinatorics, number theory, numerical analysis, modeling and visualization, fractals, computer-assisted proofs and graph theory. Prerequisites: COSC 236, MATH 265, MATH 274 and either MATH 263 or MATH 267 (or by permission of the instructor).

MATH 379 FOURIER ANALYSIS WITH APPLICATIONS (3)
Fourier series, orthogonal functions, partial differential equations, and boundary value problems. The Fourier integral and applications. Prerequisites: MATH 267 and MATH 275.

MATH 397 INTERNSHIP IN MATHEMATICS (3)
Students will be assigned to work on a mathematics project for a local business or industry under the direction of the industry supervisor and a member of the mathematics faculty. May be repeated for a maximum of 6 units. No credit toward a mathematics major or minor. Prerequisites: junior standing and 6 units, of upper-division mathematics courses. Graded S/U.

MATH 420 APPLICATIONS OF TECHNOLOGY FOR SECONDARY SCHOOL TEACHERS (3)
Utilization of instructional technology to teach mathematics for conceptual understanding, with topics from the areas of algebra, geometry, trigonometry, and calculus. Specific technologies for study will be chosen based on current use in school settings, and may include calculators, computers, mathematics software and apps, and digital fabrication tools or other makerspace technology. Prerequisites: MATH 330 and MATH 353.
MATH 423 TEACHING MATHEMATICS IN THE SECONDARY SCHOOLS (3)
Best practices for teaching mathematics at the secondary level; analysis and application of methods for planning, conducting, and reflecting on mathematics instruction and assessment. Prerequisites: MATH 353 (may be taken concurrently) and concurrent enrollment in SEMS 498, or permission of instructor.

MATH 424 SCHOOL-BASED METHODS FOR MIDDLE SCHOOL MATHEMATICS TEACHING (2)
Application of methodology for developing and conducting classroom activities in mathematical concepts and skills relevant at the middle school level of instruction. No credit toward a Mathematics major or minor. Graded S/U. Corequisite: MATH 425.

MATH 425 MATHEMATICS TEACHING IN THE MIDDLE SCHOOL (3)
Best practices for delivery and assessment of mathematical concepts and skills relevant to the middle school level of instruction. No credit toward a Mathematics major or minor. Prerequisites: MATH 215, MATH 225, MATH 235, MATH 255, and MATH 325; department consent required.

MATH 426 INTERNSHIP IN SECONDARY EDUCATION - MATHEMATICS (6-12)
Field experience in public school classrooms under the guidance of master teachers and a university supervisor. Graded S/U. Prerequisites: MATH 423, SEMS 498, and permission of Mathematics Department and Towson UTeach. Internship/Practicum fee will be assessed.

MATH 429 READINGS IN MATHEMATICS EDUCATION FOR THE SECONDARY SCHOOL TEACHER (1-3)
Directed study for the teacher of secondary school mathematics. No credit toward mathematics major. Prerequisite: consent of instructor.

MATH 430 SEMINAR IN INTERNSHIP (1)
Seminar for current student interns to discuss topics from the classroom experience and current issues. Prerequisites: MATH 423 or SEMS 370; and current with MATH 426.

MATH 435 NUMERICAL ANALYSIS I (3)
Error analysis, interpolation, numerical differentiation and integration, numerical solution of algebraic equations, direct and iterative techniques for solving linear systems of algebraic equations. Mathematical and comparable computer algebra systems will be used. Prerequisites: MATH 265, MATH 274, and COSC 236.

MATH 437 OPERATIONS RESEARCH (3)
Introduction to linear, integer and nonlinear programming, the simplex method and interior point methods, duality and sensitivity analysis; formulation of optimization models and applications to problems from industry. Prerequisites: MATH 265 and MATH 331.

MATH 438 LONG-TERM ACTUARIAL MODELS I (4)
A second course on the mathematical theory and applications of long-term actuarial models. Topics include multiple state models, multiple decrements, multiple life functions, pension plans and funding, retirement benefits, long-term health and disability, profit and loss analysis, mortality data analysis. Prerequisite: MATH 438.

MATH 439 COMPUTATIONAL PROBABILITY MODELS (3)
Markov chains, exponential distribution, Poisson process, continuous time Markov chains, Brownian motion and stationary processes. Prerequisite: MATH 331.

MATH 442 SHORT-TERM ACTUARIAL MODELS (4)
Topics from the syllabus of the Short-Term Actuarial Mathematics exam offered by the Society of Actuaries including severity models, frequency models, aggregate models, risk measures, construction and selection of parametric models, insurance and reinsurance coverages, and pricing and reserving for short-term insurance coverage. Prerequisites: MATH 332 or equivalent; and passing the Actuarial Exam P (or department permission).

MATH 444 LONG-TERM ACTUARIAL MODELS II (3)
A second course in the mathematical theory and applications of long-term actuarial models. Topics include multiple state models, multiple decrements, multiple life functions, pension plans and funding, retirement benefits, long-term health and disability, profit and loss analysis, mortality data analysis. Prerequisite: MATH 438.

MATH 445 GRAPH THEORY (3)
Hamiltonian and Eulerian graphs, coloring graphs, planar and non-planar graphs, connectivity problems; isomorphic graphs, and advanced topics. Prerequisite: MATH 263 or MATH 267.

MATH 447 DIFFERENTIAL GEOMETRY (3)
Curvatures of curves and surfaces in three dimensional Euclidean space, geodesics, invariants, mappings, and special surfaces. Prerequisite: MATH 275 and MATH 265.

MATH 463 LINEAR ALGEBRA (3)
Vector spaces over arbitrary fields, linear transformations, eigenvalues, eigenvectors, inner products, bilinear forms, direct sum decompositions and the Jordan form. Prerequisites: MATH 265 and MATH 267.

MATH 465 NUMBER THEORY (3)
An introduction to elementary number theory: prime numbers, prime factorization, modular arithmetic, arithmetic functions, primitive roots, and quadratic residues. Additional topics may include: elliptic curves, Diophantine equations, sums of squares, the distribution of primes, and applications. Prerequisites: MATH 263 or MATH 267; and MATH 274.

MATH 467 ALGEBRAIC STRUCTURES (3)
Topics include groups, solvability, and insolvability of polynomials, principal ideal, Euclidean, and unique factorization domains. Prerequisite: MATH 369.

MATH 472 REAL ANALYSIS II (3)
A second course in real analysis. Sequences of functions and uniform convergence; Metric spaces, including completeness and compactness. Functions of several variables including derivatives and differentiability, multivariable integrals and Fubini’s theorem, null sets and Riemann integrability. Prerequisite: MATH 372 or MATH 473.

MATH 473 INTRODUCTORY REAL ANALYSIS (4)
An introduction to mathematical analysis. Sequences, series, continuity, differentiation, integration and uniform convergence. Prerequisites: MATH 267 and MATH 275.

MATH 475 COMPLEX ANALYSIS (3)
Complex number system, analytic functions, Cauchy’s integral theorem and integral formula, Taylor and Laurent series, isolated singularities, Cauchy’s residue theorem and applications. Prerequisites: MATH 267 and MATH 275.
MATH 477 TOPOLOGY (3)
Basic concepts of point set topology, separation axioms, compact and connected spaces, product and quotient spaces, convergence, continuity and homeomorphisms. Prerequisites: MATH 267 and MATH 275.

MATH 480 SELECTED TOPICS IN MATHEMATICS (1-4)
Topics will be chosen from different areas in mathematics and statistics. Content will be determined so as to complement course offerings as well as the needs and desires of students. May be repeated for a maximum of 9 units, provided a different topic is covered.

MATH 485 MATHEMATICAL FINANCE (3)
Mathematical theory, computation and practical applications of financial derivatives in managing financial risk. Parity and option relationships, binomial option pricing, the Black-Scholes equation and formula, option Greeks, market-making and delta-hedging, exotic options, lognormal distribution, Brownian motion and Ito's lemma, interest rate models. Computer laboratory activities throughout. Prerequisite: MATH 331.

MATH 486 RISK MANAGEMENT AND FINANCIAL ENGINEERING (3)
Mean-variance portfolio theory, assets pricing models, market efficiency and behavioral finance, investment risk and project analysis, capital structures, Cash flow engineering, Monte Carlo methods, statistical analysis of simulated data, risk measures, framework for fixed income engineering, portfolio management, change of measures and Girsanov Theorem and tools for volatility engineering. Computer laboratory activities throughout. Prerequisite: MATH 485.

MATH 490 SENIOR SEMINAR IN MATHEMATICS (3)
Selected mathematical topics and their applications. Prerequisites: senior standing and a grade of C or better in MATH 331 and MATH 369; or permission of instructor.

MATH 491 READINGS IN MATHEMATICS (1-3)
Independent reading in selected areas of mathematics. May be repeated for a maximum of 6 units. Prerequisites: consent of instructor and senior status.

MATH 492 RESEARCH IN MATHEMATICS (1-3)
Supervised original work in pure or applied mathematics. Formal written report required. May be repeated for 6 units. Prerequisite: consent of instructor. Graded S/U.

MATH 493 READINGS IN MATH EDUCATION (1-3)
An introduction to the theory and methodology of mathematics education research, including quantitative and qualitative designs. Students will gain experience in reading and interpreting mathematics education research, with a specific focus on applying research findings to classroom practice. Prerequisites: consent of instructor and senior status.

MATH 494 INDEPENDENT STUDY: RESEARCH IN MATHEMATICS EDUCATION (1-3)
Supervised original work in mathematics education. May be repeated once for up to six units. Prerequisite: consent of instructor. Graded S/U.

MATH 495 APPLIED MATHEMATICS LABORATORY I (3)
Investigation by a team of students under faculty direction of a problem of computational nature, chosen from proposals submitted by clients in the university or local industry. Prerequisites: 9 units of mathematics and/or computer science, at least junior standing, and consent of instructor.

MATH 496 APPLIED MATHEMATICS LABORATORY II (3)
Investigation by a team of students under faculty direction of a problem of mathematical and/or computational nature, chosen from proposals submitted by clients in the university or local industry. Team involvement may include literature searches, model definition, collection and analysis of data, and model verification. Restricted to invited students. Prerequisites: 9 units of mathematics and/or computer science, at least junior standing, and consent of instructor.

MATH 498 SENIOR SEMINAR: ACTUARIAL SCIENCE AND RISK MANAGEMENT (3)
Integration of mathematical and financial knowledge in the field of Actuarial Science and Risk Management. Prerequisites: MATH 438; must have attempted two Society of Actuaries exams and passed at least one Society of Actuaries exam.

MATH 499 HONORS THESIS IN MATHEMATICS (1)
Writing an honors thesis based on research in a two-course independent research sequence under the supervision of a thesis advisor and the presentation of an oral thesis defense open to the public. Graded S/U. Prerequisites: consent of department and senior standing.