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:

• A major in Mathematics, in which there are four concentrations
• A minor in Mathematics, designed to enhance major programs to which mathematics is readily applied
• Two combined major programs, offered in conjunction with the Department of Computer and Information Sciences

Major in Mathematics
The Mathematics major has four areas of concentration from which to choose:

• The Mathematics Secondary Education Concentration, offered in conjunction with Towson UTeach (http://www.towson.edu/fcsm/departments/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.

Second Major Programs
Students may declare a second major and obtain a degree certifying that both majors have been completed. The Department of Mathematics encourages majors to pursue a second major or a minor in subjects in which mathematics is applied. In cooperation with the Department of Computer and Information Sciences, the following courses of study have been developed:

• The combined major in Mathematics and Computer Science
• The combined major in Mathematics and Computer Science with the Security Track

Departmental Policies
NOTES FOR MAJORS AND MINORS
Mathematics majors with minors in Economics may satisfy their Applications requirement by completing ECON 451.

Mathematics majors or minors who receive a grade equivalent of 1.00 in a 100-level course prerequisite to calculus must repeat the course no later than concurrently with calculus. Mathematics majors or minors must attain a grade equivalent of 2.00 or higher in any 200-, 300-, or 400-level course used as a prerequisite or applied toward a major or minor. Unless otherwise noted, prerequisites must be satisfied prior to taking a course. The program of the minor should be approved by students’ department advisers.

CORE CURRICULUM REQUIREMENTS IN MATHEMATICS
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 www.towson.edu/core. 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 Academic Achievement Center (http://catalog.towson.edu/undergraduate/academic-resources/academic-achievement-center) or the Mathematics Department Placement Testing Information (https://www.towson.edu/fcsm/departments/mathematics/resources/placement) for additional information and resources.

COURSE PREREQUISITES
The department strictly enforces prerequisites for all mathematics courses.

POLICY ON AP MATHEMATICS CREDIT

TRANSFER CREDIT POLICIES
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 that a new course be completed.

Secondary Education Mathematics majors are required to take MATH 423, MATH 426, MATH 428, and at least four additional upper-level courses in their Mathematics major program at Towson University.

All other Mathematics majors are required to take MATH 490 and at least six additional upper-level courses of their Mathematics major program at Towson University.
Mathematics minors must take at least four courses of their Mathematics minor program at Towson University; at least two courses must be upper-level.

**Majors in Mathematics**
- Major in Mathematics with concentrations in:
  - Pure Mathematics (http://catalog.towson.edu/undergraduate/fisher-science-mathematics/mathematics/pure-mathematics)
  - Applied Mathematics (http://catalog.towson.edu/undergraduate/fisher-science-mathematics/mathematics/applied-mathematics)
- Second Major Programs:
  - Combined Major in Mathematics and Computer Science (http://catalog.towson.edu/undergraduate/fisher-science-mathematics/computer-information-sciences/combined-computer-science-mathematics)

**Minors in Mathematics**

**Courses**

**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 DVMT 101 and consent of the department; not open to students completing MATH 115 or higher.

**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 nor 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. GenEd I.C. or 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. GenEd I.C. or 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. GenEd I.C. or 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 or GenEd I.C.

**MATH 119 PRE-CALCULUS (4)**
The concept of function, exponential, logarithmic, circular and trigonometric functions, systems of linear equations, vectors in two space, lines, conic sections and polar coordinates. Prerequisite: qualifying score on Math Placement exam or MATH 102. GenEd I.C. or Core: Mathematics.

**MATH 204 MATHEMATICAL CONCEPTS AND STRUCTURES I (4)**
Problem solving, sets, systems of numeration, development of numeration system through rational numbers, arithmetic operations and algorithms, number theory and use of appropriate technology. Required of all Early Childhood and Elementary Education majors. Prerequisite: qualifying score on Math Placement exam or MATH 100.

**MATH 205 MATHEMATICAL CONCEPTS & STRUCTURES II (4)**
This is the second of three mathematics courses that provide the mathematics content knowledge for prospective elementary school teachers through a conceptually-based approach to teaching. This course covers proportional reasoning, algebra, and statistics and data analysis with probability concepts through statistical investigations. Appropriate technology is integrated throughout. Required of all Early Childhood and Elementary Education Majors. Prerequisite: MATH 204. Core: Mathematics or GenEd I.C.

**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 or GenEd I.C.
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 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 230 TECHNOLOGY FOR INTRODUCTORY STATISTICS (1)
A statistical package will be used to complete computer lab assignments on data manipulation, descriptive statistics, one and two sample inference and linear regression. Intended only for students who transfer a basic statistics course without a computer lab component. Prerequisite: beginning statistics course without a computer component. Graded S/U.

MATH 231 BASIC STATISTICS (3)
Frequency distributions and graphical methods, percentiles, measures of central tendency and variability, probability emphasizing binomial and normal distributions, sampling distributions, point and interval estimation, one and two sample hypothesis tests, simple linear regression. MINITAB or an equivalent computer package is introduced as a computational tool. Practical applications of statistics. Prerequisite: qualifying score on Math Placement exam or MATH 100 (recommended) or MATH 102 or higher (except MATH 204). GenEd I.C. or Core: Mathematics. Lab/Class fee will be assessed.

MATH 233 HONORS BASIC STATISTICS (3)
Frequency distributions and graphical methods, percentiles, measures of central tendency and variability, probability, emphasizing binomial and normal distributions, sampling distributions, point and interval estimation, one and two sample hypothesis tests, simple linear regression. MINITAB or an equivalent computer package is introduced as a computational tool. Practical applications of statistics. Prerequisite: Admission to Honors College and MATH 111 or MATH 115 or equivalent. GenEd I.C or Core: Mathematics. Lab/Class fee will be assessed.

MATH 235 STATISTICS AND PROBABILITY FOR THE MIDDLE SCHOOL TEACHER (4)
Topics from data analysis, probability, and inferential statistics, including recent methodologies and standards for the middle school level. The course integrates activities using the graphing calculator and an inquiry-based computer learning environment. Prerequisite: Two years of high school algebra or MATH 102 or MATH 109 or permission of the Mathematics Department.

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). GenEd I.C. or Core: Mathematics. Lab/Class fee will be assessed.

MATH 251 ELEMENTS OF GEOMETRY (4)
Geometric vocabulary, relationships, concepts and skills in two and three dimensions using techniques of synthetic, coordinate and transformational geometries, measurement, and use of appropriate technology. (Required of all Early Childhood and Elementary Education majors.) Not open to Mathematics majors. 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: One year of high school geometry and (two years of high school algebra or MATH 102 or MATH 109 or MATH 225) or permission of the Mathematics Department.

MATH 256 GEOMETRIC PROOF AND DEDUCTION FOR MIDDLE SCHOOL TEACHER (1)
Provides additional information in both content and pedagogy to students who have successfully completed MATH 251 and wish to replace the required course of MATH 255. Focuses on the van Hiele Model for Geometric Thought, an introduction to logical reasoning through inductive and deductive methods, and geometric proofs. Not open to students who have successfully taken MATH 255. Prerequisite: MATH 251.

MATH 263 DISCRETE MATHEMATICS (3)
Sets, logic, induction, functions, relations, sequences, recursion, combinatorics, graphs and trees, matrices with an emphasis on applications in computer science. Prerequisite: four years of high school mathematics or MATH 119. GenEd I.C. or Core: Mathematics.

MATH 265 ELEMENTARY LINEAR ALGEBRA (4)
Matrix calculations and determinants, vector spaces over the real numbers, linear transformations, eigenvalues, eigenvectors, and inner products with emphasis on applications. Not open to students who successfully completed MATH 365 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 467. 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 119. GenEd I.C. or Core: Mathematics. Lab/Class fee will be assessed.
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. GenEd I.C. or Core: Mathematics. Lab/Class fee will be assessed.

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. GenEd I.C. Lab/Class fee will be assessed.

MATH 283 HONORS CALCULUS I (4)
Functions, limits, and continuity; differentiation of algebraic and trigonometric functions; mean value theorem; differentials; introduction to integration; applications. Prerequisite: Admission to Honors College and MATH 119 or calculus course in high school or adequate score on placement test. GenEd I.C. or 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. Prerequisite: 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. GenEd. I.C. or 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. Prerequisite: Admission to Honors College and special permit only by Departmental Honors Committee. Core: Mathematics or GenEd I.C.

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)
The 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. GenEd II.A.

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. Consists of three instructional units: (1) regressions in modeling; (2) functions, rates, and patterns; (3) functions in other systems. Intended for students pursuing certification in secondary mathematics education. Prerequisites: MATH 273, MATH 274, and MATH 265; MATH 267 is recommended.

MATH 312 THEORY OF INTEREST (4)
Mathematical theory and applications of key financial management concepts and procedures including term structure of interest rates; force of interest; interest rate sensitivity; annuity; perpetuity; amortization; stocks; bonds. Mathematical theory of modern financial economics and analysis; at an introductory level, involving basic derivative contracts (forwards, futures, options, swaps). Prerequisite: MATH 274.

MATH 314 INTRODUCTION TO CRYPTOGRAPHY (3)
A broad introduction to cryptography and its mathematical foundations. The course will also cover applications to computer-network security services and mechanisms (confidentiality, integrity, authentication, electronic cash, and others), and to various protocols in distributed computation. Prerequisites: COSC 236, and either MATH 263 or MATH 267, and junior standing or permission of instructor.

MATH 315 APPLIED COMBINATORICS (3)
General counting methods, pigeon-hole principle, generating functions, partitions, recurrence relations, inclusion-exclusion principle, Polyá’s enumeration, introduction to graph theory. Prerequisite: MATH 263 or MATH 265 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)
Materials of instruction and methods of presentation with emphasis on the discovery approach. No credit toward a mathematics major or minor. Prerequisites: MATH 204 and MATH 205.

MATH 322 TEACHING MATHEMATICS IN ELEMENTARY SCHOOL (3)
Nature of instruction, organization of units of instruction, provisions for developing understandings, new programs and research findings, and techniques and evaluation. Required of all Elementary Education majors. No credit toward a mathematics major or minor. Prerequisites: MATH 204 (or MATH 206), MATH 205 (or MATH 207), and MATH 251.

MATH 324 SUPERVISED OBSERVATION/PARTICIPATION IN ELEMENTARY SCHOOL MATHEMATICS (2)
Application of methodology for developing and conducting classroom activities in mathematical concepts and skills at local elementary school(s). Corequisite: MATH 323. Graded S/U.

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 225, MATH 235 (or MATH 205), MATH 255 (or MATH 251 and MATH 256).

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 (531).

MATH 337 APPLIED REGRESSION AND TIME SERIES ANALYSIS (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. Prerequisite: MATH 267 or all three of the following: MATH 251, MATH 273, and MATH 265.

MATH 369 INTRODUCTION TO ABSTRACT ALGEBRA (4)
Elementary number theory; congruencies, 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 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: MATH265, MATH 274, COSC 236 and at least junior standing.

MATH 378 SCIENTIFIC MODELING AND SIMULATION (3)
Interdisciplinary introduction to scientific simulation. Mathematical modeling, numerical analysis, and object oriented computer programming. Not open to students who have successfully completed COSC 378. Prerequisites: MATH 274 and COSC 236.

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

MATH 390 INTRODUCTION TO ACTUARIAL MATHEMATICS (3)
Introduction to actuarial science, insurance, and risk management. Problem-oriented review of fundamental probability tools for quantitatively assessing risk. The application of these tools to problems encountered in actuarial science, insurance, and risk management is emphasized. Prerequisites: MATH 265 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)
Use of technology in teaching mathematics that includes, but is not limited to, graphing calculators and their accessories, the Geometer's Sketchpad, the CBL and CBR, the Internet, Fathom, and the Equation Editor or Math Type. Utilization of the instructional technology with topics from the areas of algebra, geometry, trigonometry, and calculus. 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 225, MATH 235, MATH 255, MATH 325 (or consent of instructor).

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

MATH 428 SENIOR SEMINAR MATHEMATICS EDUCATION (2)
Integration of mathematical knowledge and pedagogical issues in secondary schools. Prerequisites: senior standing and MATH 423 (may be taken concurrently).

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 436 NUMERICAL ANALYSIS II (3)
Numerical solution of differential equations. Least squares and its applications, linear programming and extension of the concepts of MATH 435. Mathematical and comparable computer algebra systems will be used. (Offered only in the spring semester.) Prerequisite: MATH 435.

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 ACTUARIAL MODELS (3)
Theory of actuarial models and the application of the models to insurance and other financial risks. Survival models, life table, contingent payment models, contingent annuity models, funding plans of contingent contracts, contingent contract reserves, models dependent on multiple survivals, multiple contingencies with applications. Prerequisite: MATH 312 and MATH 331.

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 ACTUARIAL MODEL CONSTRUCTION (4)
Introduction to modeling in actuarial mathematics. Construction of frequency-severity models with coverage modifications, aggregate loss models, and discrete-time ruin models. Construction of empirical models using estimators and parametric methods. Introduction to credibility theory. Prerequisite: MATH 432 or equivalent.

MATH 448 ADVANCED ACTUARIAL MODELS (3)
Benefit reserves for traditional life insurances and annuities; multiple state models and multiple life functions, premiums and reserves based on these models; multiple decrement models and probabilities; models for cash flow of basic universal life insurance. Prerequisite: MATH 438.

MATH 451 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 457 ALGEBRAIC STRUCTURES (3)
Topics include groups, solvability, and insolvability of polynomials, principal ideal, Euclidean, and unique factorization domains. Prerequisite: MATH 369.

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. Prerequisite: 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. MATH 480 may not be counted towards a Mathematics major. 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)
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 494 INDEPENDENT STUDY: RESEARCH IN MATHEMATICS
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 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 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.