MATHEMATICS EDUCATION M.S.

Degree: Master of Science
https://www.towson.edu/fcsm/departments/mathematics/grad/education/

Program Director: Dr. Sandy Spitzer
Phone: 410-704-2062
Email: spitzer@towson.edu

The Master of Science in Mathematics Education program at Towson University provides mathematics teachers with advanced study in mathematics, mathematics education and general education. The program offers teachers additional experience in higher-level mathematics to enhance their teaching with additional depth and breadth of content. At the same time, it strengthens their backgrounds in the school mathematics curriculum, instructional practices, assessment and technology. It also provides them a relevant way of satisfying their in-service requirements for professional advancement.

The program offers two tracks: Secondary School and Middle School. Both tracks require students to take four courses in Mathematics Education (with a focus on pedagogy, integration of technology, and the context of school mathematics), three general education electives, and five mathematics content courses. The two tracks differ primarily in the content focus and level of the mathematics courses. The program was designed with on-the-job teachers in mind, with part-time studies in the evenings and summers available; however, full-time students are also welcome.

Secondary School Track
The Secondary School Track is aimed at current secondary mathematics teachers. Students in this track take mathematics courses to extend their knowledge beyond a bachelor’s degree in secondary mathematics, giving them access to powerful mathematics ideas to take into the classroom.

It is expected that graduates of this program will become leaders in mathematics education as master teachers, curriculum developers, mathematics supervisors and other positions that improve the teaching of mathematics in secondary schools. The special strength of this program is the opportunity to study higher mathematics content without leaving the field of school mathematics.

Middle School Track
The Middle School Track is designed to target current and future middle school mathematics teachers who are elementary or middle school certified. Students in this program will broaden and deepen their mathematical content knowledge through courses that target the conceptual ideas of middle school mathematics and beyond.

It is expected that graduates of this program will become leaders in mathematics education in positions that improve the teaching of mathematics in middle schools. The particular benefit of this track is the opportunity to learn mathematics concepts and skills that are meaningful and applicable for classroom teachers in grades 3-8. Professors will model best practices in instructional techniques to enhance students’ learning of both mathematics and pedagogical skills.

Admission Requirements
Applicants must meet the general requirements for graduate study outlined in this catalog. The applicant must possess current certification for teaching secondary school mathematics (Secondary School Track) or teaching elementary school (Middle School Track). In some circumstances, as determined by the program director, two years of recent, documented, full-time teaching experience may replace the certification requirement. For the Secondary School Track, the applicant should have an undergraduate degree (or MAT) in mathematics with a secondary education concentration or the equivalent, from a regionally accredited college or university**, with a minimum undergraduate GPA of 3.00 for full admission and 2.75 for conditional admission. For the Middle School Track, the applicant should have an undergraduate degree in elementary education or the equivalent from a regionally accredited college or university**, with a minimum undergraduate GPA of 3.00 for full admission and 2.75 for conditional admission. All GPA calculations for admission are based upon the last 60 units of undergraduate and post-baccalaureate study.

Non-immigrant International Students
Program Enrollment: F-1 and J-1 students are required to be enrolled full-time. The majority of their classes must be in-person and on campus. See the list of programs that satisfy these requirements (https://www.towson.edu/academics/graduate/admissions/international/programs-complying-j1-f1-regulations.html), and contact the International Student and Scholars Office (https://www.towson.edu/academics/international/isso) with questions.

Admission Procedures: See additional information regarding Graduate Admission policies (https://www.towson.edu/academics/graduate/admissions/policies.html) and International Graduate Application (https://www.towson.edu/academics/graduate/admissions/international) online.

**See Exceptions to Policy in Graduate Admissions (https://www.towson.edu/academics/graduate/admissions/policies.html).

Degree Requirements
The student is required to successfully complete a total of at least 36 units of course work (with no more than 9 units below the 600 level), as outlined below.

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**Section C: Mathematics Foundation**

Students complete five courses, one course from each of 15 category and one additional course from any category:

**Algebra**

- MATH 563  LINEAR ALGEBRA
- MATH 565  THEORY OF NUMBERS
- MATH 568  ALGEBRAIC STRUCTURES
- MATH 667  ALGEBRA OF SYMMETRIES

**Analysis**

- MATH 535  NUMERICAL ANALYSIS I
- MATH 576  INTRODUCTORY REAL ANALYSIS
  or MATH 628  REAL ANALYSIS FOR TEACHERS
- MATH 577  COMPLEX ANALYSIS
- MATH 578  TOPOLOGY
- MATH 579  FOURIER ANALYSIS WITH APPLICATIONS

**Geometry**

- MATH 557  DIFFERENTIAL GEOMETRY
- MATH 650  PATTERNS IN MATHEMATICAL DESIGNS
- MATH 653  TOPICS IN GEOMETRY
- MATH 671  CHAOTIC DYNAMICS AND FRACTAL GEOMETRY

**Statistics/Probability**

- MATH 531  PROBABILITY
- MATH 532  MATHEMATICAL STATISTICS
- MATH 630  STATISTICS-AN INTEGRATED APPROACH
- MATH 651  MATHEMATICS OF FUZZY LOGIC

**Section D: Mathematics Methods**

- MATH 625  SEMINAR IN MATHEMATICS EDUCATION FOR SECONDARY SCHOOL TEACHERS 3

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**Section C: Mathematics Foundation**

- MTED 611  ALGEBRA IN THE SCHOOL CURRICULUM 3
- MTED 613  MATHEMATICAL MODELING FOR MIDDLE SCHOOL TEACHERS 3

Students complete three courses, one from each category: 9

**Analysis**

- MATH 535  NUMERICAL ANALYSIS I
- MATH 576  INTRODUCTORY REAL ANALYSIS
  or MATH 628  REAL ANALYSIS FOR TEACHERS
- MATH 577  COMPLEX ANALYSIS
- MATH 578  TOPOLOGY
- MATH 579  FOURIER ANALYSIS WITH APPLICATIONS

**Geometry**

- MATH 557  DIFFERENTIAL GEOMETRY
- MATH 650  PATTERNS IN MATHEMATICAL DESIGNS
- MATH 653  TOPICS IN GEOMETRY
- MATH 671  CHAOTIC DYNAMICS AND FRACTAL GEOMETRY

**Statistics/Probability**

- MATH 531  PROBABILITY
- MATH 532  MATHEMATICAL STATISTICS
- MATH 630  STATISTICS-AN INTEGRATED APPROACH
- MATH 651  MATHEMATICS OF FUZZY LOGIC
- MTED 612  DATA ANALYSIS FOR MIDDLE SCHOOL TEACHERS

**Section D: Mathematics Methods**

- MTED 605  MIDDLE SCHOOL MATHEMATICAL METHODS AND PROBLEM SOLVING 3

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**Section B: Courses in General Education and Pedagogy**

Students complete a total of three education-related courses. The following are examples of such courses. 9

1. Students exiting the graduate program should have an adequate knowledge of mathematics contents in Algebra.
2. Students exiting the graduate program should have an adequate knowledge of mathematics contents in Geometry.
3. Students exiting the graduate program should have an adequate knowledge of mathematics contents in Calculus and Analysis.
4. Students exiting the graduate program should have an adequate knowledge of mathematics contents in Probability and Statistics.
5. Students exiting the graduate program should have an adequate knowledge of mathematics education principles and standards and be able to communicate those principles in oral and written form. Student should be able to plan a lesson using these principals and standards.
6. Students exiting the graduate program should possess a broad knowledge of recent teaching methodologies and pedagogical issues in mathematics education and be able to communicate them in oral and written form.
7. Students should become familiar with the appropriate instructional technology in mathematics and mathematics education and be able to use it properly in their own classrooms or in their researches of mathematics teaching.

Courses

MATH 501 HISTORY OF MATHEMATICS (3)
Development of mathematics emphasizing mathematical concepts and contributions and individuals and societies. Prerequisites: MATH 263 or MATH 265, and MATH 274.

MATH 512 THEORY OF INTEREST (4)
The mathematical theory and applications of key financial management concepts and procedures including interest, force, annuities, perpetuities, amortization of loans, bonds, stocks, approximating yields, the term structure of interest rates, duration, convexity, asset matching, swaps, and determinants of interest. Prerequisite: MATH 274.

MATH 523 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: admission to the MTED-MS program; not open to students who have previously completed MATH 423 (or its equivalent).

MATH 525 MATHEMATICAL PROBLEM SOLVING FOR TEACHERS (3)
A problem-solving seminar designed for teachers to build their understanding of mathematics content and analytical skills. 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. Prerequisites: admission to the Mathematics Education M.S. program; MATH 273 or its equivalent; not open to students who have previously completed MATH 325 or its equivalent.

MATH 527 READINGS IN MATHEMATICS EDUCATION FOR THE ELEMENTARY SCHOOL TEACHER (1-3)
Directed study for the teacher of elementary school mathematics. Prerequisites: MATH 321 or MATH 323 and approval of instructor.

MATH 531 PROBABILITY (4)
Probability in sample spaces, discrete and continuous random variables, distribution theory, Tchebychev's theorem, central limit theorem, expected values and moments. Prerequisite: MATH 274.

MATH 532 MATHEMATICAL STATISTICS (3)
Sample theory and distributions, point estimation, confidence intervals, tests of hypothesis, regression, correlation and analysis of variance. Prerequisite: MATH 331 (531).

MATH 533 APPLIED REGRESSION AND TIME SERIES PREDICTIVE MODELING (4)
Simple and multiple regression models, least squares estimates, hypothesis testing, confidence intervals and prediction intervals, model building methods and diagnostic checking. Non-seasonal time series models: autoregressive, moving-average, autoregressive moving-average, and/or autoregressive integrated moving-average models, parameter estimation and forecasting. Minotab or a similar software is used for real data analysis. Prerequisite: MATH 265 or equivalent and MATH 332/MATH 532 or equivalent.

MATH 535 NUMERICAL ANALYSIS I (3)
Error analysis, interpolation, numerical differentiation and integration, numerical solution of algebraic equations and of systems of algebraic equations.

MATH 537 OPERATIONS RESEARCH (3)
Introduction to linear, integer and nonlinear programming; the simplex method and interior point methods, duality and sensitivity analysis: formulation of optimizations models and applications to problems from industry. Prerequisites: MATH 211 or MATH 273 and MATH 265.

MATH 538 LONG-TERM ACTUARIAL MODELS I (3)
Theory and applications of long-term actuarial mathematics in the area of life insurance, annuities and pensions. Topics include survival models, life table, present value random variables for contingent insurance and annuities, future loss random variables, actuarial equivalence principle and other principles for pricing life insurance and annuity contracts, benefit reserves. Prerequisites: MATH 331, MATH 312.

MATH 539 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. Minotab 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 542 SHORT-TERM ACTUARIAL MODELS (4)
Covers part of the syllabus of the Short-Term Actuarial Mathematics exam offered by Society of Actuaries. Topics include severity models, frequency models, aggregate models, risk measures, construction and selection of parametric models, insurance and reinsurance coverages, and pricing and reserving for short-time insurance coverages. Prerequisites: MATH 390 or Pass Exam P, and MATH 332 or equivalent.

MATH 548 LONG-TERM ACTUARIAL MODELS II (3)
Covers the second part of the syllabus of the Long-Term Actuarial Mathematics offered by the Society of Actuaries. Topics include future loss random variables; reserves for traditional life insurances and annuities; multiple state models including multiple decrements models, multiple life functions; estimates of survival models, profit testing, pension plans and retirement benefits. Prerequisite: MATH 538.

MATH 551 GRAPH THEORY (3)
Statistical process control including principles of control charts, control charts for attributes and variables and special control charts; methods for quality improvement. Acceptance sampling including single, double, multiple and sequential attribute sampling and acceptance sampling by variable. Prerequisite: One course in elementary statistics.

MATH 557 DIFFERENTIAL GEOMETRY (3)
Curvatures of curves and surfaces in E3, geodesics, invariants, mappings and special surfaces. Prerequisites: MATH 275 Calculus III and MATH 265 Eled. Linear Algebra.
MATH 563 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 565 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: either MATH 263 or MATH 267; and MATH 274.

MATH 568 ALGEBRAIC STRUCTURES (3)
Topics include groups, solvability and insolubility of polynomials, principal ideal, Euclidean, and unique factorization domains. Prerequisite: MATH 369.

MATH 574 DIFFERENTIAL EQUATIONS (3)

MATH 575 MATHEMATICAL MODELS (3)
Consideration of some mathematical problems in sociology, psychology, economics, management science and ecology, and developing appropriate mathematical models and techniques to solve them.

MATH 576 INTRODUCTORY REAL ANALYSIS (4)
Introduction to mathematical analysis. Sequence series, continuity, differentiation, integration and uniform convergence. Prerequisites: MATH 267 and MATH 275.

MATH 577 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 conformal mappings. Prerequisite: MATH 275.

MATH 578 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 579 FOURIER ANALYSIS WITH APPLICATIONS (3)
Vector, integral and differential calculus including the divergence and Stoke’s theorems. Fourier series, orthogonal functions and applications. Prerequisite: MATH 275.

MATH 580 SELECTED TOPICS IN MATHEMATICS (1-4)
Topics will be chosen from different areas in mathematics. Content will be determined so as to complement course offerings, as well as the needs and desires of the students. May be repeated for a maximum of 9 units provided a different topic is covered each time. Prerequisite will vary from topic to topic.

MATH 585 MATHEMATICAL FINANCE (3)
Mathematical theory, computation and practical application of 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 586 RISK MANAGEMENT AND FINANCIAL ENGINEERING (3)
Mean-variance portfolio theory, asset 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 585 or equivalent or consent of department.

MATH 602 CULTURAL AND PHILOSOPHICAL BACKGROUND OF MATHEMATICS (3)
Meanings and origins of mathematical concepts, schools of philosophical thought, cultural and ethnomathematical context of mathematics, philosophy and purpose of mathematics education, current issues in mathematics and mathematics education, role of the mathematics teacher in current debates. Prerequisite: Admission to master’s in Mathematics Education program.

MATH 621 SEMINAR IN TEACHING ELEMENTARY/MIDDLE SCHOOL MATHEMATICS (3)
Analysis of pedagogical methods and materials in elementary and middle school mathematics instruction and assessment. Mathematics topics include, but are not limited to, those taught in grades 1 – 8. Prerequisites: MATH 204, MATH 205, and MATH 251, or their equivalents.

MATH 622 SEMINAR IN TEACHING ADVANCED PLACEMENT CALCULUS (3)
Discussion and analysis of materials, pedagogy, and technology for the teaching of Advanced Placement Calculus in high schools. Prerequisites: Admitted into the MS program in Mathematics Education or the consent of the instructor.

MATH 624 EUCLIDEAN AND NON-EUCLIDEAN GEOMETRY THROUGH AN INQUIRY APPROACH (3)
An exploration and comparison of the geometry of Euclidean and Non-Euclidean surfaces, including spherical geometry. Problem solving, problem posing, and the use of physical and technological models will be integrated throughout. Prerequisite: admission to the Mathematics Education M.S. program.

MATH 625 SEMINAR IN MATHEMATICS EDUCATION FOR SECONDARY SCHOOL TEACHERS (3)
Investigations of recent curricula and research, pedagogy, materials, technology and assessment techniques for middle and high school teachers of mathematics. Prerequisite: MATH 423 or equivalent.

MATH 626 TECHNOLOGY IN SCHOOL MATHEMATICS TEACHING AND LEARNING (3)
History and use of technology in teaching mathematics in grades 6 through 12. Students will use scientific and graphing calculators, computers and other devices such as the Calculator-Based Laboratory (CBL) to solve problems found in secondary mathematics curriculum and apply this knowledge in the teaching of mathematical concepts. Software such as Mathematica, MathCad and Geometer’s Sketchpad will be studied and students will write lessons using one of these software packages. The use of the Internet and other technological resources to teach mathematics will also be studied. Prerequisite: Admission to the graduate program.
MATH 627 CURRICULUM ISSUES IN SECONDARY SCHOOL MATHEMATICS (3)
Analyze secondary school mathematics curriculum development from a historical perspective and discuss past influences on current methodology. Distinguish current curriculum trends and design alternatives. Evaluate contemporary curriculum by assessing an existing text or program. Create a selected mathematics unit. Prerequisite: MATH 625.

MATH 628 REAL ANALYSIS FOR TEACHERS (3)
Principles underlying calculus, including topics in real analysis such as completeness for the reals, limits, continuity, differentiation/integration, sequences and series. Emphasis on mathematical theory and the pedagogy of teaching functions. Prerequisites: Admission to the master’s program in Mathematics Education (or approval of department), MATH 273 and MATH 274 or equivalent.

MATH 629 UNDERSTANDING AND USING MATHEMATICS EDUCATION RESEARCH (3)
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. Prerequisite: admission to the Mathematics Education M.S. program.

MATH 630 STATISTICS-AN INTEGRATED APPROACH (4)
Theory and practices of basic statistical analysis and inference with emphasis on analyzing and solving real problems using statistics. Descriptive statistics, introduction to probability, sampling distributions, estimation, hypotheses testing, regression, correlation, nonparametric techniques and analysis of variance, and computer programming incorporated throughout. Prior knowledge of programming is not necessary. Prerequisite: MATH 274 (not open to students who have completed MATH 332).

MATH 631 TOPICS IN PROBABILITY (3)
Review of basic probability theory, types of convergence and limit theorems, elementary stochastic processes. Markov chains, birth and death processes. Gaussian processes. Examples from engineering, physical and social sciences, management and statistics. Prerequisite: MATH 331.

MATH 632 COMPUTATIONAL STOCHASTIC MODELING (3)

MATH 633 QUEUING SYSTEMS (3)
Characterization and analysis of basic queuing systems, both single-server and multiple-server. The M/G/1 and G/M/m queuing systems. Multiserver with queuing, multiserver queuing rules, priority queues. Networks of queues: response time, routing, flow and congestion control. Manufacturing systems: capacity/inventory investment and scheduling. Prerequisites: MATH 331, MATH 531, or consent of chairperson.

MATH 634 TIME SERIES ANALYSIS AND FORECASTING (3)
An introduction to statistical models for time series analysis and forecasting. Topics include time series decompositions, exponential smoothing, dynamic regression, spectral analysis and filtering. A variety of models will be discussed including the Holt, Holt-Winters, ARMA, ARIMA, SARIMA, and state-space models. Prerequisites: MATH 265 and MATH 332, or MATH 532, or consent of department chair.

MATH 635 APPLIED NUMERICAL ANALYSIS (3)

MATH 636 LINEAR AND NONLINEAR PROGRAMMING (3)
Formulations and model building in linear programming. The simplex method and its variants: duality theory, sensitivity analysis, polynomial time algorithms, multiobjective optimization models and algorithms. Prerequisite: MATH 265, MATH 275 and graduate standing, or consent of chairperson.

MATH 637 ADVANCED TOPICS IN APPLIED OPERATIONS RESEARCH (3)
Dynamic programming, formulation of deterministic decision-process problems, analytic and computational methods of solution, application to problems of equipment replacement, resource allocation, scheduling, search and routing. Brief introduction to decision making under risk and uncertainty. Prerequisites: MATH 275 and MATH 331, or MATH 531, or consent of chairperson.

MATH 638 APPLIED MULTIVARIATE STATISTICAL ANALYSIS (3)
A brief review of vector and matrix algebra and an introduction to applications of multivariate statistical methods. Multivariate normal distribution and its properties, inference for mean vector of a multivariate normal distribution, and simultaneous inference for components of the mean vector. Principle components, factor analysis, and discrimination & classifications. The course introduces many applications of the topics related to real world problems in the fields of engineering, sciences, and business. Minitab or a similar software is used for real data analysis. Prerequisites: MATH 531 or equivalent, MATH 533 or equivalent, MATH 265 or equivalent.

MATH 639 LOSS MODELS (4)
Severity models, frequency models, aggregate models, survival models, construction of parametric models, and credibility models. Prerequisites: MATH 532 or equivalent.

MATH 641 ENTERPRISE RISK MANAGEMENT (3)
Covers part of the syllabus of the Enterprise Risk Management exam offered by Society of Actuaries. Serves as an introduction to Enterprise Risk Management. It will define and categorize different types of risks an entity faces, and define an ERM framework. Ways to measure and quantify the risk, such as (principle based) Economic Capital, Value at Risk (VaR), and stress scenarios will be analyzed and compared. The course will conclude with applications of these methods in a case study of an insurance company and recent regulatory developments. Prerequisite: Pass Exam P or MATH 331/ MATH 531.

MATH 642 CREDIBILITY AND SIMULATION (3)
Techniques of modeling and simulation including limited fluctuation (classical) credibility, Bayesian credibility, conjugate priors, Buhlmann and Buhlmann-Straub models, and empirical Bayes methods in the nonparametric and semiparametric cases. Prerequisite: MATH 332 or MATH 532.
MATH 643 COMPUTATIONAL METHODS OF MATHEMATICAL FINANCE (3)
Computation techniques involving tree method, finite difference scheme, Monte Carlo simulation, term structure fitting and modeling, financial derivative pricing, the Greeks of options, Capital Asset Pricing Model, Value-at-Risk calculation. Software package such as Mathematica or Excel will be used. Prerequisites: MATH 585 or equivalent.

MATH 644 MATHEMATICS OF FINANCIAL DERIVATIVES (3)
Modern pricing theory for financial derivatives, stochastic differential equations, Ito formula, martingales, Girsanov Theorem, Feynman-Kac PDE, term structure, Interest-Rate models and derivatives, optimal stopping and American options. Prerequisites: Math 585, or equivalent.

MATH 647 PREDICTIVE ANALYTICS (3)
Principles and methodologies of predictive modeling. Topics include prediction versus interpretation; assessing model accuracy; resampling methods; bootstrapping; subset selection; shrinkage methods; dimension reduction methods; the logistic model; bagging; random forests; principal component analysis; clustering methods. R, SAS, SPSS or a similar software package will be used for data analysis. Prerequisite: MATH 337 or MATH 533.

MATH 650 PATTERNS IN MATHEMATICAL DESIGNS (3)
A geometrical bridge between science and art covering topics such as the systems of proportion in mathematics, art, architecture, and in nature; the golden mean, Fibonacci series, Archimedes and logarithmic spirals, growth and similarity in nature; graphs and maps on the Euclidean plane and on a sphere, on a torus, and map coloring; periodic and non-periodic tilings, duality and the modules of semi regular tilings; polyhedral and platonic solids and their duality and combinatorial and space-filling properties. Prerequisite: Admission to the Master's Program in Mathematics Education or approval of the department.

MATH 651 MATHEMATICS OF FUZZY LOGIC (3)
Basic concepts of fuzzy logic, fuzzy sets, fuzzy uncertainty, fuzzy relations, comparing fuzzy logic with first-order predicate logic, algebra of fuzzy logic, approximate reasoning, rule-based systems. Description of linguistic data using fuzzy sets. Applications: rule-based expert systems, decision making, pattern recognition, control theory, optimization. Prerequisite: Graduate standing or consent of chairperson.

MATH 653 TOPICS IN GEOMETRY (3)
Axiomatic development of Euclidean, elliptic and hyperbolic geometries; the study of the analytic plane, the sphere and the Poincare model as models for these axiomatic systems. Not open to students who have had MATH 353. Prerequisites: MATH 274 and MATH 467 (or MATH 568).

MATH 657 ALGEBRA OF SYMMETRIES (3)
Complex integers, permutation groups, properties of abstract groups of plane transformations and matrix representations of transformations. Culminates in developing the 17 groups of symmetries of the Euclidean plane. No credit toward the master’s in Applied and Industrial Mathematics. Prerequisite: Admission to the Master of Science in Mathematics Education Program or approval of the department.

MATH 668 COMPUTATIONAL TOPOLOGY (3)
The homology of a simplicial complex and the notion of persistence in a sequence of simplicial complexes; implementing persistent homology; applications to biology, data clustering, and denoising.

MATH 671 CHAOTIC DYNAMICS AND FRACTAL GEOMETRY (3)
Introduction to the classical theory of linear systems and the modern theory of nonlinear and chaotic systems. Modeling of discrete and continuous time systems. Bifurcation theory, symbolic dynamics, fractals and complex dynamics, Julia sets and the Mandelbrot set. Mathematica or an equivalent software package will be used. Prerequisites: MATH 265 and MATH 275, and graduate standing or consent of chairperson.

MATH 673 INTEGRAL TRANSFORMS AND APPLICATIONS (3)
Integral transforms and their applications: Fourier, Laplace, Hankel, Mellin, and z-transforms and their applications for solving ordinary differential equations, partial differential equations, integral equations, and difference equations arisen from physics, engineering and sciences. Prerequisites: MATH 374, (or MATH 574) and MATH 379 (or MATH 579); and MATH 475 (or MATH 577); or consent of chairperson.

MATH 674 APPLIED PARTIAL DIFFERENTIAL EQUATIONS (3)
Discussions of the typical partial differential equations of applied mathematical physics: Heat equations. Wave equations, Beam equations, Laplace equations. Separation of variables, variation of parameters and Fourier transform for initial and boundary value problems, Calculus of variation and Ritz-Galerkin's numerical method. Prerequisite: MATH 374 (or MATH 574), MATH 379 (or MATH 579), or consent of chairperson.

MATH 675 ASYMPTOTIC AND PERTURBATION ANALYSIS (3)
Asymptotic series and asymptotic methods for approximating solutions to linear and nonlinear ordinary differential equations. Asymptotic expansion of integrals; Watson's Lemma. Perturbation series; regular and singular perturbation theory. Boundary layer theory for ordinary differential equations. Prerequisites: MATH 374/ MATH 574 or equivalent and MATH 475/ MATH 577 or equivalent.

MATH 676 INTRODUCTION TO MATHEMATICAL CONTROL THEORY (3)
Problems and specific models of mathematical control theory. Elements of classical control theory: controllability, observability, stability, stabilizability and realization theory for linear and nonlinear systems. Optimal control, Maximum Principle and the existence of optimal strategies. Prerequisites: MATH 265 and MATH 374/MATH 574.

MATH 677 ADVANCED MATHEMATICAL MODELING (3)
Development of appropriate stochastic as well as deterministic models to solve applied mathematical problems in the fields of physics, engineering, and the social sciences. Topics include optimization models, dynamic models, probability models and Monte Carlo simulation. Mathematica or a similar software package will be used. Prerequisites: MATH 331 or MATH 531, and MATH 379 or MATH 579, or consent of chairperson.

MATH 680 SPECIAL TOPICS IN MATHEMATICS EDUCATION (3)
Topics will be chosen focusing on pedagogy, educational theories, curriculum, research, policy, or other issues of mathematics education. Content will be determined to complement graduate course offerings in mathematics education. May be repeated for a total of 9 units provided a different topic is taken each time. Prerequisite: program admission.

MATH 681 SPECIAL TOPICS IN MATHEMATICS FOR TEACHERS (3)
Topics will be chosen from a mathematical field related to, or extending, the K-12 school mathematics curriculum. Content will be determined to complement graduate course offerings in mathematics education. May be repeated for a total of 9 units provided a different topic is taken each time. Prerequisite: program admission.

MATH 684 SPECIAL TOPICS IN MATHEMATICS AND STATISTICS (3)
Topics will be chosen in mathematics or statistics. Course content will be determined so as to complement course offerings in mathematics and statistics. Course may be repeated for a maximum of 8 units. Prerequisite: will vary depending on topic.
MATH 685 SPECIAL TOPICS IN APPLIED MATHEMATICS (3)
Topics will be chosen in a mathematical field not directly related to
differential equations/optimization or applied statistics/mathematical
finance. Course content will be determined to complement the existing
course offerings. Prerequisite: will vary depending on topic.

MATH 686 SPECIAL TOPICS IN DIFFERENTIAL EQUATIONS OR
OPTIMIZATION (3)
Topics will be chosen in a mathematical field related to
differential equations or optimization. Course content will be determined to
complement the existing course offerings in the differential equations/
optimization track. Prerequisite: will vary depending on topic.

MATH 687 SPECIAL TOPICS IN APPLIED STATISTICS OR
MATHEMATICAL FINANCE (3)
Topics will be chosen in a mathematical field related to statistics or
mathematical finance. Course content will be determined to complement
the existing course offerings in the applied statistics/mathematical
finance track. Prerequisite: will vary depending on topic.

MATH 688 TOPICS IN ACTUARIAL SCIENCE AND RISK MANAGEMENT (3)
Topics in actuarial science, risk management, and predictive analytics
selected by the instructor. Selected topics include financial reporting,
valuation, and management considerations for life insurance companies;
capital and risk management, including securitization techniques in
the insurance industry; worker’s compensation programs and pricing;
emerging techniques for use by actuaries; actuarial studies and
communication techniques, and other topics. Prerequisite: MATH 538 or
MATH 585.

MATH 695 INDEPENDENT STUDY IN MATHEMATICS (1-3)
Directed independent study in selected areas of graduate level
mathematics. Prerequisite: Permission of instructor and graduate
adviser.

MATH 791 MASTERS INTERNSHIP I (3)
An original investigation of a problem to be pursued in cooperation with
a local industry or business under the direction of an industry supervisor
and a member of the mathematics faculty. Prerequisites: Completion
of at least 15 units toward the M.S. degree in Applied and Industrial
Mathematics and consent of chairperson.

MATH 792 MASTER’S INTERNSHIP II (3)
An original investigation of a problem to be pursued in cooperation with
a local industry or business under the direction of an industry supervisor
and a member of the mathematics faculty. Prerequisites: Completion
of at least 15 units toward the M.S. degree in Applied and Industrial
Mathematics and consent of chairperson.

MATH 880 APPLIED MATHEMATICS GRADUATE PROJECT I (3)
An internal applied mathematics graduate project based on mutual
research interests of a graduate student in the APIM program and a
faculty advisor will be investigated. The advisor will guide the student
throughout different phases of solving the applied mathematics problem.
Prerequisites: permit required, APIM graduate students only.

MATH 881 APPLIED MATHEMATICS GRADUATE PROJECT II (3)
An internal applied mathematics graduate project based on mutual
research interests of a graduate student in the APIM program and a
faculty advisor will be investigated. The advisor will guide the student
throughout different phases of solving the applied mathematics problem.
Permit required, only APIM graduate students.