Mathematics

Faculty and Fields of Interest

Mathematics can be pursued as a scholarly discipline of an especially elegant kind—a creative art form—or it can be treated as a valuable tool in an applied discipline.

The program for mathematics majors is designed to provide a solid foundation in the theoretical and applied aspects of mathematics necessary for a variety of professional careers. The flexibility within the third and fourth years was established to enable mathematics majors to concentrate in areas of their interest. The Computational Mathematics Option is designed for those seeking positions in industry or with the government. The program emphasizes applied and computer mathematics. Students can choose their curricula so as to emphasize that role of mathematics which will be useful to them in later years. For example, students may use our offerings as preparation for

- secondary school teaching;
- graduate school in mathematics, applied mathematics, or computer science;
- a career in applied mathematics in either the public or private sector; and
- graduate school in an area that uses mathematics, such as economics, biology or psychology.

Some mathematics majors have had success in law school, pharmaceutical school, and medical school.

The Department offers both a major and a minor program.

Nurit Budinsky nonlinear differential equations, numerical analysis, nonlinear dynamical systems

Gary Davis mathematical education, computational discrete mathematics

Richard Faulkenberry linear algebra

Dana Fine applied math, relativity theory

Sigal Gottlieb applied mathematics, scientific computing, parallel computing

Adam Hausknecht algebra, analysis of algorithms

Alfa Heryudono applied mathematics, numerical analysis, scientific computing

Saeja Kim computational algebra, applied mathematics, scientific computing

Robert Kowalczyk probability, numerical analysis, computer applications

Steven Leon numerical analysis, linear algebra

Gary Martin logic

Ronald Tannenwald (chairperson) dynamical systems

Cheng Wang applied mathematics, numerical analysis, scientific computing

Biyong Luo applied math, scientific computing

The need for K-12 teachers in the areas of mathematics and science is great in the region. Mathematics is a strong major for future teachers. The Mathematics Department participates in UMass Dartmouth's programs to prepare teachers who are highly qualified, helping provide opportunities for students to receive both initial and professional licensure. Specifically, the department supports students who seek initial licensure as a Teacher of Mathematics (5-8) (8-12) through the Post-Baccalaureate Education Certificate and professional licensure as a Teacher of Mathematics (5-8) (8-12) through the MAT program. Students should indicate their interest both to their Mathematics major advisor and to an advisor in UMass Dartmouth's Education Department, to plan to take appropriate prerequisite and enrichment courses.

Student Learning Outcomes

- Students should know, and be able to recall and use, basic ideas from their core mathematics courses.
- Students should be able to determine independently that their work, including calculation and argument, is correct. This includes developing regular habits of checking solutions, verifying answers, and checking for correct calculations and correct reasoning.
- Students should write coherent answers to mathematical problems. This includes correct and clearly presented English, logical and clearly laid-out solutions, and clear and well-labeled diagrams where appropriate.
- Students should be able to argue logically and correctly, and be able to produce proofs for mathematical assertions.
- Students should have familiarity with graphing calculators and mathematics software including *Mathematica* or *Maple*. Students should know how to use mathematical technology appropriately to enhance, and not to replace, basic skills and understanding of concepts.
- Students should be flexible problem solvers. They should be able to recall basic facts, concepts, and skills, and use them in context, and should be able to use those same facts, concepts, and skills in novel problem settings.
- Students should be able to see connections between different areas of mathematics, and understand relationships between ideas.
- Students should learn to communicate mathematics effectively.

Mathematics Major
BA degree

At the end of the sophomore year, students, aided by their faculty advisors, should plan a course of study for the completion of the college program.

The advanced courses selected during the third and fourth years should be consistent with the students' interests and goals.

Students must earn a grade of C- or higher in all mathematics courses taken at the 200 or higher level in all undergraduate mathematics degree programs.

Mathematics Major
BS degree

Students may elect to earn a Bachelor of Science degree provided that they complete certain requirements for the BA degree and also take an additional six credits of Natural Science (but only courses that the science departments themselves would credit to a major in their areas). The humanities/social science requirements for the BS degree are a combined total of eighteen credits. At least six must be taken from each area.

General Education Departmental Requirements

Students majoring in Mathematics will meet their departmentally-determined General Education requirements as follows:

Area E: Students select a course from approved list
Area I, Tier 2: Students select a course from approved list
Area W, Tier 2: Students select a course from approved list
Area O: Students select a course from approved list

Requirements
Regular Option

		Semester Credits	
		First	**Second**
First Year			
MTH 111, 112	Analytic Geometry and Calculus I & II	4	4
CIS 180	Object-Oriented Programming **OR**	3	
CIS 261	Computer Programming Fortran		
ENL 101, 102	Critical Writing and Reading I, II	3	3
	Humanities, Social Science or Free Electives	3	6
MTH 181, 182	Discrete Structures	3	3
		16	**16**
Second Year			
MTH 211	Analytic Geometry and Calculus III	4	
MTH 212	Differential Equations		3
MTH 221	Linear Algebra	3	
PHY 113, 114	Classical Physics	4	4
	Literature	3	3
	Humanities, Social Science or Free Electives	3	6
		17	**16**
Third Year			
MTH 311	Advanced Calculus I	3	
MTH 312	Advanced Calculus II		3
	Mathematics Electives	3	3
	Humanities or Social Sciences	3	3
	Unspecified Electives	6	6
		15	**15**
Fourth Year			
MTH 441	Modern Algebra	3	
	Mathematics Electives	3	3
	Humanities or Social Science	3	3
	Unspecified Electives	4	6
		13	**12**
		Total credits:	**120**

Mathematics Electives

		code*
MTH 302	Theory of Numbers	T
MTH 310	Modern Methods in Mathematics Teaching	T
MTH 311, 312	Advanced Calculus I, II	T, G, A
MTH 321, 322	Topics in Applied Math I, II	A, G
MTH 331	Probability	A, G
MTH 332	Mathematical Statistics	A, G
MTH 353	Applied Linear Algebra	A
MTH 361, 362	Numerical Analysis I, II	A, G
MTH 381	Combinatorial Theory	A, G
MTH 382	Graph Theory	A,G
MTH 421	Complex Variables	A, G
MTH 441, 442	Modern Algebra I, II	A, G
MTH 443	Applied Modern Algebra	A, G
MTH 451	Differential Geometry	G
MTH 452	Higher Geometry	G, T
MTH 461	Elementary Topology	G
MTH 463	Math Models	A
MTH 487	Math Inquiry I	T, G
MTH 488	Math Inquiry II	T, G
MTH 499	Selected Topics in Math	T, G

*** Code**
T—recommended for students preparing to teach **G**—recommended for students preparing for graduate school **A**—recommended for students in applied mathematics

Mathematics Major: Computational Mathematics Option

BS degree

In order to meet the needs of our present-day technological society, the Mathematics Department presently offers an alternative to the mathematics major program of study—a computational mathematics program leading to the BS degree in Mathematics. This program requires a core of computer science courses and emphasizes the applied mathematics areas of study. The program allows the student a large choice of electives within the context of computational and applied mathematics. The student can thus pursue his or her interests in any particular phase of applied mathematics.

The Computational Mathematics program has virtually the same freshman and sophomore requirements as the other mathematics program and the courses taken in those years are also similar to those required in other programs such as computer and information science, computer engineering, and electrical engineering. This allows a student to find his or her interests and make a final choice of programs before the end of the second year without any loss of time.

A BS degree with the Computational Mathematics Option prepares the student to enter graduate programs that specialize in computational and applied mathematics. It also prepares the student for jobs in industry, work in government labs, actuarial careers, jobs with high tech companies, careers in biomathematics, and for careers in business. Almost every area of modern society now analyzes problems mathematically and consequently there is a demand for applied mathematicians in a growing number of fields.

Requirements

Computational Mathematics Option

		Semester Credits	
		First	**Second**
First Year			
MTH 111, 112	Analytical Geometry and Calculus I, II	4	4
CIS 180	Object-Oriented Programming	4	
CIS 181	Programming Paradigms		4
ENL 101, 102	Critical Writing and Reading I, II	3	3
	Humanities/Social Science Electives	3	3
MTH 181, 182	Discrete Structures I, II	3	3
		17	**17**
Second Year			
MTH 211	Analytical Geometry and Calculus III	4	
MTH 212	Differential Equations		3
MTH 221	Linear Algebra	3	
CIS 261	Computer Programming—FORTRAN **OR**		
CIS 265	Program Design and Data Structures with C		3
PHY 113, 114	Classical Physics I, II	4	4
	Humanities/Social Science Electives	3	6
		14	**16**
Third Year			
MTH 361, 362	Numerical Analysis I, II	3	3
MTH 353	Applied Linear Algebra		3
	Science Electives*	3	3
	Free Electives	3	3
	Literature	3	3
	Humanities/Social Science Electives	3	
		15	**15**
Fourth Year			
MTH 331	Probability	3	
MTH 332	Mathematical Statistics		3
MTH 471	Partial Differential Equations	3	
	Computational Mathematics**		3
	Technical Electives***	3	3
	Free Electives	6	3
		15	**12**
	Total credits:		**121**

*
The Science Elective is defined as any course in Biology, Chemistry, Physics, or Medical Laboratory Science which is accepted for credit by majors in those programs.

**
The Computational Mathematics elective is any one of the numerical Mathematics courses MTH 472, 473, or 474.

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The Technical Elective is defined as any upper-division Mathematics or Computer and Information Science course.

Students must receive a grade of C- or higher in all Mathematics courses, technical electives, and required Physics and CIS courses.

Mathematics Minor

The minor in mathematics comprises a central core of required courses followed by opportunities for advanced work and some specialization. Any student of the university is eligible for the designation "Minor in Mathematics" upon completion of the following requirements. Each course for the minor must be completed with a grade of C- or better, and the student must maintain at least a C average (2.0 GPA) in the minor program.

Requirements

		Credits
MTH 111	Analytic Geometry and Calculus I	4
MTH 112	Analytic Geometry and Calculus II	4
MTH 211	Analytic Geometry and Calculus III	4

At least one of the following courses:

MTH 212	Differential Equations	3
MTH 221	Linear Algebra	
MTH 227	Linear Algebra for Applied Science	

At least three additional three-credit courses, numbered 300 or higher.	9
Total	**24**

Mathematics Courses

MTH 100 three administrative credits *
Basic Algebra
An introductory level algebra course intended primarily for those with weak or no skills or those who have been away from the subject for some time. This course provides the algebra background required for all entry level courses in mathematics.

MTH 101 three credits **M**
Elements of College Mathematics I
MTH 101, 102 comprise a terminal course of study for students whose curriculum calls for one year of mathematics. MTH 101 is also a prerequisite for MTH 231. The first semester covers selected topics from algebra, set theory, matrix algebra, and elementary functions.

MTH 102 three credits **M**
Elements of College Mathematics II
Prerequisite: MTH 101 or MTH 103
Introduction to differential and integral calculus.

MTH 103 three credits **M**
Finite Mathematics
Will cover selected topics from Logic, Set Theory, Vectors and Matrices, Linear Programming, Probability, Graphs and Theory of Games. May be taken in lieu of MTH 101.

MTH 104 three credits **M**
Fundamentals of Statistics
The mathematical techniques involved in organizing data, averages and variation, elementary probability theory, the binomial distribution, normal distributions and related topics, estimation, hypothesis testing, regression and correlation, Chi Square- tests of independence, Chi Square- goodness of fit and analysis of variance: comparing several sample means.

MTH 105 three credits
Technical Calculus I
First semester of a four-term calculus sequence required of technology students and recommended for non-physical science majors desiring a basic introduction to analysis. The first term will review those topics from algebra and trigonometry needed in the sequel. Then the basic concepts of the differential calculus will be studied.

MTH 106 three credits
Technical Calculus II
Prerequisite: MTH 105
Continuation of MTH 105. Further study of algebraic and transcendental functions of one variable and topics from the integral calculus of these functions.

MTH 107 three credits **M**
Elements of College Mathematics Enhanced
Elements of college mathematics in application to business, selected to emphasize interpretation and explanation and to de-emphasize computation.

MTH 109 two credits
Mathematical Problem Solving and Reasoning I
Basic mathematical problem solving and reasoning skills development. The course uses an intensive hands-on, problem-centered approach to develop mathematical thinking skills, frequently using computer software and group work. The course begins with simple thinking skills and mathematical ideas, and "what to do when you're stuck" strategies. The goal is to develop strategies for solving hard problems and understanding complex or abstract ideas.

MTH 110 three credits **M**
Mathematical Problem Solving and Reasoning II
Continuation of MTH 109.

MTH 111 four credits
Analytic Geometry and Calculus I
Prerequisite: Trigonometry
First semester of a four term sequence required of majors in mathematics, the physical sciences and engineering. Recommended for others desiring a thorough background in elementary analysis. Term 1 will cover topics in analytic geometry, the concepts of function and limit, continuity, differentiability and integrability of elementary algebraic and transcendental functions. Techniques of differentiation and applications will then be studied.

MTH 112 four credits
Analytic Geometry and Calculus II
Prerequisite: MTH 111
Continuation of MTH 111. Topics from the integral calculus, stressing techniques of integration (including numerical methods). Infinite series.

MTH 113 four credits
Calculus for Applied Science and

* Administrative credits do not count towards the total credits required for graduation.

Gen Ed note: Mathematics courses satisfy the Mathematics requirement. Those marked **M** below are appropriate for non- science/engineering majors.

Engineering I
Prerequisite: Trigonometry
Corequisites: PHY 111, EGR 107
Functions, limits, differentiation and integration of elementary algebraic and transcendental functions. Vectors, vector operations, vector fields and line integrals will be introduced. Technological tools an a computer algebra system will be used extensively throughout the course. This course, a version of MTH 111 for the integrated freshman year curriculum in engineering, may be repeated as MTH 111.

MTH 114 four credits
Calculus for Applied Science and Engineering II
Prerequisite: MTH 113 or MTH 111
Corequisites: PHY 112, EGR 108
Continuation of MTH 113 or MTH 111. Techniques of integration, improper integrals, applications of integrals, series, polar coordinates and an introduction to differential equations. Selected topics from multivariable calculus will include partial differentiation, double and triple integrals, line integrals and flux. This course, a version of MTH 112 for the integrated freshman year curriculum in engineering, may be repeated as MTH 112.

MTH 117 three credits **M**
Fractals and Chaos via Elementary Mathematics
Prerequisite: Satisfactory score on mathematics placement exam
The new science of chaos revealed through its fascinating history and stimulating examples. The connection will be demonstrated between such seemingly unrelated topics as weather and stock prediction, management and scientific decisions, the erratic motion of a pendulum and the delicate design of snowflakes, clouds, or the fjords of Sweden. Students will create their own fractals and play the chaos game using computer software, calculators, or even just pencil and paper.

MTH 118 three credits **M**
Mathematics for Artists
Prerequisite: Satisfactory score on mathematics placement exam
Relationships between fine art and mathematics, with an emphasis on understanding geometric patterns and concepts. Topics include art-related examples and hands-on experiences which give basic mathematical background for future artistic students' endeavors.

MTH 119 three credits **M**
Math and Music
Prerequisite: Minimal ability to read music; satisfactory score on mathematics placement exam
Topics which emphasize and explore the close connection between mathematics and music. Historical connections will be studied, as well as the mathematics behind acoustics, rhythm, and 20th century music, and mathematical theories of randomness, leading to fractal music and fractal noise. The mathematical structures behind non-Western musical theories such as pentatonic and quarter-tone scalings, and polyrhythms will be explored.

MTH 120 three credits **M**
Quantitative Reasoning
Prerequisite: Satisfactory score on mathematics placement exam
Fundamentals of quantitative literacy including inductive-deductive reasoning, paradoxes, and problem-solving strategies. Numeracy including estimation, scaling, uncertainty, and infinity will be discussed. Rate of change, linear and exponential models will be explored. Applications of quantitative reasoning to the social sciences will be emphasized.

MTH 121 three credits **M**
Women in Mathematics
Prerequisite: Satisfactory score on mathematics placement exam
Developing math literacy through a study of the lives and work of notable women mathematicians. Six women mathematicians, from Hypatia to Emmy Noether, are discussed at length, with emphasis on obstacles faced and equity issues. The fields in which they worked are introduced along with sample problems. Topics include conic sections, Diophantine equations, Fibonocci sequences, partial differential equations, and other concepts. As a final project, students are expected to research an additional notable woman mathematician and present her work and life.

MTH 131 three credits **M**
Pre-calculus
This course is designed to provide students with the precalculus background necessary for MTH 111 or MTH 105. The course covers topics in algebra, trigonometry and finite mathematics.

MTH 181/182 three credits each
Introduction to Discrete Structures I, II
Review of set algebra including mappings and relations, algebraic structures including semigroups and groups. Elements of the theory of directed and undirected graphs. Boolean algebra and propositional logic. Applications of these structures to various areas of computers.

MTH 204 three credits
Computational Experiments in the Mathematical Sciences
This is an introductory course aimed at helping students develop the skills necessary to do computational research in the mathematical sciences. Students will work individually and in groups on assigned projects. They will write up their results and post them on a Web site accessible to all in the class. The course work will be broken up into ten or more units each of which will explore an area or application of mathematics using software tools such as MATLAB or Maple. Typical topics include: iterations and fixed points, Fibonnaci numbers, fractals, the Google PageRank, magic squares and mathematical recreations, predator prey models, and computer animation.

MTH 211 four credits
Analytic Geometry and Calculus III
Prerequisite: MTH 112
Continuation of MTH 112. Two and three dimensional vectors, partial differentiation, multiple integrals and applications.

MTH 212 three credits
Differential Equations I
Prerequisite: MTH 112
Continuation of MTH 211. Ordinary differential equations of the first order, linear differential equations of the nth order, some nonlinear second order equations, series solutions and Laplace transforms.

MTH 213 four credits
Calculus for Applied Science and Engineering III
Prerequisite: MTH 114
Continuation of MTH 114. An introduction to multivariable and vector calculus. The course covers multivariable functions, partial differentiation, multiple integrals, parameterized curves and surfaces, vector fields, line integrals, flux and divergence. This course, a version of MTH 211 for the integrated freshman year curriculum in engineering, may be repeated as MTH 211.

MTH 221 three credits
Linear Algebra
Prerequisite: MTH 111
Required of all second-year mathematics majors and recommended for students in the physical, natural, behavioral and management sciences. Course material includes systems of linear equations, matrix theory, vector spaces, linear transformations, Eigenvalues.

MTH 231 three credits
Elementary Statistics I
Prerequisite: MTH 101 or equivalent
Fundamental business statistics. The text, examples, and applications are all business-oriented. The first-semester topics include

descriptive statistics, probability, estimation, statistical inference and sampling.

MTH 232 three credits
Elementary Statistics II
Prerequisite: MTH 231
Continuation of MTH 231. Regression and correlation analysis. Analysis of variance. Goodness-of-fit tests. An introduction to Bayesian decision methods.

MTH 298 one to six credits
Experiential Learning
Prerequisites: At least sophomore standing; permission of the instructor, department chairperson, and college dean
Work experience at an elective level supervised for academic credit by a faculty member in an appropriate academic field. Conditions and hours to be arranged. Graded CR/NC. For specific procedures and regulations, see section of catalogue on Other Learning Experiences.

MTH 302 three credits
Theory of Numbers
A study of the integers, divisibility properties, diophantine equations, congruences, quadratic residues, Pythagorean triangles and selected higher topics.

MTH 310 three credits
Modern Methods in Mathematics Teaching
Prerequisite: mathematics major
The use of techniques and materials in teaching the mathematical sciences in grades 8-12. Special attention will be given to new information technology and its use in enhancing learning and problem-solving abilities. This course will concentrate on the integration of commercially-available computer software into the mathematics curriculum in algebra, geometry, statistics, and precalculus, as well as with more traditional materials. This course is for mathematics majors intending to teach.

MTH 311 three credits
Advanced Calculus I
Prerequisite: MTH 212
This course is a rigorous analysis of the concept of limits, continuity, the derivative and other selected areas.

MTH 312 three credits
Advanced Calculus II
Prerequisite: MTH 311
Continuation of MTH 311 with emphasis on uniform convergence and related topics.

MTH 331 three credits
Probability
Prerequisite: MTH 112
A calculus-based introduction to statistics. This course covers probability and combina- torial problems, discrete and continuous random variables and various distributions including the binomial, Poisson, hyper- geometric normal, gamma and chi-square. Moment generating functions, transforma- tion and sampling distributions are studied.

MTH 332 three credits
Mathematical Statistics
Prerequisite: MTH 331
Continuation of MTH 331. Classical estimation methods and hypothesis testing are studied. This course also covers Chi square tests for goodness-of-fit and independence, regression and correlation analysis, and one-way and two-way analysis of variance including factorial designs and tests for the separation of means.

MTH 353 three credits
Applied Linear Algebra
Prerequisites: MTH 221, CIS 261
Orthogonality and least square problems. Other topics include applications of eigenvalue, quadratic forms, Numerical Linear Algebra.

MTH 361 three credits
Numerical Analysis I
Prerequisites: MTH 221, 212, CIS 261, (MTH 221 may be taken concurrently)
Theory and computer-oriented practice in obtaining numerical solutions of various problems. Topics include stability and conditioning, nonlinear equations, systems of linear equations, interpolation and approximation theory.

MTH 362 three credits
Numerical Analysis II
Prerequisite: MTH 361
Numerical methods for solving initial value problems. Topics include: numerical differentiation and integration, Euler method and Taylor's series method, Runge-Kutta methods, multi-step methods, and stiff equations.

MTH 421 three credits
Complex Analysis
Prerequisite: MTH 211
Analytic functions, differentiation, integration, conformal mapping, calculus of residues and infinite series.

MTH 441 three credits
Modern Algebra I
Prerequisite: MTH 221
The study of relations, functions, groups, rings and fields.

MTH 463 three credits
Math Modeling
Selected topics from the areas of linear programming, dynamic programming, Markov chains and game theory. Mathematical model building will be developed through the use of numerous case studies from the natural and social sciences, e.g., ecological models, network models, scheduling models, urban structure, traffic flow, growth, etc.

MTH 471 three credits
Partial Differential Equations
Prerequisite: MTH 212
Introduction to partial differential equations. Topics include: the classification of partial differential equations, the heat equation, the potential equation, separation of variables, Fourier series, the wave equation, and Sturm-Liouville eigenvalue problems.

Math 472 three credits
Numerical Methods for Partial Differential Equations
Prerequisites: MTH 362, 471; or permission of instructor
Numerical methods for solving parabolic, hyperbolic, and elliptic partial differential equations. The course emphasizes the concepts of consistency, convergence, and stability. Topics include: implicit and explicit methods, truncation error, Von Neumann stability analysis, and the Lax equivalence theorem.

MTH 473 three credits
Numerical Linear Algebra
Prerequisite: MTH 353, 361; or permission of instructor
Introduction to numerical linear algebra. Numerical linear algebra is fundamental to all areas of computational mathematics. This course will cover direct numerical method for solving linear systems and linear least squares problems, stability and conditioning, computational methods for finding eigenvalues and eigenvectors, and iterative methods for both linear systems and eigenvalue problems.

MTH 474 three credits
Numerical Optimization
Prerequisites: MTH 353, 361; or permission of instructor
Introduction to constrained and unconstrained optimization. Numerical optimization is an essential tool in a wide variety of applications. The course covers fundamental topics in unconstrained optimization and

also methods for solving linear and nonlinear constrained optimization problems.

MTH 487 three credits
Mathematical Inquiry I
Prerequisite: MTH 212
Course is conducted as a seminar. An elementary question is posed to the students who must generate their own mathematics in an attempt to find a solution. The aim is to develop student independence and creativity.

MTH 488 three credits
Mathematical Inquiry II
Prerequisite: MTH 212
A second semester of inquiry, independent of the first.

MTH 495 variable credit
Independent Study
Prerequisites: Upper-division standing; permission of instructor, department chairperson, and college dean
Study under the supervision of a faculty member in an area not otherwise part of the discipline's course offerings. Conditions and hours to be arranged.

MTH 196, 296, 396, 496 three credits
Directed Study
Prerequisites: Permission of the instructor, department chairperson, and college dean
Study under the supervision of a faculty member in an area covered in a regular course not currently being offered. Conditions and hours to be arranged.

MTH 499 three credits
Selected Topics in Mathematics
Prerequisites: MTH 212 and permission of department
A special course to meet the needs of students for material not encountered in other courses. Topics dealt with require the approval of the departmental chairperson.

Graduate Courses in Mathematics and Mathematics Education

MTH 508 three credits **M**
Math for Elementary Teachers
Problems of the changing modern mathematics curriculum. Current issues, attitudes, and learning theories will be studied, including the mathematical foundations of the elementary school curriculum.

MTH 509 three credits
Statistics for Teachers
Prerequisite: Permission of instructor or MTH 507
Statistics for Teachers surveys the statistical methods used in science and everyday life and addresses the problem of pedagogy and statistical misconceptions. The course also examines the modern educational technology and software used in statistics.

MTH 511 three credits
Calculus and Analysis for Teachers
Prerequisite: Permission of instructor or undergraduate calculus
Calculus and Analysis for Teachers assumes successful completion of a standard university calculus sequence. It addresses the key underlying idea of the mathematics change: notions of variation, rate, mean value, and accumulation across many contexts and representations, as well as the connections between rates and accumulation as embodied in the Fundamental Theorem of Calculus. It also addresses relations between discrete and continuous models of change, including conceptions of limit.

MTH 520 three credits
Discrete Math for Teachers
Prerequisite: Permission of instructor or modern algebra
Topics in Discrete Mathematics, including combinatorics, logic and set theory, algorithms, linear algebra, relations and functions, elements of number theory, and chaos/fractals. The focus will be on the connections and deep structural themes unifying these areas, and on using discrete math to gain a deeper understanding of high-school algebra and calculus.

MTH 522 three credits
Algebraic Structures for Teachers
Prerequisite: Permission of instructor or undergraduate algebra
Algebraic Structures for Teachers examines the many forms of algebraic reasoning and their conceptual underpinnings, the fundamental shift in the place of algebra in school mathematics, and the potential unifying role of abstract and general algebraic structures at the upper secondary level. The course will engage students in vigorous critique of traditional and innovative algebra learning materials and technologies.

MTH 530 three credits
Technology in Mathematics Education
Prerequisite: MTH 211 or enrollment in MAT program
Relevant contemporary mathematics investigated through new innovative technologies in an inquiry-based classroom. Explores non-Euclidean geometries, stereographic projection, and the complex plane using dynamic geometry environ- ments, nonlinear dynamical systems using Chaotic Waterwheels, and parametric variation using new hardware infrastruc- tures, as well as multi-dimensional math- ematics using graphing software and haptic technology.

MTH 540 three credits
Mathematical Challenges
Developing understanding of student mathematical learning and needs through the completion of mathematical challenges. Each week a new challenge will be set with hints offered at various times. Each challenge will not have a straightforward solution, and the class is expected to develop personal insights into the nature of their mathematical behavior and relate these reflections to practice. An email discussion list and website will facilitate continued inquiry and sharing of ideas outside of class.

MTH 591/2 three credits
Topics in Mathematics for Teachers
Prerequisite: Permission of instructor Individual and/ or group study under supervision of a faculty member in an area of mathematics for teachers that is not otherwise part of graduate course offerings.

MTH 572 three credits
Numerical Methods for Partial Differential Equations
See MTH 472.

MTH 573 three credits
Numerical Linear Algebra See MTH 473.

MTH 574 three credits
Numerical Optimization See MTH 474.