

# MATHEMATICS BA, BS AND MINORS

## Mathematics

College of Science, Engineering & Technology  
Department of Mathematics and Statistics  
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Website: [www.cset.mnsu.edu/dept/mathstat/](http://www.cset.mnsu.edu/dept/mathstat/)

Chair: Charles W. Waters

Faculty: Francis T Hannick, Jonathan Harper, In-Jae Kim, Namyong Lee, Hyekyung Min, Galkande Premarathna, Mezbahur Rahman, Brandon Rowekamp, Deepak Sanjel, Soo Yeon Shin, Dan Singer, Yea-Ling Tsao, Chia-Chi Tung, Hongxia Yin, Han Wu, Ruijun Zhao, Ke Zhu, Mark Zuiker

Mathematics in its purest form is an art concerned with ideas. The Department of Mathematics believes that an undergraduate major should be both an introduction to more advanced study and a survey of the many facets of mathematics. From the profound insights of Thales to the undecidability of Godel, from the intuitive to the rigorous, from the abstract to the applied, with a solid emphasis on both the discrete and the continuous cases, the department expects all majors to be engaged in a wide range of mathematical ideas.

Unlike many other disciplines, mathematics is a very structured subject. Consequently, the curriculum consists of sequences of interrelated courses which must be taken in the appropriate order. The department expects that the well prepared student will complete the mathematics major in four years.

The Department offers three mathematics majors and two minors. The primary focus of the B.S. Mathematics Teaching program is to prepare students to teach mathematics at the middle and secondary levels. The B.A. Mathematics and B.S. Mathematics programs are intended to prepare students for advanced study in mathematics or to work in business, industry, or government. The mathematics minor is intended for non-mathematics majors who desire a stronger background in mathematics. The Actuarial Science Minor combines finance, statistics, and mathematics to analyze risk and ensure financial security for individuals, corporations and society at large.

### Academic Map/Degree Plan at [www.mnsu.edu/programs/#All](http://www.mnsu.edu/programs/#All)

#### POLICIES/INFORMATION

**Admission to Major** is required to enroll in 300 and 400 level courses. Admission is granted by the Department. Admission requirements are:

- A minimum of 32 earned semester credit hours and a 2.0 minimum cumulative GPA
- Completion of 8 credits of mathematics in courses numbered MATH 121 or higher
- A minimum 2.5 cumulative GPA in mathematics courses.

Contact the College of Science, Engineering and Technology Student Relations Office for application procedures.

**Accelerated Combined Degree (BS and MA/MS) Program.** Students intending to complete their Bachelor's and Master's degree at Minnesota State Mankato may be granted permission to take classes that count toward their graduate program during their undergraduate studies. Admission to the program is conducted through the department. Upon being accepted, students will be assigned an advisor to aid in the design of an accelerated program of study (generally 5 years). Students must maintain a minimum 3.0 GPA overall and a 3.6 in major (as an undergraduate) to continue in the program. Please contact the Department Graduate Coordinator for detailed information.

**Course Application Policy.** Within each major or minor, no course may be applied to more than one requirement.

**Residency Policy.** At least 3 credits applied to the mathematics minor must be earned at Minnesota State Mankato.

**GPA Policy.** Mathematics majors or minors must earn a grade of "C" (2.0) or better in all courses taken for grade that are applied to the major or minor, respectively.

**P/N Grading Policy.** Not more than one-fourth of the credits in mathematics courses numbered MATH 121 or above can be taken under P/N and applied to a major or minor. All 300 and 400 level courses are offered for grade only with the exception of MATH 487, MATH 498, and MATH 499, which are available for both P/N and letter grade.

**Credit by Examination.** Credit by examination will not be approved for courses in which a student has already received a grade.

**Credit Limitations.** A student may accumulate a maximum of six credits from MATH 110 and the College Level Examination Program (CLEP). After completing MATH 122 with a grade of "C" or better, a student may not receive credit for MATH 110, MATH 112, MATH 113, MATH 115, or MATH 180 without the consent of the department. Since the following courses have some common content, credit is not allowed for both MATH 115 and either MATH 112 or MATH 113. A student may not receive credit for MATH 354 or STAT 354 after completing MATH 455 or STAT 455.

**Policy:** Students seeking enrollment in Math 112: College Algebra or Math 201: Elements of Mathematics must demonstrate readiness to succeed in the course through one of the following means:

1. ACT mathematics sub-score of 22 or higher, or
2. ACCUPLACER Intermediate Algebra Test score of 60 or higher

Students not meeting one of these requirements are placed in Math 098: Intermediate Algebra.

Students seeking enrollment in courses beyond those listed above must demonstrate readiness to succeed in the course through one of the following means: ACT score, SAT score, ACCUPLACER score(s), or satisfactory completion (i.e. grade of C or better) of prerequisite coursework, according to the chart below.

| Course   | Minimum ACT/SAT Math Subscore |    | Minimum Accuplacer Intermediate Algebra Score |     | Minimum Accuplacer College Level Math Score |     | Minimum Accuplacer Calculus Readiness Score |    | Course Prerequisites                                 |
|----------|-------------------------------|----|---|-----|---|-----|---|----|--|
| Math 112 | 22/520                        | OR | 60  |     | N/A   |     | N/A   | OR | Successful Completion of Math 098                    |
| Math 113 | 22/520                        | OR | 60  | AND | 84  |     | N/A   | OR | Math 112 with "C" or better                          |
| Math 115 | 23/530                        | OR | 60  | AND | 96  |     | N/A   | OR | Math 98 and permission from Dept. Chair              |
| Math 121 | 24/550                        | OR | 60  | AND | 84  | AND | 21  | OR | Math 115 or both Math 112 and 113 with "C" or better |
| Math 130 | 23/530                        | OR | 60  | AND | 84  |     | N/A   | OR | Math 112 or Math 115 with a "C" or better            |
| Math 181 | 23/530                        | OR | 60  | AND | 84  |     | N/A   | OR | Math 112 or Math 115 with a "C" or better            |
| Math 201 | 22/520                        | OR | 60  |     | N/A   |     | N/A   | OR | Successful Completion of Math 098                    |
| Stat 154 | 19/460                        | OR | 60  |     | N/A   |     | N/A   | OR | Successful Completion of Math 098, 112, 115, or 121  |

Students who earned an SAT Math score of 530 or higher are eligible to place in MATH 112 as a minimum. Please contact the Department of Mathematics & Statistics for further placement information when using SAT scores.

Students who earned a Minnesota Comprehensive Assessment (MCA) score of 1158 or higher are eligible to place in Math 112 as a minimum. An earned MCA score

of 1148 or higher is eligible to place in STAT 154. Please contact the Department of Mathematics & Statistics for further placement information when using MCA scores.

**Procedures:** Students may substitute for the above requirements based on documentation of:

1. equivalent or higher scores on standardized college admissions tests, such as SAT quantitative scores, that report a separate mathematics sub-score within two calendar years;
2. successful completion of equivalent prior post-secondary education, such as course transfer evaluations or Cambridge International Examinations; or
3. enrollment exclusively in non-credit courses or programs.

Students requesting such substitutions should submit the documentation to the Chair of the Department of Mathematics and Statistics for evaluation. The evaluation will be based on nationally accepted concordances between the testing instruments and/or courses. The Chair of the Department of Mathematics and Statistics or designee should respond in writing to student requests within three weeks of receiving them.

#### Procedure for Waiver

1. Students not meeting the requirements for enrollment in Math 112, Math 201 or Stat 154 may request a waiver to this policy.
2. Written requests for waivers to the policy must be submitted to the Chair of the Department of Mathematics and Statistics, and should include evidence of alternate means of demonstrating readiness for college algebra including but not limited to:
  - a. High school or recent post-secondary coursework which would indicate adequate preparation (transcripts or other records which include course titles, levels and grades are acceptable), or
  - b. Verification of extenuating circumstances which may have affected performance on previous exams.
3. Requests for waivers should be submitted by the following deadlines:
  - a. August 5th for fall semester enrollment,
  - b. December 1st for spring semester enrollment, and
  - c. May 1st for summer session enrollment.
4. The Chair of the Department of Mathematics and Statistics or designee should respond in writing to student requests within three weeks of receiving them.
5. Students whose initial requests are denied may submit a written appeal to the Dean of the College of Science, Engineering and Technology. The Dean should respond in writing, with a copy to the Chair of the Department of Mathematics and Statistics.
6. The Dean's decision is the final step in this appeal process

**Policy Rationale:** The purpose of the policy is to place students in a course that is developmentally appropriate to help ensure their long term success. Data suggests students not meeting these guidelines have a higher likelihood of having to repeat a course.

#### MATH BA

Degree completion = 120 credits

#### Required General Education

MATH 121 Calculus I (4)  
MATH 290 Foundations of Mathematics (4)

#### Major Common Core

MATH 122 Calculus II (4)  
MATH 170 Introduction to Mathematical Software Programming (3)  
MATH 223 Calculus III (4)  
MATH 247 Linear Algebra I (4)  
MATH 316 Intermediate Analysis (3)  
MATH 345 Abstract Algebra I (4)  
MATH 375 Introduction to Discrete Mathematics (4)  
MATH 492W Mathematics Capstone Experience (3)

**Note:** MATH 492 can substitute for MATH 492W

#### Major Restricted Electives

(Choose a minimum of 12 credits from the following; at least seven (7) credits must be at the 400 level)

MATH 321 Ordinary Differential Equations (4)  
MATH 332 College Geometry (4)  
MATH 354 Concepts of Probability & Statistics (4)  
MATH 402 Introduction to Topology (4)  
MATH 411 Introduction to Complex Variables (4)  
MATH 417 Real Analysis I (4)  
MATH 418 Real Analysis II (3)

MATH 422 Partial Differential Equations (4)  
MATH 425 Mathematical Modeling (4)  
MATH 428 Linear Optimization Methods (4)  
MATH 435 Modern Geometry (4)  
MATH 442 Theory of Numbers (4)  
MATH 446 Abstract Algebra II (4)  
MATH 447 Linear Algebra II (3)  
MATH 455 Theory of Statistics I (4)  
MATH 456 Theory of Statistics II (4)  
MATH 460 Actuarial Applications in Probability (3)  
MATH 461 Mathematical Theory of Interest (4)  
MATH 470 Numerical Analysis I (4)  
MATH 471 Numerical Analysis II (4)  
MATH 480 History of Mathematics (3)

STAT 354, STAT 455 and STAT 456 can substitute for MATH 354, MATH 455 and MATH 456, respectively.

#### Other Graduation Requirements

Language (8 credits)

**Required Minor. Yes. Any.**

#### MATH BS

Degree completion = 120 credits

#### Required General Education

MATH 121 Calculus I (4)  
MATH 290 Foundations of Mathematics (4)

#### Major Common Core

MATH 122 Calculus II (4)  
MATH 170 Introduction to Mathematical Software Programming (3)  
MATH 223 Calculus III (4)  
MATH 247 Linear Algebra I (4)  
MATH 316 Intermediate Analysis (3)  
MATH 321 Ordinary Differential Equations (4)  
MATH 345 Abstract Algebra I (4)  
MATH 375 Introduction to Discrete Mathematics (4)  
MATH 492W Mathematics Capstone Experience (3)  
MATH 492 may substitute for MATH 492W

#### Major Restricted Electives

Choose a minimum of eleven (11) credits. At least seven (7) credits must be at the 400-level. Credits must be chosen from at least two categories.

#### Applied Mathematics

Choose 0 - 12 Credit(s).

MATH 422 Partial Differential Equations (4)  
MATH 425 Mathematical Modeling (4)  
MATH 428 Linear Optimization Methods (4)  
MATH 470 Numerical Analysis I (4)  
MATH 471 Numerical Analysis II (4)

#### Algebra

Choose 0 - 12 Credit(s).

MATH 442 Theory of Numbers (4)  
MATH 446 Abstract Algebra II (4)  
MATH 447 Linear Algebra II (3)

#### Analysis, Geometry and Topology

Choose 0 - 12 Credit(s).

MATH 332 College Geometry (4)  
MATH 402 Introduction to Topology (4)  
MATH 411 Introduction to Complex Variables (4)  
MATH 417 Real Analysis I (4)  
MATH 418 Real Analysis II (3)  
MATH 435 Modern Geometry (4)

#### Statistics and Finance

Choose 0 - 12 Credit(s).

STAT 354, STAT 455 and STAT 456 may substitute for MATH 354, MATH 455 and MATH 456, respectively.

MATH 354 Concepts of Probability & Statistics (4)  
MATH 455 Theory of Statistics I (4)  
MATH 456 Theory of Statistics II (4)  
MATH 460 Actuarial Applications in Probability (3)  
MATH 461 Mathematical Theory of Interest (4)

## Major Unrestricted Electives

Choose 0-10 Credit(s).

|      |     |   |
|------|-----|---|
| MATH | 332 | College Geometry (4)                      |
| MATH | 354 | Concepts of Probability & Statistics (4)  |
| MATH | 402 | Introduction to Topology (4)              |
| MATH | 411 | Introduction to Complex Variables (4)     |
| MATH | 417 | Real Analysis I (4)                       |
| MATH | 418 | Real Analysis II (3)                      |
| MATH | 422 | Partial Differential Equations (4)        |
| MATH | 425 | Mathematical Modeling (4)                 |
| MATH | 428 | Linear Optimization Methods (4)           |
| MATH | 435 | Modern Geometry (4)                       |
| MATH | 442 | Theory of Numbers (4)                     |
| MATH | 446 | Abstract Algebra II (4)                   |
| MATH | 447 | Linear Algebra II (3)                     |
| MATH | 455 | Theory of Statistics I (4)                |
| MATH | 456 | Theory of Statistics II (4)               |
| MATH | 460 | Actuarial Applications in Probability (3) |
| MATH | 461 | Mathematical Theory of Interest (4)       |
| MATH | 470 | Numerical Analysis I (4)                  |
| MATH | 471 | Numerical Analysis II (4)                 |
| MATH | 480 | History of Mathematics (3)                |

STAT 354, STAT 455 and STAT 456 may substitute for MATH 354, MATH 455 and MATH 456, respectively.

## Minor

Required Minor. Yes. Any.

### MATH MINOR

#### Required for Minor

|      |     |                      |
|------|-----|----------------------|
| MATH | 121 | Calculus I (4)       |
| MATH | 122 | Calculus II (4)      |
| MATH | 247 | Linear Algebra I (4) |

#### Required for Minor (Electives, 7 credits)

(choose 7 credits from any courses listed for the BA and BS major)  
(see Residency Requirement)

### ACTUARIAL MINOR

#### Minor Core

Mathematics (choose 8 credits)

|      |     |                 |
|------|-----|-----------------|
| MATH | 121 | Calculus I (4)  |
| MATH | 122 | Calculus II (4) |

Statistics (choose 6-7 credits)

(Select 2 courses from the following)

|      |     |  |
|------|-----|--|
| STAT | 354 | Concepts of Probability & Statistics (4) |
| STAT | 450 | Regression Analysis (3)                  |
| STAT | 455 | Theory of Statistics I (4)               |

Finance (choose 6 credits)

|      |     |                      |
|------|-----|----------------------|
| FINA | 362 | Business Finance (3) |
| FINA | 460 | Investments (3)      |

#### Elective

Finance Electives (choose 3 credits)

|      |     |                                   |
|------|-----|-----------------------------------|
| FINA | 467 | Insurance and Risk Management (3) |
| FINA | 480 | Options and Futures (3)           |

(see Residency Requirement)

#### Recommended Courses

Along with the above courses, the following courses satisfy aspects the VEE (Validation of Educational Experience) of the professional societies associated to actuarial science. Students taking these additional courses may apply them towards becoming certified in the three areas of the VEE: economics, applied statistical methods and corporate finance.

|      |     |                                  |
|------|-----|----------------------------------|
| ECON | 201 | Principles of Macroeconomics (3) |
| ECON | 202 | Principles of Microeconomics (3) |
| MATH | 223 | Calculus III (4)                 |
| STAT | 458 | Categorical Data Analysis (3)    |

## COURSE DESCRIPTIONS

### **MATH 094 (4) Essential Mathematics with Elementary Algebra**

Basic mathematics skills integrating the fundamental operations of whole numbers, integers, fractions, decimals, percents, ratio and proportion with the elementary algebra topics of linear equations and inequalities, graphs, exponents, polynomials and factoring. Credit does not apply toward graduation. P/N only.  
Summer

### **MATH 098 (4) Intermediate Algebra**

Topics covered include intermediate study of graphs, systems of linear equations, introduction to functions, linear and nonlinear inequalities, factoring, rational expressions and equations, radicals, and basic quadratic equations. Credit does not apply toward graduation.  
P/ N only  
Fall, Spring, Summer

### **MATH 110 (3) Perspectives in Mathematics**

A survey of mathematics and its relationship to society, showing its development and evolution to meet the needs of humankind.  
Prerequisite: Three years high school algebra/geometry or MATH 098  
Fall, Spring, Summer  
GE-4

### **MATH 112 (4) College Algebra**

Concepts of algebra (real numbers, exponents, polynomials, rational expressions), equations and inequalities, functions and graphs, polynomial and rational functions, exponential and logarithmic functions, systems of equations and inequalities, matrices and determinants, conic sections, sequences and series, probability, and binomial theorem. Prerequisite: Satisfy Placement Table in this section, or MATH 098 with grade of P.  
Fall, Spring, Summer  
GE-4

### **MATH 113 (3) Trigonometry**

Basic concepts of trigonometry as preparation for college level mathematics and science course work. Topics include concepts of algebra (real numbers, functions, graphs of functions, exponential and logarithmic functions), trigonometric functions, analytic trigonometry, applications of trigonometry, and analytic geometry. Prerequisite: Satisfy Placement Table in this section, or MATH 112 with "C" (2.0) or better.  
Fall, Spring, Summer  
GE-4

### **MATH 115 (4) Precalculus Mathematics**

This course will cover topics of precalculus mathematics. Topics covered will include functions, graphs of functions, exponential and logarithmic functions, conic sections, systems of equations, and inequalities, matrixes, trigonometric functions, circular functions, vectors and complex numbers, induction, series, and probability. Prerequisite: Satisfy Placement Table in this section, or grade of P in MATH 098 and consent of the department chair.  
Fall, Spring  
GE-4

### **MATH 121 (4) Calculus I**

Limits, continuity, the derivative and applications, transcendental functions, L'Hopital's Rule, and development of the Riemann integral. Prerequisite: Satisfy Placement Table in this section, MATH 115 or both MATH 112 and MATH 113 with "C" (2.0) or better.  
Fall, Spring, Summer  
GE-4

### **MATH 122 (4) Calculus II**

Techniques of integration, applications of integration, improper integrals, numerical integration, the calculus of parametric curves, infinite series and sequences, and vectors in two and three dimensions. Prerequisite: MATH 121 with "C" (2.0) or better or consent  
Fall, Spring, Summer

### **MATH 127 (2) Calculus II for Engineering Technology: Integration**

A continuation of the study of calculus from MATH 121 including transcendental functions, L'Hopital's rule, techniques of integration, and vectors in two and three dimensions. Content is intended for students enrolled in any engineering technology program. Credit for both MATH 127 and MATH 122 is not allowed. Prerequisite: MATH 121 with "C" (2.0) or better or consent  
Fall

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**MATH 130 (4) Finite Mathematics and Introductory Calculus**

This course develops concepts and skills in algebra and introductory calculus needed to model applications in business, economics, social sciences and life sciences, using polynomials, exponentials, logarithms, linear systems, linear programming, sequences, series, derivatives and integrals.

Prerequisite: Satisfy Placement Table in this section, or grade of "C" (2.0) or better in either MATH 112 or MATH 115.

Fall, Spring, Summer  
GE-4

**MATH 170 (3) Introduction to Mathematical Software Programming**

Students will learn the rudiments of algorithmic processes such as iteration and recursion and implement simple mathematical algorithms in a commonly used mathematical software package. Applications may include graphing, equation solving, numerical approximation, recurrence relations, and generation of mathematical objects such as sets, lists, permutations and trees.

Prerequisite: MATH 121

Fall (On Demand), Spring (On Demand)

**MATH 180 (4) Mathematics for Computer Science**

This course is an introduction to the mathematical concepts needed in computer science, including sets, logic, representations of numbers, counting techniques, discrete functions, matrices, trees and graphs, and algorithm analysis.

Prerequisite: MATH 112 or equivalent, with "C" (2.0) or better, or consent

Spring  
GE-4

**MATH 181 (3) Intuitive Calculus**

This course presents the concepts of the differential and integral calculus from an intuitive (non-theoretical) point of view. The course emphasis is on the applications of the calculus. Credit for both MATH 181 and MATH 121 is not allowed.

Prerequisite: Satisfy Placement Table in this section, or Math 112 with "C" (2.0) or better.

Fall, Spring

GE-4

**MATH 201 (3) Elements of Mathematics I**

Nature of mathematics from a problem solving approach using sets, relations, number systems through integers, rational numbers and discrete mathematics.

Prerequisite: Satisfy Placement Table in this section, or MATH 098 with grade of P.

Fall, Spring

GE-4

**MATH 202 (3) Elements of Mathematics II**

A continuation of MATH 201, including rational and real number systems, informal geometry and measurement, statistics, and probability.

Prerequisite: MATH 201, with "C" (2.0) or better or consent

Fall, Spring

**MATH 203 (3) Elements of Math III**

Transformational and Euclidean geometry, coordinate geometry and applications of discrete mathematics.

Prerequisite: MATH 202 with "C" (2.0) or better or consent

Spring

**MATH 223 (4) Calculus III**

Surfaces, vector-valued functions, partial differentiation, multiple integration, and vector calculus.

Prerequisite: MATH 122 with "C" (2.0) or better, or consent

Fall, Spring

**MATH 247 (4) Linear Algebra I**

Matrices, determinants, systems of linear equations, vector spaces, linear transformations, and characteristic value problems.

Prerequisite: MATH 122 with "C" (2.0) or better or consent

Fall, Spring, Summer

**MATH 290 (4) Foundations of Mathematics**

Logic, proof techniques, set theory, relations, functions, cardinality, operations, and an introduction to mathematical structures and number theory.

Prerequisite: MATH 122 with "C" (2.0) or better or consent.

Fall, Spring

GE-2

**MATH 293 (1) MAX Scholar Seminar**

This class provides MAX scholars with an opportunity to explore a set of topics related to achieving success in academic, professional and personal realms. Speakers will include faculty, graduate students, visiting researchers and industry members as well as student participants. Cannot be used towards a math major.

Prerequisite: Recipient of a MAX scholarship or instructor consent.

Fall, Spring

**MATH 316 (3) Intermediate Analysis**

Limits, sequences, continuity, and differentiation of a real valued function of a real variable.

Prerequisite: MATH 223 and MATH 290 with "C" (2.0) or better or consent

Spring

**MATH 321 (4) Ordinary Differential Equations**

This course presents the theory, computations, and applications of first and second order differential equations and two-dimensional systems.

Prerequisite: MATH 122 with "C" (2.0) or better or consent

Fall, Spring, Summer

**MATH 332 (4) College Geometry**

This course covers several geometric systems including Euclidean, non-Euclidean, transformational and projective. Other topics studied are topological properties and the relationship between coordinate and synthetic geometry.

Prerequisite: MATH 290 with "C" (2.0) or better or consent

Fall

**MATH 345 (4) Abstract Algebra I**

An introduction to the theory of groups and rings; including polynomial rings, homomorphisms, isomorphisms, and concepts of normal subgroups, ideals, quotient groups, and quotient rings.

Prerequisite: MATH 290 with "C" (2.0) or better or consent

Fall

**MATH 354 (4) Concepts of Probability & Statistics**

This is a calculus-based course covering introductory level topics of probability and statistics. It is designed to meet the needs of both the practitioner and the person who plans further in-depth study. Topics include probability, random variables and probability distributions, joint probability distributions, statistical inference (both estimation and hypothesis testing), analysis of variance, regression, and correlation. Same as STAT 354.

Prerequisite: MATH 122 with "C" (2.0) or better or consent

Fall, Spring, Summer

**MATH 375 (4) Introduction to Discrete Mathematics**

An introduction to the concepts fundamental to the analysis of algorithms and their realization. Topics will include combinatorics, generating functions, recurrence relations, graph theory, and networks.

Prerequisite: MATH 247 and MATH 290 with grade of "C" (2.0) or higher.

Fall, Spring

**MATH 398 (0) CPT: Co-Operative Experience**

Curricular Practical Training: Co-Operative Experience is a zero-credit full-time practical training experience for one summer and on adjacent fall or spring term. Special rules apply to preserve full-time student status. Please contact an advisor in your program for complete information.

Prerequisite: At least 60 credits earned; in good standing; instructor permission; co-op contract; other prerequisites may also apply.

Fall, Spring, Summer

**MATH 402 (4) Introduction to Topology**

An introduction to topological spaces and their fundamental properties such as compactness, connectedness, separation properties and countability properties. Continuous functions between topological spaces and common examples of topological spaces are also discussed.

Prerequisite: MATH 290 with grade of "C" (2.0) or higher.

On Demand: Spring

**MATH 411 (4) Introduction to Complex Variables**

Algebra and geometry of complex numbers, analytic functions, power series, Cauchy's theorem and residue theorem.

Prerequisite: MATH 223 and MATH 290 with "C" (2.0) or better or consent

Spring (Odd Years)

**MATH 417 (4) Real Analysis I**

The topology of Euclidean spaces, norms, classical inequalities, local and global properties of continuous functions, preservation of compactness and connectedness, sequences in Euclidean space and sequences of functions.

Prerequisite: MATH 223 and MATH 290 with "C" (2.0) or better or consent

Fall

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**MATH 418 (3) Real Analysis II**

A continuation of MATH 417. The course may include topics from metric spaces, Riemann-Stieltjes integration, differentiation in Euclidean space, sequences and series of functions, approximation theorems, implicit and inverse function theorems, equicontinuity, and mapping theorems.

Prerequisite: MATH 417 with "C" (2.0) or better or consent

On Demand: Spring

**MATH 422 (4) Partial Differential Equations**

This course presents the theory, computations, and applications of partial differential equations and Fourier series.

Prerequisite: MATH 223 and MATH 321 with "C" (2.0) or better or consent

Spring (Even Years)

**MATH 425 (4) Mathematical Modeling**

This course presents topics from mathematical analysis of both discrete and continuous models taken from problems in the natural sciences, economics and resource management.

Prerequisite: MATH 223 and MATH 247 with "C" (2.0) or better or consent

Spring (Odd Years)

**MATH 428 (4) Linear Optimization Methods**

Simplex method and its variants, duality, sensitivity analysis, interior-point methods, quadratic programming and linear complementarity problems. Applications such as classification problems and game theory with linear optimization software.

Prerequisite: MATH 122, MATH 247

On Demand: Fall, Spring, Summer

**MATH 435 (4) Modern Geometry**

Geometry of spaces including Euclidean and non-Euclidean and applications of contemporary geometry.

Prerequisite: MATH 332 with "C" (2.0) or better or consent

Fall (On Demand), Spring (On Demand), Summer (On Demand)

**MATH 442 (4) Theory of Numbers**

Euclidean algorithm, primes, composites, number theoretic functions, congruencies, Diophantine equations, Euler and Fermat theorems, algebraic number fields.

Prerequisite: MATH 345 with "C" (2.0) or better or consent

Spring (Even Years)

**MATH 446 (4) Abstract Algebra II**

A continuation of MATH 345. The course will include topics from groups, rings, and fields.

Prerequisite: MATH 345 with "C" (2.0) or better or consent

Fall (On Demand), Spring (On Demand), Summer (On Demand)

**MATH 447 (3) Linear Algebra II**

An in-depth study of linear operators and their related spaces, dimension, rank, matrix representation of linear operators, special matrices, determinants, eigenvectors and eigenvalues.

Prerequisite: MATH 345 with "C" (2.0) or better or consent

Spring

**MATH 455 (4) Theory of Statistics I**

A mathematical approach to statistics with derivation of theoretical results and of basic techniques used in applications. Includes probability, continuous probability distributions, multivariate distributions, functions of random variables, central limit theorem and statistical inference. Same as STAT 455.

Prerequisite: MATH 223 with "C" (2.0) or better or consent

Fall

**MATH 456 (4) Theory of Statistics II**

A mathematical approach to statistics with derivation of theoretical results and of basic techniques used in applications, including sufficient statistics, additional statistical inference, theory of statistical tests, inferences about normal models and nonparametric methods. Same as STAT 456

Prerequisite: MATH 455 / STAT 455 with "C" (2.0) or better or consent

Spring

**MATH 460 (3) Actuarial Applications in Probability**

This course applies probabilistic methods to problems encountered in actuarial science that prepares students for the Society of Actuaries Exam P/1.

Prerequisite: (MATH 354, STATS 354, MATH 455 or STAT 455) and MATH 223

Fall (On Demand), Spring (On Demand), Summer (On Demand)

**MATH 461 (4) Mathematical Theory of Interest**

This course covers the theory of interest portion of Exam FM/2 of the Society of Actuaries. Topics include time value of money, measurement of interest, annuities certain, arithmetic and geometric annuities, amortization schedules and sinking fund, bonds and other securities, yield rates, and interest rate immunization.

Prerequisite: MATH 223

Fall (On Demand), Spring (On Demand), Summer (On Demand)

**MATH 470 (4) Numerical Analysis I**

This course provides an introduction to techniques and analysis involved with solving mathematical problems using technology. Topics included are errors in computation, solutions of linear and nonlinear equations, numerical differentiation and integration, and interpolation.

Prerequisite: MATH 122, MATH 247 with "C" (2.0) or better or consent

Fall

**MATH 471 (4) Numerical Analysis II**

This course is a continuation of MATH 470. Topics included are the algebraic eigenvalue problem, least squares approximation, solutions of systems of nonlinear equations, numerical solutions of ordinary differential equations.

Prerequisite: MATH 470 and MATH 223 with "C" (2.0) or better or consent

On Demand: Spring

**MATH 480 (3) History of Mathematics**

The development of selected topics from before the Hellenistic time period to the late twentieth century. Familiarity with the content of HIST 180W is beneficial.

Prerequisite: MATH 345 with "C" (2.0) or better or consent

Spring (Odd Years)

**MATH 483 (3) Advanced Viewpoint of 5-8 School Mathematics**

Advanced viewpoint of mathematics content and learning theories, teaching strategies, reading strategies, assessments, and planning, teaching and reflecting on grades 5-8 mathematics. Field experiences in grades 5-8 mathematics classroom required.

Prerequisite: MATH 290 with "C" (2.0) or better or consent

Spring

**MATH 484 (3) Technology in 5-12 School Mathematics**

Numerical, verbal, symbolic and graphical representations of quantitative relationships, concatenations in written mathematics, problem solving, dynamic geometry, perspective drawing, parametric equations, geometric probability, transition matrices, statistics and calculus using technology.

Prerequisite: MATH 290 with "C" (2.0) or better or consent

Fall

**MATH 485 (3) Teaching Secondary School Mathematics**

Learning theories, teaching strategies, assessments and planning, teaching and reflecting on secondary (grades 9-12) school mathematics. Field experiences in grades 9-12 mathematics classroom required.

Prerequisite: MATH 290 with "C" (2.0) or better or consent

Fall

**MATH 487 (1) Teaching Experiences in Mathematics**

Student will work with an experienced member of the faculty in teaching a college mathematics course.

**MATH 488 (1-3) Seminar**

A course of study in which a group of students study a topic by examining results through reports and discussions. May be repeated for credit on each new topic.

**MATH 490 (1-4) Workshop**

A short course devoted to a specific mathematical topic. May be repeated for credit on each new topic.

**MATH 491 (1-4) In-Service**

A course designed to upgrade the qualifications of persons on-the-job. May be repeated for credit on each new topic.

**MATH 492 (3) Mathematics Capstone Experience**

This course is designed to allow undergraduate students an opportunity to integrate their undergraduate mathematics experiences by engaging each student in working on a problem in applied or theoretical mathematics. Content will vary by semester. Because of the breadth of mathematics topics needed for successful completion of the course, students need to have senior standing.

Prerequisite: Two of the following: MATH 316, MATH 321, MATH 345, MATH 375 and senior standing (or permission of the instructor). Course can also be taken independent study with permission of a cooperating faculty member.

On Demand: Fall

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**MATH 492W (3) Mathematics Capstone Experience**

This course is designed to allow undergraduate students an opportunity to integrate their undergraduate mathematics experiences by engaging each student in working on a problem in applied or theoretical mathematics. Content will vary by semester. Because of the breadth of mathematics topics needed for successful completion of the course, students need to have senior standing.

Prerequisite: Two of the following: MATH 316, MATH 321, MATH 345, MATH 375 and senior standing (or permission of the instructor). Course can also be taken independent study with permission of a cooperating faculty member.

Fall

**MATH 493 (1) MAX Scholar Seminar**

This class provides MAX scholars with an opportunity to explore a set of topics related to achieving success in academic, professional and personal realms. Speakers will include faculty, graduate students, visiting researchers and industry members as well as student participants. Students will be required to participate in mentoring of lower division MAX scholarship recipients and provide written and oral presentations of various topics during the semester.

Prerequisite: Recipient of a MAX scholarship or instructor consent

Fall, Spring

**MATH 495 (1-4) Selected Topics**

A course in an area of mathematics not regularly offered. May be repeated for credit on each new topic.

**MATH 498 (1-12) Internship**

Provides a student the opportunity to gain expertise and experience in a special field under the supervision of a qualified person.

**MATH 499 (1-4) Individual Study**

Independent individual study under the guidance and direction of a faculty member in mathematics. Special arrangements must be made with an appropriate faculty member. May be repeated for credit on each new topic.