Mathematics

Chair: Larry M. Pearson

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Mary Wiest, 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 courses in mathematics are organized with the needs of three groups of students in mind: (1) those interested in mathematics as a major field of study who may be planning more advanced study in the field, preparing to teach or intending to use their skill in business, industry or government; (2) those needing mathematics primarily as a tool in other disciplines (some special courses and sequences are provided to better meet this need); and (3) those interested in the logical and cultural aspects of mathematics as an element in their general education.

Admission to Major is granted by the department. Minimum university admission requirements are:

- a minimum of 32 earned semester credit hours.
- a minimum cumulative GPA of 2.00 ("C"), including 8 credits in mathematics.

The department expects a student to complete MATH 121 or higher, with a 2.5 GPA in mathematics.

Contact the department for application procedures.

MATH BA, BS

Required for Major (Core, 30-31 credits):

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>MATH 121</td>
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<td>MATH 122</td>
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<tr>
<td>MATH 223</td>
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<td>MATH 247</td>
<td>4</td>
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<td>MATH 290</td>
<td>4</td>
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<tr>
<td>MATH 316</td>
<td>3</td>
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<tr>
<td>MATH 345</td>
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<tr>
<td>MATH 375</td>
<td>4</td>
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</tbody>
</table>

Choose two from the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>MATH 316</td>
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<td>MATH 345</td>
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<td>MATH 375</td>
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<td>MATH 392</td>
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<td>MATH 411</td>
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<td>MATH 417</td>
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<td>MATH 418</td>
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<td>MATH 422</td>
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<td>MATH 471</td>
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<td>MATH 480</td>
<td>4</td>
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<td>MATH 492</td>
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</tbody>
</table>

Required for Major (Electives, 7 credits):

Choose 7 credits from any courses listed for the BA and BS major.

POLICIES/INFORMATION

GPA Policy. Mathematics majors or minors must earn a grade of "C" or better in all courses applied to the major or minor.

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, MATH 121, or higher.

Placement Information for Mathematics Course Enrollment. Students may register for mathematics courses at several different levels, depending on their background in mathematics. Verification of adequate preparation is required for enrollment in MATH 112, MATH 113, MATH 115, MATH 121, or higher. Students planning to register for these courses must achieve a minimum score on the mathematics placement exam (administered at orientation) or a minimum score on the ACT sub-score in math.
Mathematics Placement based on Test Scores

<table>
<thead>
<tr>
<th>Course</th>
<th>Minimum ACT Math Subscore</th>
<th>Minimum Score on Functions and Graphs Placement Test</th>
<th>Minimum Score Intermediate Algebra Placement Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 121 Calculus I</td>
<td>22</td>
<td>16 total 6 (on trig functions)</td>
<td>NA</td>
</tr>
<tr>
<td>Math 115 Pre-Calculus</td>
<td>20</td>
<td>6 (on Algebra functions)</td>
<td>19</td>
</tr>
<tr>
<td>Math 113 Trigonometry</td>
<td>19</td>
<td>6 (on algebra functions)</td>
<td>18</td>
</tr>
<tr>
<td>Math 112 College Algebra</td>
<td>19</td>
<td>NA</td>
<td>18</td>
</tr>
</tbody>
</table>

New transfer students may base their course enrollment on achievement in previously completed pre-requisite courses in mathematics. For further information about placement and mathematics course pre-requisites, students may contact the Department of Mathematics and Statistics or the College’s Student Relations Coordinator.

Advising Suggestions. A person with a major in mathematics is encouraged to have a significant concentration in an area of recognized application. By proper selection of electives and willingness to exceed the required minimum number of credits for graduation, a student may earn a second major in fields such as accounting, business administration, biology, chemistry, computer science, economics, environmental sciences, geography, or physics.

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

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 mankind. Pre: Three years high school algebra/geometry or MATH 098 Fall, Spring 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. Pre: Must achieve a score of 18 or better on the MnSCU Math Readiness Test, or have achieved an ACT Math subscore of 19 or higher, or successful completion of Math 098. Fall, Spring 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. Pre: Must achieve a score of 18 or better on the MnSCU Math Readiness Test, or have achieved an ACT Math subscore of 19 or higher, or successful completion of MATH 098. Fall, Spring 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, matrices, trigonometric functions, circular functions, vectors and complex numbers, induction, series, and probability. Pre: Must achieve the appropriate score on the Intermediate Algebra Placement Test, Functions and Graphs Placement Test or ACT math subscore (see Placement Table). Alternatively, must successfully complete Math 098 and receive permission from the department chair. Fall, Spring GE-4

MATH 121 (4) Calculus I
Limits, continuity, the derivative and applications, and the integral and applications. Pre: MATH 115 or both MATH 112 and MATH 113 with "C" or by Math Placement Score (see Mathematics Placement Policy). Fall, Spring GE-4

MATH 122 (4) Calculus II
Transcendental functions, L'Hopital's rule, techniques of integration, sequences and series, parametric equations and polar coordinates, and vectors in two and three dimensions. Pre: MATH 121 with C or better or consent Fall, Spring

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. Pre: MATH 121 with "C" or better or consent Spring

MATH 128 (2) Calculus II for Engineering Technology: Infinite Series
A continuation of the study of calculus from MATH 127 including infinite series, parametric equations, and polar coordinates. Content is intended for students enrolled in any engineering technology program. Credit for both MATH 128 and MATH 122 is not allowed. Pre: MATH 127 with "C" or better or consent Spring

MATH 130 (3) Finite Math and Its Applications
This course is an introduction to the mathematical concepts needed in business, the social sciences, and the life sciences including problem solving and linear models, linear algebra, linear programming, consumer mathematics, probability and statistics, and decision making. Pre: Must achieve a score of 18 or better on the MnSCU Math Readiness Test, or have achieved an ACT Math subscore of 19 or higher, or successful completion of MATH 098. GE-4

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. Pre: MATH 112 or equivalent, with "C" or better, or consent
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.
Pre: MATH 112 with "C" or better or consent
Fall
GE-4

MATH 184 (3) Mathematical Reasoning
Designed to increase a student's ability to reason quantitatively and to communicate mathematics effectively through verbal, graphical, and symbolic forms. The acquisition of both mathematical skills and higher-order thinking are learning outcomes. Students will learn how technology can be used to solve mathematical problems. An integral part of this course is student interpretation and evaluation of real-data models and contemporary applications. Students will learn modeling strategies and relevant historical perspectives of mathematics.
Pre: Must achieve a score of 18 or better on the MnSCU Math Readiness Test, or have achieved an ACT Math subscore of 19 or higher, or successful completion of MATH 098.
Fall, Spring

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.
Pre: Must achieve a score of 18 or better on the MnSCU Math Readiness Test, or have achieved an ACT Math subscore of 19 or higher, or successful completion of MATH 098.
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.
Pre: MATH 201, with "C" or better or consent
Fall, Spring

MATH 203 (4) Calculus III
Surfaces, vector-valued functions, partial differentiation, multiple integration, and vector calculus.
Pre: MATH 221 with "C" or better, or consent
Fall, Spring

MATH 221 (4) Linear Algebra I
Matrices, determinants, systems of linear equations, vector spaces, linear transformations, and characteristic value problems.
Pre: MATH 202 with "C" or better or consent
Fall, Spring

MATH 223 (4) Calculus III
Surfaces, vector-valued functions, partial differentiation, multiple integration, and vector calculus.
Pre: MATH 202 with "C" 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.
Pre: MATH 202 with "C" or better or consent
Fall, Spring

MATH 290 (4) Foundations of Mathematics
Logic, proof techniques, set theory, relations, functions, cardinality, operations, and an introduction to mathematical structures and number theory.
Pre: MATH 247 with "C" or better or consent
Fall, Spring

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.
Pre: Recipient of a MAX scholarship or instructor consent.
Fall, Spring

MATH 303 (3) Elements of Math III
Transformational and Euclidean geometry, coordinate geometry and applications of discrete mathematics.
Pre: MATH 202 with "C" or better or consent
Spring

MATH 316 (3) Intermediate Analysis
Limits, sequences, continuity, and differentiation of a real valued function of a real variable.
Pre: MATH 223 and MATH 290 with "C" or better or consent
Spring

MATH 318 (3) Ordinary Differential Equations
This course presents the theory, computations, and applications of first and second order differential equations and two-dimensional systems.
Pre: MATH 222 with "C" or better or consent
Fall, Spring

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.
Pre: MATH 290 with "C" 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.
Pre: MATH 290 with "C" or better or consent
Fall

MATH 354 (3) 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.
Pre: MATH 122 with "C" or better or consent
Fall, Spring

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.
Pre: MATH 247 with "C" or better or consent
Fall, Spring

MATH 392 (4) Topology of Euclidean Spaces
Metric spaces, topology of Euclidean spaces, compactness in metric spaces, and Euclidean n-space.
Pre: MATH 290 with "C" or better or consent

MATH 399 (1-4) Special Topics
A special course offering in mathematics not represented by other course numbers. Topics may vary from semester to semester. Course may be repeated for credit if topic varies.

MATH 411 (4) Introduction to Complex Variables
Algebra and geometry of complex numbers, analytic functions, power series, Cauchy’s theorem and residue theorem.
Pre: MATH 223 and MATH 290 with "C" or better or consent
ALT-Spring

MATH 417 (3) Real Analysis I
Limits and continuity, sequences and series, differentiation and integration.
Pre: MATH 223 and MATH 290 with "C" or better or consent
Fall

MATH 418 (3) Real Analysis II
Topology of Euclidean spaces, continuous functions, sequences of functions and differentiable mappings.
Pre: MATH 417 with "C" or better or consent

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MATH 422 (4) Partial Differential Equations  
This course presents the theory, computations, and applications of partial differential equations and Fourier series.  
Pre: MATH 223 and MATH 321 with "C" or better or consent  
ALT-Spring

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.  
Pre: MATH 223 and MATH 247 with "C" or better or consent  
ALT-Spring

MATH 435 (4) Modern Geometry  
Geometry of spaces including Euclidean and non-Euclidean and applications of contemporary geometry.  
Pre: MATH 332 with "C" or better or consent

MATH 442 (4) Theory of Numbers  
Euclidean algorithm, primes, composites, number theoretic functions, congruencies, Diophantine equations, Euler and Fermat theorems, algebraic number fields.  
Pre: MATH 345 with "C" or better or consent

MATH 446 (4) Abstract Algebra II  
A continuation of MATH 345. The course will include topics from groups, rings, and fields.  
Pre: MATH 345 with "C" or better or consent  
Spring

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.  
Pre: MATH 345 with "C" or better or consent  
Fall

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.  
Pre: MATH 223 with "C" 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  
Pre: MATH 455 / STAT 455 with "C" or better or consent

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.  
Pre: MATH 122, MATH 247 with "C" or better or consent; and familiarity with a programming language  
Spring

MATH 471 (4) Numerical Analysis II  
This course is a continuation of MATH 470. Topics included are the algebraic eigenvalue problem, leastsquares approximation, solutions of systems of nonlinear equations, numerical solutions of ordinary differential equations.  
Pre: MATH 470 and MATH 223 with "C" or better or consent

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.  
Pre: MATH 345 with "C" or better or consent  
Fall

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.  
Pre: MATH 290 with "C" or better or consent  
Fall

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.  
Pre: MATH 290 with "C" 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.  
Pre: MATH 290 with "C" or better or consent  
Fall

MATH 486 (3) Advanced Viewpoint of 5-12 School Mathematics  
Advanced viewpoint of mathematics content and learning theories, teaching strategies, reading strategies, assessments, and planning, teaching and reflecting on grades 5-12 mathematics. Field experiences in grades 5-12 mathematics classroom required.  
Pre: MATH 290 with "C" 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.  
Pre: Two of the following: MATH 316, MATH 345, MATH 375 and senior standing (or permission of the instructor). Course also can be taken as an independent study with permission of a cooperating faculty member.  
Fall, Spring

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.  
Pre: 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 496 (3) Mathematical Logic
Propositional logic, first and second order logic, completeness, consistency, models of theories, Godel’s Incompleteness theorem.
Pre: MATH 345

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.