

# Mathematics

<http://www.und.edu/dept/math/mathhome.html>

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## Degrees Granted: Master of Science (M.S.) and Master of Education (M.Ed.)

The Department offers courses leading to the M.S. (thesis and non-thesis) and M.Ed. degrees with a major in mathematics. The Department also offers a graduate minor in statistics.

Details pertaining to admission requirements, degree requirements and courses offered can be found in the Degree section.

## Master of Science (M.S.)

### Mission Statement and Program Goals

The mission of the Mathematics Department graduate program is to provide a quality education in a variety of areas at the master's level and to produce graduates who are qualified to pursue doctoral work, if they should desire, or careers in government, industry, and teaching. The program maintains high standards while also providing an atmosphere in which capable students with less developed academic backgrounds can maximize their potentials. The program attempts to immerse students in an atmosphere of scholarly and creative activity in a way that will encourage them to interact with each other, with the faculty, and with undergraduates. The program seeks to expand the creative abilities of students and encourages them to communicate their results effectively in written and oral forms and to become involved in mathematical and social communities. Overall, the mission is to produce graduates who love to create and use mathematics and who are able to take an active part in their own learning.

## Master of Science (M.S.)

### Admission Requirements

The applicant must meet the School of Graduate Studies' current minimum general admission requirements as published in the graduate catalog.

1. The equivalent of a bachelor's degree with a major in mathematics.
2. A cumulative grade point average (GPA) of at least 2.75 for all undergraduate work or a GPA of at least 3.0 for the junior and senior years of undergraduate work (based on A=4.0).
3. Students who have not completed the equivalent of MATH 431 Introduction to Real Analysis will be required to do so as part of their graduate program.
4. Satisfy the School of Graduate Studies' English Language Proficiency requirements as published in the graduate catalog. Students without the required degree, or equivalent, may be admitted but will be required to satisfactorily complete undergraduate courses to make up their deficiency before advancement to Approved status.

### Degree Requirements

Students seeking the Master of Science degree at the University of North Dakota must satisfy all general requirements set forth by the School of Graduate Studies as well as particular requirements set forth by the Mathematics Department.

### Thesis Option

1. A minimum of 30 semester credits in a major field, including the credits granted for the thesis and the research leading to the thesis.
2. The program may include just the major, the major and a minor, or the major and a cognate area. The major must include 20 credits from the major department, and a minor or cognate area must include at least nine credits.
3. At least one-half of the credits must be at or above the 500-level.

4. A maximum of one-fourth of the credit hours required for the degree may be transferred from another institution.
5. Comprehensive final examination.
6. Required Courses:

<b>Select two of the following sequences:</b>		<b>12</b>
MATH 512 & MATH 513	Modern Analysis I and Modern Analysis II	
MATH 515 & MATH 516	Applied Mathematics and Applied Mathematics	
MATH 518 & MATH 519	Algebra I and Algebra II	
MATH 520 & MATH 521	Topology I and Topology II	
MATH 541 & MATH 542	Linear Statistical Models and Advanced Topics in Statistics and Probability	
At least one additional graduate level mathematics course		3
MATH 998	Thesis	4
Electives/Cognates		11
<b>Total Credits</b>		<b>30</b>

### Non-Thesis Option

1. Thirty-two (32) credits including a minimum of two credits of MATH 997 Independent Study.
2. At least one-half of the credits must be at or above the 500-level.
3. A maximum of one-fourth of the credit hours required for the degree may be transferred from another institution.
4. The program may include just the major, the major and a minor, or the major and a cognate area. The major must include 20 credits from the major department, and a minor or cognate area must include at least nine credits.
5. Preparation of a written independent study approved by the faculty advisor.
6. Comprehensive final examination.
7. Required Courses:

<b>Select two of the following sequences:</b>		<b>12</b>
MATH 512 & MATH 513	Modern Analysis I and Modern Analysis II	
MATH 515 & MATH 516	Applied Mathematics and Applied Mathematics	
MATH 518 & MATH 519	Algebra I and Algebra II	
MATH 520 & MATH 521	Topology I and Topology II	
MATH 541 & MATH 542	Linear Statistical Models and Advanced Topics in Statistics and Probability	
At least one additional graduate level mathematics course		3
MATH 997	Independent Study	2
Electives/Cognates		15
<b>Total Credits</b>		<b>32</b>

## Master of Education (M.Ed.)

### Admission Requirements

The applicant must meet the School of Graduate Studies' current minimum general admission requirements as published in the graduate catalog.

1. Satisfy the undergraduate requirements in Education, i.e., 18 credit hours in Education including student teaching.
2. The equivalent of a bachelor's degree with a major in mathematics.
3. A cumulative grade point average (GPA) of at least 2.75 for all undergraduate work or a GPA of at least 3.0 for the junior and senior years of undergraduate work (based on A=4.0).
4. Students who have not completed the equivalent of the following courses will be required to do so as part of their graduate program.
5. MATH 409 Geometry 3  
MATH 421 Statistical Theory I 3

MATH 431	Introduction to Analysis I	3
MATH 441	Abstract Algebra	3
MATH 442	Linear Algebra	3

6. Satisfy the School of Graduate Studies' English Language Proficiency requirements as published in the graduate catalog.

## Degree Requirements

1. A minimum of 32 semester credits is required for the M.Ed. degree, including two credits for the independent study.
2. At least one-half of the credits must be at or above the 500-level.
3. A maximum of one-fourth of the credit hours required for the degree may be transferred from another institution.
4. A minimum of 16 credits, including 2 for the independent study, in Mathematics with at least 8 credits at or above the 500 level as approved by the department.
5. A minimum of 6 credits in an area cognate to the area of concentration.
6. The courses T&L 569, EFR 500, T&L 580, MATH 505 Seminar: Methods and Materials for Secondary Mathematics will be required.
7. Preparation of a written independent study approved by the faculty advisor.
8. Comprehensive final exam.

## Graduate Minor in Statistics

The requirements consist of 9 hours of which MATH 421 Statistical Theory I and MATH 422 Statistical Theory II are required if they were not taken as an undergraduate. The remaining credits may be selected from various probability and statistics-oriented courses in mathematics and other disciplines. For further information about this option, contact the chair of the Mathematics Department.

## Courses

**MATH 505. Seminar in Mathematics. 1-3 Credits.**  
Repeatable.

**MATH 512. Modern Analysis I. 3 Credits.**  
Algebras and  $\sigma$ -algebras, Borel sets, measures, measurable sets and Lebesgue measure, non-measurable sets, measurable functions, the definition and basic properties of the Lebesgue integral, Fatou's lemma, the monotone convergence theorem, and Lebesgue's dominated convergence theorem.  
Prerequisite: MATH 432.

**MATH 513. Modern Analysis II. 3 Credits.**  
Product measures, Fubini's theorem, the Radon Nikodym theorem, inequalities of Hölder and Minkowski, definitions and basic properties of normed spaces and Banach spaces, some classical Banach spaces such as  $L_p$  and  $l_p$ , bounded linear operators, and dual spaces. Prerequisite: MATH 512.

**MATH 515. Applied Mathematics. 3 Credits.**  
The content of the course varies but includes current topics in applied mathematics such as: (1) ordinary or partial differential equations, (2) approximation theory and perturbation techniques, (3) modeling and computer simulation, (4) special functions, (5) numerical analysis, (6) variational methods, (7) transforms, (8) integral equations. Prerequisite: MATH 266 or consent of instructor.

**MATH 516. Applied Mathematics. 3 Credits.**  
The content of the course varies but includes current topics in applied mathematics such as: (1) ordinary or partial differential equations, (2) approximation theory and perturbation techniques, (3) modeling and computer simulation, (4) special functions, (5) numerical analysis, (6) variational methods, (7) transforms, (8) integral equations. Prerequisite: MATH 266 or consent of instructor.

**MATH 518. Algebra I. 3 Credits.**  
Group theory, rings and fields, vector spaces, Galois theory and finite fields. Prerequisites: MATH 441 and MATH 442.

**MATH 519. Algebra II. 3 Credits.**  
Group theory, rings and fields, vector spaces, Galois theory and finite fields. Prerequisites: MATH 441 and MATH 442.

**MATH 520. Topology I. 3 Credits.**  
Point set topology, including metric spaces and such topics as homeomorphisms, separation axioms, compactness, connectedness, general convergence, compactification and metrizability. Prerequisite: MATH 431.

**MATH 521. Topology II. 3 Credits.**  
Point set topology, including metric spaces and such topics as homeomorphisms, separation axioms, compactness, connectedness, general convergence, compactification and metrizability. Prerequisite: MATH 431.

**MATH 541. Linear Statistical Models. 3 Credits.**  
Distributions of quadratic forms, general linear hypotheses of full rank, least squares, Gauss-Markoff theorem, estimability, parametric transformations, Cochran's theorem, projection operators and conditional inverses in generalized least squares, applications to ANOVA and experimental design models. Prerequisite: MATH 422 or consent of instructor.

**MATH 542. Advanced Topics in Statistics and Probability. 3 Credits.**  
The content of the course varies but may include (but is not restricted to) current topics in statistics and probability such as (1) time series, (2) sampling, (3) nonparametric statistics, (4) experimental design, (5) probability theory, (6) statistical theory, (7) multivariate statistical analysis. Prerequisite: MATH 541 or consent of instructor.

**MATH 576. Algebra and Geometry for Middle School Teachers. 3 Credits.**  
Algebra and Geometry course intended for middle school teachers: a) planning to qualify to teach middle school mathematics; or b) teachers looking to enrich their content knowledge in mathematics. Topics may include: rational number system, introduction to number theory, algebraic thinking, spatial reasoning and representation, introduction to Euclidean and non-Euclidean geometry, problem solving and pedagogical issues. May not be used in Ph.D. or Master's programs. Prerequisites: Licensed K-12 teacher, College Algebra, and instructor consent.

**MATH 577. Calculus Concepts for Middle School Teachers. 3 Credits.**  
Calculus course intended for middle school teachers: a) planning to qualify to teach middle school mathematics; or b) teachers looking to enrich their content knowledge in mathematics. Topics may include: analysis of functions, mathematical modeling, limits, continuity, differentiation, integration, and pedagogical issues. May not be used in Ph.D. or Master's programs. Prerequisites: Licensed K-12 teacher, College Algebra, and instructor consent.

**MATH 578. Probability and Statistics for Middle School Teachers. 3 Credits.**  
Probability and statistics course intended for middle school teachers: a) planning to qualify to teach middle school mathematics; or b) teachers looking to enrich their content knowledge in mathematics. Topics may include: counting, empirical and theoretical probabilities, simulation of probabilistic events, conditional probability, expected value, data and variables, random sampling, measures of central tendency and spread, least squares regression, and pedagogical issues. May not be used in Ph.D. or Master's programs. Prerequisites: Licensed K-12 teacher, College Algebra, and instructor consent.

**MATH 579A. Practicum in Middle School Mathematics. 2 Credits.**  
Teachers will use their content and pedagogical knowledge to plan lesson(s) and develop and implement an action research project in their school. May be repeated for up to 6 credits. May not be used in Ph.D. or Master's programs. Prerequisites: Licensed K-12 teacher, Math 276, 577 or 578 and instructor consent. Repeatable to 6 credits.

**MATH 579B. Practicum in Middle School Mathematics. 2 Credits.**  
Teachers will use their content and pedagogical knowledge to plan lesson(s) and develop and implement an action research project in their school. May be repeated for up to 6 credits. May not be used in Ph.D. or Master's programs. Prerequisites: Licensed K-12 teacher, Math 276, 577 or 578 and instructor consent.

**MATH 996. Continuing Enrollment. 1-12 Credits.**  
Repeatable. S/U grading.

**MATH 997. Independent Study. 2 Credits.**

**MATH 998. Thesis. 1-9 Credits.**  
Repeatable to 9 credits.

## Undergraduate Courses for Graduate Credit

**MATH 403. Theory of Probability. 3 Credits.**  
Sets, sample spaces, discrete probability, distribution functions, density functions, characteristic functions, study of normal, Poisson, binomial and other distributions with applications. Prerequisite: MATH 265. S, odd years.

**MATH 405. Selected Topics in Mathematics. 1-3 Credits.**  
May be repeated to maximum of six credits. Prerequisite: Permission of the Mathematics Department. Repeatable to 6 credits. On demand.

**MATH 408. Combinatorics. 3 Credits.**

Introduction to the techniques and reasoning needed in combinatorial problem-solving. The course may include topics related to combinatorics, such as graph theory. Prerequisites: MATH 166 and MATH 208. S.

**MATH 409. Geometry. 3 Credits.**

Metric and synthetic approach to Euclidean geometry. The usual topics in elementary geometry treated in a mathematically logical way. Topics include congruence, inequalities, parallelism, similarity, area, solid geometry and the circle. Prerequisite: MATH 208 or MATH 330. F.

**MATH 412. Differential Equations. 3 Credits.**

Basic types of ordinary differential equations. Existence and uniqueness of solutions. Prerequisite: MATH 266. F, odd years.

**MATH 415. Topics in Applied Mathematics. 1-3 Credits.**

An introduction to selected areas in applied mathematics chosen from a variety of topics including: Applied algebra, difference equations, linear programming, modeling and simulation, operations research, optimization, partial differential equations and computers in mathematics. Topics to be considered will be illustrated with examples and practical applications. May be repeated for credit with consent of instructor up to a maximum of six credits. Prerequisites: MATH 265 and consent of instructor. Repeatable to 6 credits. On demand.

**MATH 416. Topics in Statistics. 1-3 Credits.**

An introduction to a variety of topics in statistics including: Linear models in categorical analysis, Bayesian methods, decision theory, ridge regression, Non parametric techniques, stochastic games and models. The number of topics to be considered during a semester will be limited to permit greater depth of coverage and sufficient practical illustrations. May be repeated for credit with consent of instructor up to six credits. Prerequisites: MATH 265 and MATH 321 or consent of instructor. Repeatable to 6 credits. On demand.

**MATH 421. Statistical Theory I. 3 Credits.**

Discrete and continuous random variables, expectation, moments, moment generating functions, properties of special distributions, introduction to hypothesis testing, sampling distributions, Central Limit Theorem, curve of regression, correlation, empirical regression by least squares, maximum likelihood estimation, Neyman-Pearson lemma, likelihood ratio test, power function, chi-square tests, change of variable, "t" and "F" tests, one and two-way ANOVA, nonparametric methods. Prerequisite: MATH 265. F.

**MATH 422. Statistical Theory II. 3 Credits.**

Discrete and continuous random variables, expectation, moments, moment generating functions, properties of special distributions, introduction to hypothesis testing, sampling distributions, Central Limit Theorem, curve of regression, correlation, empirical regression by least squares, maximum likelihood estimation, Neyman-Pearson lemma, likelihood ratio test, power function, chi-square tests, change of variable, "t" and "F" tests, one and two-way ANOVA, nonparametric methods. Prerequisite: MATH 421. S.

**MATH 431. Introduction to Analysis I. 3 Credits.**

Development of the real number system, functions, sequences, limits, continuity, and differentiation. Prerequisite: MATH 330 or consent of instructor. F.

**MATH 432. Introduction to Analysis II. 3 Credits.**

A continuation of MATH 431, topics in the second semester include integration, partial differentiation, infinite series, power series and vector analysis. Prerequisite: MATH 431. S.

**MATH 435. Theory of Numbers. 3 Credits.**

Basic properties of numbers, including divisibility, primes, congruences, Diophantine equations and residue theory. Prerequisite: MATH 208 or 330. S.

**MATH 441. Abstract Algebra. 3 Credits.**

Rings, integral domains, fields, elements of group theory. Prerequisite: MATH 330 or consent of instructor. F.

**MATH 442. Linear Algebra. 3 Credits.**

A theoretical treatment of systems of linear equations, matrices, vector spaces, linear transformations and elementary canonical forms. Prerequisites: MATH 207 and MATH 330 or consent of instructor. S.

**MATH 460. Mathematical Modeling. 3 Credits.**

The primary goal of the course is to present the mathematical analysis provided in scientific modeling. Topics may include population modeling, mechanical vibrations, traffic flow, epidemic modeling, queues and decay processes. Prerequisites: MATH 266 and MATH 207 or consent of instructor. F, even years.

**MATH 461. Numerical Analysis. 3 Credits.**

Numerical techniques for: the solution of equations in one or several unknowns, approximate integration, differential equations, approximation theory, optimization theory and matrix analysis. Corresponding error analysis will be investigated. Prerequisites: MATH 266 and a scientific programming language. F, odd years.

**MATH 471. Introduction to Complex Variables. 3 Credits.**

The complex plane, analytic functions, complex integration, power series, the theory of residues and contour integration, conformal mapping, Fourier and Laplace transformations, and applications. Prerequisite: MATH 265. F, even years.

**MATH 494. Reading Course in Mathematics. 1-3 Credits.**

Directed individual reading on selected topics not developed in other courses. Repeatable to six credits. Prerequisites: Consent of instructor. Repeatable to 6 credits. F,S,SS.

**MATH 495. Readings in Mathematics. 1-3 Credits.**

Directed individual reading on selected topics not developed in other courses. Repeatable to six credits. Prerequisite: Consent of instructor. Repeatable to 6 credits. F,S,SS.