Mathematics

M.Ed. in Mathematics (https://catalog.und.edu/graduateacademicinformation/departmentalcoursesprograms/mathematics/math-med/)

M.S. in Applied Statistics (https://catalog.und.edu/graduateacademicinformation/departmentalcoursesprograms/mathematics/math-as/)

M.S. in Mathematics (https://catalog.und.edu/graduateacademicinformation/departmentalcoursesprograms/mathematics/math-ms/)

Minor in Statistics (https://catalog.und.edu/graduateacademicinformation/departmentalcoursesprograms/mathematics/minor/)

Mathematics

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. On demand.

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 Lp and lp, 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. Prerequisite: MATH 441 and MATH 442.

MATH 519. Algebra II. 3 Credits.
Group theory, rings and fields, vector spaces, Galois theory and finite fields. Prerequisite: 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 520. On demand.

MATH 530. Basics of Machine Learning for Non-Specialists. 3 Credits.
The intent of this course is to provide students in the Human-Technology Interaction program a survey of the mathematical techniques used in machine learning applications. The emphasis will be to develop a basic conceptual understanding of areas such as regression, classification, and unsupervised approaches. Basic work with datasets and programming will be incorporated into the course. Prerequisite: Enrollment in the MA in Human-Technology Interaction Degree Program. F, even years.

MATH 555. Mathematics of Finance. 3 Credits.
The course introduces the main classes of financial securities, the mathematical tools employed to model their prices, and common models for risk and investment management. Topics covered include Derivatives, Option pricing, Hedging, Portfolio Risk, Swaps, Asset pricing models. Covers topics and problems included in the SOA/ CAS Actuarial Exam FM/2. Prerequisite: MATH 355 and MATH 421. S.

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. Prerequisite: 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. Prerequisite: 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. Prerequisite: Licensed K-12 teacher, College Algebra, and instructor consent.

MATH 579. 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. Prerequisite: Licensed K-12 teacher, MATH 576, MATH 577 or MATH 578 and instructor consent. Repeatable to 6.00 credits. On demand.

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

MATH 997. Independent Study. 2 Credits.
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MATH 998. Thesis. 1-9 Credits.
Repeatable to 9.00 credits.

Undergraduate Courses for Graduate Credit

MATH 405. Selected Topics in Mathematics. 1-3 Credits.
An introduction to selected areas of mathematics, such as algebra, analysis, combinatorics, graph theory, or topology. Prerequisite: Permission of the Mathematics Department. Repeatable to 6.00 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. Prerequisite: MATH 166 and MATH 208. S, odd years.

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. S, even 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. Prerequisite: MATH 265 and consent of instructor. Repeatable to 6.00 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. Prerequisite: MATH 265 and MATH 321 or consent of instructor. Repeatable to 6.00 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 425. Cryptological Mathematics. 3 Credits.
This course develops the math behind elementary symmetric-key cryptoschemes and a variety of public-key schemes. Modern block ciphers may be discussed. Prerequisite: MATH 208. F, odd years.

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. On demand.

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. On demand.

MATH 435. Theory of Numbers. 3 Credits.
Basic properties of numbers, including divisibility, primes, congruences, Diophantine equations and residue theory. Prerequisite: MATH 208 or MATH 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. Prerequisite: 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. Prerequisite: MATH 266 and MATH 207 or consent of instructor. On demand.

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. Prerequisite: MATH 266 and a scientific programming language. On demand.

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. Undergraduate Research. 0-4 Credits.
Advanced experience as a research assistant working alongside a faculty member. A total of 45 hours is typically required over the course of the semester per credit. Prerequisite: Consent of instructor. Repeatable to 6.00 credits. F,S,SS.

MATH 495. Readings in Mathematics. 1-3 Credits.
Directed individual reading on selected topics not developed in other courses. Prerequisite: Consent of instructor. Repeatable to 6.00 credits. F,S,SS.

Statistics

STAT 500. Computing for Statistics. 1 Credit.
Use and programming of computer packages for statistics. Preparation for use of software in graduate-level statistics courses. Packages covered may include R, Python, SAS, and others. Prerequisites: At least one course in statistics, and prior programming coursework or experience. Prerequisite: At least one course in statistics and computer programming coursework or experience. F,SS.

STAT 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. F.

STAT 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) sampling, (2) spatial statistics, (3) probability theory, (4) statistical theory. Prerequisite: STAT 541 or consent of instructor. Repeatable to 12.00 credits. On demand.

STAT 543. Design of Experiments. 3 Credits.
Design and analysis of experimental data. Includes the use of factorial designs, Latin square designs, randomized block designs, split-plot designs and others. Prerequisite: STAT 541. S, even years.

STAT 545. Multivariate Statistics. 3 Credits.
Theory-based statistical methods for analyzing and displaying multivariate data with applications in machine learning and data mining. Topics include inference in multivariate populations, multivariate analysis of variance, summarizing high dimensional data using principal component analysis, factor analysis, canonical correlation analysis, linear and quadratic methods of classification, cluster analysis, classification trees and random forests, multi-dimensional scaling, and support vector machines. Prerequisite: STAT 500, STAT 541, and MATH 442 or experience with linear algebra concepts. S, odd years.

STAT 547. Time Series. 3 Credits.
Statistical methods for analyzing a sequence of observations ordered by a time parameter. Possible topics include the identification of trends and seasonality in the data, modeling stationary and non-stationary time series, exponential smoothing, autoregressive integrated moving average models (ARIMA), transfer function models, autoregressive error models, ARCH and GARCH models for time series with non-heteroskedastic error variances, model and forecast evaluation, and time series applications in machine learning such as the LSTM (Long Short-term Memory) model. Prerequisite: MATH 422 and STAT 500. S, even years.

STAT 551. Statistical Graphics. 3 Credits.
Statistical graphics and visualization of one-, two-, or higher-dimensional data. Well-designed graphs and charts are essential for exploration of data, assessment of models, and presentation of results. Includes specific methods as well as general principles, such as effective use of color and motion. Prerequisite: STAT 500. F, odd years.

STAT 553. Modern Nonparametric Statistics. 3 Credits.
Statistical analyses conducted with no or minimal assumptions on population distributions. Topics include: the empirical cumulative distribution function (e.c.d.f); methods of inference using ranks, permutations, and e.c.d.f; bootstrap estimates of bias, standard error, and confidence intervals; histograms, kernel density estimates, and other nonparametric estimates of population shape; and kernel- and spline-based estimates of nonlinear regression curves. Prerequisite: MATH 422 and STAT 500. F, even years.

STAT 555. Applied Bayesian Statistics. 3 Credits.
A general introduction to Bayesian modeling, analysis, and computing. A variety of Bayesian models, including hierarchical Bayesian models for modeling complex systems with multiple data sources, will be introduced. Numerical techniques such as Gibbs sampling and Markov chain Monte Carlo (MCMC) will be used to fit Bayesian models using JAGS and STAN and estimation and prediction using these models will be performed. Assessing the appropriateness of Bayesian models and comparisons with traditional models will be discussed. Prerequisite: MATH 422 and STAT 500. F, even years.

STAT 994. Internship. 2 Credits.
Internship with a business or industry partner requiring the application of statistical and data analytical skills. F,S.

STAT 997. Independent Study. 2 Credits.
Independent Study. F,S.