

MATHEMATICS AND STATISTICS (MATH)

The Department of Mathematics and Statistics offers a variety of programs leading to five different degrees:

- B.A. degree: mathematics major;
- B.S. in mathematics degree;
- B.S. in applied mathematics degree;
- B.S. in mathematics education degree; and
- B.S. in statistics degree.

These programs provide flexibility through elective choices and are designed to maximize educational and employment opportunities. Each student must enroll in one specific program; however, changes between programs usually can be accommodated.

The first two years of all programs are similar. In the first year, students are expected to take MATH 425 Calculus I and MATH 426 Calculus II, as well as an introductory programming course (either MATH 445 Mathematics and Applications with MATLAB or CS 410 Introduction to Scientific Programming). A sophomore typically takes follow-up calculus courses in MATH 527 Differential Equations with Linear Algebra and MATH 528 Multidimensional Calculus, MATH 539 Introduction to Statistical Analysis, and MATH 531 Mathematical Proof. The senior capstone experience is fulfilled by a variety of designated courses in each of the degree programs; specific details are given in each program's course listing below.

For more information about the department's undergraduate programs, visit <http://ceps.unh.edu/mathematics-statistics>

Standards for Graduation

In all courses used to satisfy the requirements for its major programs, the Department of Mathematics and Statistics requires that a student earn a grade of C- or better and have an overall grade-point average of at least 2.00 in these courses.

Minoring in Mathematics

The Department of Mathematics and Statistics offers three minor programs: mathematics, applied mathematics, and statistics. These programs, which are open to all students enrolled at the University, require a minimum of five MATH courses as detailed below. Students whose major program requires more than two courses required by the minor program must substitute additional courses from the list of elective courses to meet the five-course minimum.

<http://ceps.unh.edu/mathematics-statistics>

Programs

- Applied Mathematics Major: Computation Option (B.S.) (<http://catalog.unh.edu/archives/2017-2018/undergraduate/engineering-physical-sciences/programs-study/mathematics-statistics/applied-mathematics-major-computation-option-bs>)
- Applied Mathematics Major: Dynamics and Control Option (B.S.) (<http://catalog.unh.edu/archives/2017-2018/undergraduate/>

[engineering-physical-sciences/programs-study/mathematics-statistics/applied-mathematics-major-dynamics-control-option-bs](http://catalog.unh.edu/archives/2017-2018/undergraduate/engineering-physical-sciences/programs-study/mathematics-statistics/applied-mathematics-major-dynamics-control-option-bs))

- Applied Mathematics Major: Economics Option (B.S.) (<http://catalog.unh.edu/archives/2017-2018/undergraduate/engineering-physical-sciences/programs-study/mathematics-statistics/applied-mathematics-major-economics-option-bs>)
- Applied Mathematics Major: Fluid Dynamics Option (B.S.) (<http://catalog.unh.edu/archives/2017-2018/undergraduate/engineering-physical-sciences/programs-study/mathematics-statistics/applied-mathematics-major-fluid-dynamics-option-bs>)
- Applied Mathematics Major: Solid Mechanics and Vibrations Option (B.S.) (<http://catalog.unh.edu/archives/2017-2018/undergraduate/engineering-physical-sciences/programs-study/mathematics-statistics/applied-mathematics-major-solid-mechanics-vibrations-option-bs>)
- Mathematics Education Major: Elementary/Middle School Education K-8 Option (B.S.) (<http://catalog.unh.edu/archives/2017-2018/undergraduate/engineering-physical-sciences/programs-study/mathematics-statistics/mathematics-education-major-bs>)
- Mathematics Major (B.A.) (<http://catalog.unh.edu/archives/2017-2018/undergraduate/engineering-physical-sciences/programs-study/mathematics-statistics/mathematics-major-ba>)
- Mathematics Major (B.S.) (<http://catalog.unh.edu/archives/2017-2018/undergraduate/engineering-physical-sciences/programs-study/mathematics-statistics/mathematics-major-bs>)
- Statistics Major (B.S.) (<http://catalog.unh.edu/archives/2017-2018/undergraduate/engineering-physical-sciences/programs-study/mathematics-statistics/statistics-major-bs>)
- Applied Mathematics Minor (<http://catalog.unh.edu/archives/2017-2018/undergraduate/engineering-physical-sciences/programs-study/mathematics-statistics/applied-mathematics-minor>)
- Mathematics Minor (<http://catalog.unh.edu/archives/2017-2018/undergraduate/engineering-physical-sciences/programs-study/mathematics-statistics/mathematics-minor>)
- Statistics Minor (<http://catalog.unh.edu/archives/2017-2018/undergraduate/engineering-physical-sciences/programs-study/mathematics-statistics/statistics-minor>)

Courses

Mathematics & Statistics (MATH)

MATH 301 - Elementary Math I

Credits: 4

Beginning algebra including integer operations, solving linear equations, graphing linear functions, solving linear inequalities, systems of linear equations, polynomials, rational expressions and equations, and exponents and radicals. May not be taken for credit toward a bachelor's degree.

MATH 302 - Elementary Math II

Credits: 4

Review of elementary algebra, exponents, polynomials, factoring, rational exponents, and absolute value. Solving linear and quadratic equations and inequalities; systems of equations; radical equations. Linear functions and related notions; quadratic functions. May not be taken for credit toward a bachelor's degree. Prereq: MATH 301 or the equivalent.

MATH 400 - Freshman Seminar**Credits:** 1

A seminar experience that presents a mathematical culture associated with first-year college mathematics, including the ideas of abstraction, theorem and proof, and that provides a perspective of the diversity of mathematical areas of research and their interrelationships. Emphasis is on reading and writing mathematics. Cr/F.

MATH 418 - Analysis and Applications of Functions**Credits:** 4

Analysis and applications of algebraic and transcendental functions, with special emphasis on exponential, logarithmic, and trigonometric functions. Graphical analysis. Written projects are required on some or all of the following topics: rates of change, optimization, logarithmic or exponential modeling, and trigonometric functions. Intended for students planning to take MATH 425. Prereq: MATH 302 or equivalent. Not offered for credit if credit is received for MATH 424 or MATH 425.

MATH 420 - Finite Mathematics**Credits:** 4

Topics selected from probability, systems of linear equations, matrix algebra, linear programming, mathematics of finance. Not a preparation for calculus. Prereq: MATH 302 or the equivalent. Not offered for credit to mathematics majors.

Attributes: Quantitative Reasoning(Disc); Quantitative Reasoning GP 2**MATH 421 - Pathways between Mathematics and the Arts****Credits:** 4

Exploration of the interaction between mathematics and the arts on numerous levels. The course builds on basic knowledge of elementary number systems to illuminate such topics symmetry, fractals, light, color, sound structures and musical materials. Student immediately apply new knowledge and techniques to make computer generated 2-D and 3-D images, animations and sound/music.

Attributes: Quantitative Reasoning(Disc); Quantitative Reasoning GP 2**MATH 424A - Calculus for Social Sciences****Credits:** 4

Rational, exponential and logarithmic functions; associated derivatives and their applications; associated antiderivatives and their applications. Applications focus on contexts relevant to majors in the College of Liberal Arts and the Paul College. Not offered for credit to CEPS majors. Not offered for credit if credit is received for MATH 425. Students wanting a two-semester calculus course are strongly advised to take MATH 425-426. Those students who successfully complete MATH 424A and subsequently wish to continue their study of mathematics with MATH 426 are encouraged to complete supplementary modules available from the Mathematics Center (MaC).

Attributes: Quantitative Reasoning(Disc); Quantitative Reasoning GP 2**MATH 424B - Calculus for Life Sciences****Credits:** 4

Rational, exponential and logarithmic functions; associated with derivatives and their applications; associated with antiderivatives and their applications. Applications focus on contexts relevant to majors in the College of Life Sciences and Agriculture. Not offered for credit for CEPS majors. Not offered for credit if credit is received for MATH 425. Students wanting a two-semester calculus course are strongly advised to take MATH 425-426. Those students who successfully complete MATH 424B and subsequently wish to continue their study of mathematics with MATH 426 are encouraged to complete supplementary modules available from the Mathematics Center (MaC).

Attributes: Quantitative Reasoning(Disc); Quantitative Reasoning GP 2**MATH 425 - Calculus I****Credits:** 4

Calculus of one variable covering limits, derivatives of algebraic, trigonometric, exponential, and logarithmic functions; applications include curve sketching, max-min problems, related rates, and volume and area problems. Prereq: completing MATH 418 with a grade of C or better or qualifying with the placement evaluation. (Not offered for credit if credit is received for MATH 424.)

Attributes: Quantitative Reasoning(Disc); Quantitative Reasoning GP 2**MATH 425H - Honors/Calculus I****Credits:** 4

Calculus of one variable covering limits, derivatives of algebraic, trigonometric, exponential, and logarithmic functions; applications include curve sketching, max-min problems, related rates, and volume and area problems. Prereq: completing MATH 418 with a grade of C or better or qualifying with the placement evaluation. (Not offered for credit if credit is received for MATH 424.) Enrollment in MATH 425H requires concurrent enrollment in PHYS 407H.

Attributes: Quantitative Reasoning(Disc); Quantitative Reasoning GP 2**MATH 426 - Calculus II****Credits:** 4

Second course in calculus of one argument, techniques and applications of integration, polar coordinates, and series. Prereq: MATH 425.

MATH 426H - Honors/Calculus II**Credits:** 4

Second course in calculus of one argument, techniques and applications of integration, polar coordinates, and series. Prereq: MATH 425.

Enrollment in MATH 426H requires concurrent enrollment in PHYS 408H.

MATH 439 - Statistical Discovery for Everyone**Credits:** 4

Introduces the framework and concepts for learning with data. Emphasis on statistical discovery in everyday life and on drawing valid conclusion from data. Topics include: good and bad data, data ethics, how to conduct a valid survey, how to describe a population distribution; when to believe a poll; how to design an experimental study; how to avoid ambiguous results caused by "lurking" variables; how to make inference about an entire population based on a sample; how to describe relationships among variables; an understanding of the question of causation and chance in everyday life and in scientific studies, as well as the use and misuse of statistics in explaining what is statistical significance. This course has an activity-based learning component with lab exercises using statistical software for calculations without assuming a calculus background. The course may be used as a preparation for a more technical introductory statistics course. Not offered for credit if credit is received for ADM 430, ADMN 420, BIOL 528, EREC 525, HHS #540, MATH 539, MATH 644, PSYC 402, SOC 502. Science and Engineering students should take MATH 539 or MATH 644 according to their programs.

Attributes: Quantitative Reasoning(Disc); Quantitative Reasoning GP 2

MATH 444 - Excursions in Quantitative Reasoning**Credits:** 4

Problems involving quantitative reasoning (most are nontraditional, some are fun, while others are interdisciplinary) designed to inspire curiosity encourages students to formulate and evaluate questions, all the while slowly drawing them into the process of scholarly investigation. In this regard, in addition to traditional mathematics homework, students need to do research outside of class to write and present projects.

Attributes: Quantitative Reasoning(Disc); Quantitative Reasoning GP 2; Inquiry (Discovery)

MATH 445 - Mathematics and Applications with MATLAB**Credits:** 4

Through the use of the MATLAB computation software, this course reinforces and builds on a student's mathematics foundation and previews more advanced mathematical concepts. The power and limitations of modern computational algorithms to solve real world problems are introduced and shown to influence nearly every aspect of modern society. The state-of-the-art computational tools afforded by MATLAB provide the student with a strategy for enhancing their knowledge and comprehension in subsequent Science, Engineering, or Technology themed courses. Prereq: MATH 418 or permission.

Attributes: Environment,TechSociety(Disc); Technology GP 3T

MATH 525 - Linearity I**Credits:** 6

Examines the fundamental role that linear models play in science and engineering; and the role of linearization in understanding nonlinear phenomena. Models are considered along several conceptual axes: discrete to continuous, one-dimensional to multidimensional, and static to dynamic, with an emphasis on the former. Mathematical areas of coverage include matrix algebra, concepts from calculus of several variables, difference equations, and linear transformations. Prereq: MATH 426, permission. Lab.

MATH 526 - Linearity II**Credits:** 6

Continuation of study of linear models and the process of linearization begun in MATH 525, with an emphasis on models of dynamic phenomena. Additional mathematical areas of coverage include differential equations, eigenvalue and eigenvector analysis, phase plane analysis, and additional concepts from vector calculus. Prereq: MATH 525, permission. Lab.

MATH 527 - Differential Equations with Linear Algebra**Credits:** 4

Fundamental methods of solving first-order equations, essentials of matrix algebra; higher-order linear equations, and linear systems; series solutions; Laplace transforms; selected applications. Prereq: MATH 426.

MATH 528 - Multidimensional Calculus**Credits:** 4

Partial differentiation; composite functions and chain rules; maximum and minimum; transformations; vector algebra; vector functions; gradient, divergence, and curl; curves and surfaces; multiple, line, and surface integrals; divergence, Green's and Stoke's theorem. Prereq: MATH 426.

MATH 531 - Mathematical Proof**Credits:** 4

Introduces reading and writing proofs in mathematics. The basic language of mathematics common to all branches of the subject, especially set theory and basic logic. Prereq: MATH 425; or permission. Writing intensive.

Attributes: Writing Intensive Course

MATH 539 - Introduction to Statistical Analysis**Credits:** 4

A first course introducing concepts of probability and scientific methods for data analysis. Exploratory data analysis, survey sampling, probability, discrete and continuous distributions, confidence intervals, hypothesis testing, comparing samples, linear regression, analysis of variance. Statistical software is used. Prereq: MATH 425; or permission. Not offered for credit if credit is received for MATH 644. Offered primarily for mathematics majors; engineering majors should take MATH 644.

MATH 545 - Introduction to Linear Algebra**Credits:** 4

Designed to reinforce ideas seen throughout the mathematics curriculum. Centered on a study of vector spaces and linear systems, beginning with a brief focus on systems of linear equations and progressing to a full discussion of linear transformation and vector spaces. The course includes a survey of properties of matrices, such as rank, kernel, eigenvalues, eigenvectors, and diagonalization. Prereq: MATH 426 Writing intensive. No credit offered if credit is received for MATH 645 or MATH 762.

Attributes: Writing Intensive Course

MATH 601 - Exploring Mathematics for Teachers I**Credits:** 4

Provides prospective elementary teachers with the opportunity to explore and master concepts involving number systems and operations, data analysis and probability. Additional topics may include geometry, measurement, and algebraic thinking. Mathematical reasoning, problem solving, and the use of appropriate manipulatives and technology are integrated throughout the course. Readings, class discussions, and assignments focus on mathematics content as well as applicable theories of learning, curriculum resources, and state and national recommendations. The course models instructional techniques that can be adapted to the elementary curricula. (Not offered for credit if credit is received for MATH 621 or MATH 623; not offered for credit to CEPSS majors.)

MATH 621 - Number Systems for Teachers**Credits:** 4

Ways of representing numbers, relationships between numbers, number systems, the meanings of operations and how they relate to one another, and computation within the number system as a foundation for algebra; episodes in history and development of the number system; and examination of the developmental sequence and learning trajectory as children learn number concepts. Prereq: permission.

MATH 622 - Geometry for Teachers**Credits:** 4

Explorations of the foundations of informal measurement and geometry in one, two and three dimensions. The van Hiele model for geometric learning is used as a framework for how children build their understanding of length, area, volume, angles and geometric relationships. Visualization, spatial reasoning and geometric modeling are stressed. As appropriate, transformational geometry, congruence, similarity and geometric constructions will be discussed. Prereq: permission.

MATH 623 - Probability and Statistics for Teachers**Credits:** 4

An introduction to probability, descriptive statistics and data analysis; exploration of randomness, data representation and modeling. Descriptive statistics will include measures of central tendency, dispersion, distributions and regression. Analysis of experiments requiring hypothesizing, experimental design and data gathering. Prereq: permission.

MATH 624 - Analysis of Secondary School Mathematics**Credits:** 4

Examines concepts from calculus and pre-calculus mathematics with an emphasis on connecting and logically refining the concepts of function, limit, sequences, series, and probability. Includes a deeper analysis of problems and topics drawn from secondary school mathematics with the kind of mathematical knowledge and sophistication that the student has gained from other collegiate mathematics courses. Proofs for many of the theorems that are typically introduced in a non-rigorous fashion in calculus are studied. Prereq: EDUC 500, MATH 425 and 545 (or equivalent); or permission. Offered in alternate years in the spring semester following MATH 623.

MATH 625 - Functions and Algebra for Teachers**Credits:** 4

Representation and analysis of mathematical situations and structures using generalization and algebraic symbols and reasoning. Attention is given to the transition from arithmetic to algebra, working with quantitative change, and the description of and prediction of change. Prereq: MATH 621. The course is offered in alternative years in spring semester.

MATH 632 - Financial Mathematics**Credits:** 4

A mathematical introduction to interest theory and an overview of mathematical models used to analyze and price standard financial instruments including: interest bearing accounts, stocks and bonds. Introduction to basic concepts used in mathematical finance including: random variables, mathematics of arbitrage, risk and diversification. Includes a substantive introduction to all aspects of the financial mathematics actuarial exam.

MATH 644 - Statistics for Engineers and Scientists**Credits:** 4

Introduces the design of controlled experiments and the collection and analysis of scientific data. Use of a statistical software package is an integral part of the course; interpreting and drawing conclusions from standard software output is emphasized. Graphical data analysis, statistical process control, regression and correlation, multifactor experimental designs, confidence intervals, hypothesis testing. Not offered for credit if credit is received for MATH 539. Prereq: MATH 426.

MATH 645 - Linear Algebra for Applications**Credits:** 4

Fundamental notions of vector space theory, linear independence, basis, span, scalar product, orthogonal bases. Includes a survey of matrix algebra, solution of systems linear equations, rank, kernel, eigenvalues and eigenvectors, the LU- and QR-factorizations, and least squares approximation. Selected applications in mathematics, science, engineering and business. Prereq: MATH 426. (Not offered for credit if credit is received for MATH 545 or MATH 762.)

MATH 647 - Complex Analysis for Applications**Credits:** 4

Complex numbers, analytic functions, Cauchy-Riemann equations, conformal mapping, contour integration, Cauchy's integral formula, infinite series, residue calculus, Fourier and Laplace transforms. Prereq: MATH 528. (Not offered for credit if credit is received for MATH 788.)

MATH 656 - Introduction to Number Theory**Credits:** 4

Unique factorization, arithmetic functions, linear and quadratic congruence's, quadratic reciprocity law, quadratic forms, introduction to algebraic numbers. Prereq: MATH 531. Offered in alternate years.

MATH 658 - Topics in Geometry**Credits:** 4

Topics selected from among projective geometry, finite geometrics, convexity, transformational geometry, non-Euclidean geometry, and other areas of elementary geometry within the framework of modern mathematics. Prereq: MATH 657. Offered in alternate years.

MATH 696 - Independent Study**Credits:** 1-4

Individual projects of study developed by the student and a faculty sponsor. Intended for students with superior scholastic achievement. May be repeated up to 8 credits. May be taken as writing intensive. Prereq: a written proposal, including goals and assessment, endorsed by a faculty sponsor and approved by the department chairperson.

MATH 696W - Independent Study**Credits:** 1-4

Individual projects of study developed by the student and a faculty sponsor. Intended for students with superior scholastic achievement. May be repeated up to 8 credits. May be taken as writing intensive. Prereq: a written proposal, including goals and assessment, endorsed by a faculty sponsor and approved by the department chairperson. Writing intensive.

Attributes: Writing Intensive Course**MATH 699 - Internship Experience****Credits:** 1

Provides the opportunity to apply and enhance knowledge in a setting associated with future professional employment. A written mid-semester report is required as well as a final report along with an oral presentation that is open to other undergraduates. Prereq: A written proposal, endorsed by a faculty sponsor and approved by the department chairperson (or designee), that outlines the goals, academic merit and assessment of the work experience. May be repeated up to 4cr. Only open to Math majors. Cr/F.

MATH 700 - Introduction to Mathematics Education**Credits:** 4

General background information about mathematics education, such as theories of learning and teaching mathematics, mathematics curricula, classroom management, and techniques for the teaching and learning of mathematics that are common to all levels of mathematics education K-12. Prereq: MATH 426 and EDUC 500; or permission.

MATH 703 - Teaching of Mathematics, K-6**Credits:** 4

Methods of teaching mathematics at the elementary school level; uses of technology, manipulatives, models, and diagrams; developing unit and lesson plans; assessment ; instructional formats; teaching reading and writing in mathematics. Prereq: MATH 621 (or MATH 601) and MATH 700; or permission.

MATH 708 - Teaching Mathematics in Grades K-8**Credits:** 4

Methods of teaching mathematics in grades K-8, uses of technology, manipulatives, models, and diagrams; developing unit and lesson plans; investigating instructional formats. Prereq: MATH 700 or permission. Offered in alternate years in the spring semester.

MATH 709 - Teaching of Mathematics, 7-12**Credits:** 4

Methods of teaching content at the secondary school level; uses of technology, manipulatives, models, and diagrams; developing unit and lesson plans; assessment; instructional formats; teaching reading and writing in mathematics. Prereq: MATH 700; or permission. Offered in alternate years in the spring semester.

MATH 736 - Advanced Statistical Methods for Research**Credits:** 4

An introduction to multivariate statistical methods, including principal components, discriminant analysis, cluster analysis, factor analysis, multidimensional scaling, and MANOVA. Additional topics include generalized linear models, general additive models, depending on the interests of class participants. The use of statistical software, such as JMP, S PLUS, or R, is fully integrated into the course. Prereq: MATH 739.

MATH 737 - Statistical Methods for Quality Improvement and Design**Credits:** 4

Six Sigma is a popular, data-focused methodology used worldwide by organizations to achieve continuous improvement of their existing processes, products and services or to design new ones. This course provides a thorough introduction to the Six Sigma principles, methods, and applications for continuous improvement (DMAIC process) and an overview of Design for Six Sigma (DFSS). Both manufacturing and non-manufacturing (transactional Six Sigma) applications are included. Emphasis is placed on the use of case studies to motivate the use of, as well as the proper application of, the Six Sigma methodology. Formal Six Sigma Green Belt certification from UNH may be attained by successfully completing TECH 696. Prereq: MATH 539, MATH 644; or permission.

MATH 738 - Data Mining and Predictive Analytics**Credits:** 4

An introduction to supervised and unsupervised methods for exploring large data sets and developing predictive models. Unsupervised methods include: market basket analysis, principal components, clustering, and variables clustering. Important statistical and machine learning methods (supervised learning) include: Classification and Regression Trees (CART), Random Forests, Neural Nets, Support Vector Machines, Logistics Regression and Penalized Regression. Additional topics focus on metamodeling, validation strategies, bagging and boosting to improve prediction or classification, and ensemble prediction from a set of diverse models. Required case studies and projects provide students with experience in applying these techniques and strategies. The course necessarily involves the use of statistical software and programming languages. Undergraduate students are required to have junior or senior status to enroll in this course. Prereq: MATH 539 (or MATH 644); or permission.

MATH 739 - Applied Regression Analysis**Credits:** 4

Statistical methods for the analysis of relationships between response and input variables: simple linear regression, multiple regression analysis, residual analysis and model selection, multi-collinearity, nonlinear curve fitting, categorical predictors, analysis of variance, analysis of covariance, examination of validity of underlying assumptions, logistic regression analysis. Emphasizes real applications with use of statistical software. Prereq: MATH 539 (or 644). Writing intensive.

Attributes: Writing Intensive Course**MATH 740 - Design of Experiments I****Credits:** 4

Course in design of experiments with applications to quality improvement in industrial manufacturing, engineering research and development, or research in physical and biological sciences. Experimental factor identification, statistical analysis and modeling of experimental results, randomization and blocking, full factorial designs, random and mixed effects models, replication and sub-sampling strategies, fractional factorial designs, response surface methods, mixture designs, and screening designs. Focuses on various treatment structures for designed experimentation and the associated statistical analyses. Use of statistical software. Prereq: MATH 539 (or 644); or permission.

MATH 741 - Survival Analysis**Credits:** 4

Explorations of models and data-analytic methods used in medical, biological, and reliability studies. Event-time data, censored data, reliability models and methods, Kaplan-Meier estimator, proportional hazards, Poisson models, loglinear models. The use of statistical software, such as SAS, JMP, or R, is fully integrated into the course. Prereq: MATH 739. (Offered in alternate years in the spring semester.)

MATH 743 - Time Series Analysis**Credits:** 4

An introduction to univariate time series models and associated methods of data analysis and inference in the time domain and frequency domain. Topics include: auto regressive (AR), moving average (MA), ARMA and ARIMA processes, stationary and non-stationary processes, seasonal ARIMA processes, auto-correlation and partial auto-correlation functions, identification of models, estimation of parameters, diagnostic checking of fitted models, forecasting, spectral density function, periodogram and discrete Fournier transform, linear filters, parametric spectral estimation, dynamic Fournier analysis. Additional topics may include wavelets and long memory processes (FARIMA) and GARCH Models. The use of statistical software, such as JMP, or R, is fully integrated into the course. Prereq: MATH 739. Offered in alternate years in the spring semester.

MATH #744 - Design of Experiments II**Credits:** 4

A second course in design of experiments, with applications in quality improvement and industrial manufacturing, engineering research and development, research in physical and biological sciences. Covers experimental design strategies and issues that are often encountered in practice: complete and incomplete blocking, partially balanced incomplete blocking (PBIB), partial confounding, intra and inter block information, split plotting and strip plotting, repeated measures, crossover designs, Latin squares and rectangles, Youden squares, crossed and nested treatment structures, variance components, mixed effects models, analysis of covariance, optimizations, space filling designs, and modern screening design strategies. Prereq: MATH 740; or permission.

MATH 745 - Foundations of Applied Mathematics I**Credits:** 4

An introduction to Partial Differential Equations (PDEs) and associated mathematical methods and the analytical foundation for applied mathematics. Topics include: PDE classification, superposition, separation of variables, orthonormal functions, completeness, convergence, Fourier Series, Sturm-Liouville eigenvalue problems, and eigenfunctions. Methods are introduced for the analysis and solution of boundary value problems, in particular, the Heat, Wave, and Laplace equations. Prereq: MATH 527 and MATH 528; or equivalent.

MATH 746 - Foundations of Applied Mathematics II**Credits:** 4

An introduction to special functions, asymptotic analysis, and transform methods applied to partial differential equations. Topics include: Boundary value problems in cylindrical coordinates, the Bessel equation and Bessel functions, Fourier-Bessel expansions in cylindrically symmetric spatial domains, the Fourier Transform, the Hilbert Transform, Cosine and Sine Transforms, problems on semi-infinite intervals, and Asymptotic Analysis. Prereq: MATH 527 and MATH 528; or equivalent.

MATH 747 - Introduction to Nonlinear Dynamics and Chaos**Credits:** 4

The mathematics of chaos and nonlinear dynamics. Topics include linear and nonlinear systems of ordinary differential equations, discrete maps, chaos, phase plane analysis, bifurcations and computer simulations. Prereq: MATH 527, MATH 528, and MATH 645.

MATH 753 - Introduction to Numerical Methods I**Credits:** 4

Introduces mathematical algorithms and methods of approximation. Topics include a wide survey of approximation methods. Methods examined include polynomial interpolation, root finding, numerical linear algebra, numerical integration, and the approximation of differential equations. Included in each case is a study of the accuracy and stability of a given technique, as well as its efficiency. Prereq: MATH 426; MATH 445 (or CS 410 or IAM 550).

MATH 755 - Probability with Applications**Credits:** 4

Introduces the theory, methods, and applications of randomness and random processes. Probability concepts, random variable, expectation, discrete and continuous probability distributions, joint distributions, conditional distributions; moment-generating functions, convergence of random variables. Prereq: MATH 528 and MATH 539 (or MATH 644).

MATH 756 - Principles of Statistical Inference**Credits:** 4

Introduces the basic principles and methods of statistical estimation and model fitting. One- and two-sample procedures, consistency and efficiency, likelihood methods, confidence regions, significance testing, Bayesian inference, nonparametric and re-sampling methods, decision theory. Prereq: MATH 755; or permission.

MATH 759 - Introduction to the R Software**Credits:** 1

This course provides a basic introduction to the open-sources statistical software R for students who have never used this software or have never formally learned the basics of it. Topics include: Numeric calculations, simple and advanced graphics, object management and work-flow, RStudio, user-contributed packages, basic programming, writing of functions, statistical modeling and related graphs, distributed computing, reproducible research and document production via markup language.

MATH 760 - Geometry**Credits:** 4

Advanced approach to fundamental properties of Euclidean and other geometries through deductive reasoning and proof. Prereq: MATH 531. Writing intensive.

Attributes: Writing Intensive Course**MATH 761 - Abstract Algebra****Credits:** 4

This course establishes the axiomatic framework that underlies number systems and similar mathematical structures, investigating basic properties of groups, rings, fields and their homomorphisms. Prereq: MATH 531. Writing intensive.

Attributes: Writing Intensive Course**MATH 762 - Linear Algebra****Credits:** 4

Vector spaces over arbitrary fields, linear transformations and their relationship with matrices, eigenvalues and eigenvectors, the rational and Jordan canonical forms for linear transformations. Prereq: MATH 761.

MATH 763 - Abstract Algebra II**Credits:** 4

This course extends the investigations of MATH 761 into more specialized situations related to old and new problems in mathematics, such as the nature of solutions of polynomial equations. It presents advanced properties of groups, rings, fields and their applications. Prereq: MATH 761.

MATH 765 - Introduction to Commutative Algebra and Algebraic Geometry**Credits:** 4

Methods of determining solution sets of polynomial systems; affine varieties and their ideals; the 'algebra-geometry correspondence'; theory and applications of Grobner bases. Prereq: MATH 531, MATH 761 or permission of instructor.

MATH 767 - One-Dimensional Real Analysis**Credits:** 4

Theory of limits, continuity, differentiability, and integrability. Prereq: MATH 531. Writing intensive.

Attributes: Writing Intensive Course**MATH 768 - Real Analysis II****Credits:** 4

Theory of integration; series; power series and uniform convergence of power series. Prereq: MATH 767.

MATH 769 - Introduction to Differential Geometry**Credits:** 4

Introduction to the study of geometric properties of curves and surfaces in 3-dimensional space. Prereq: MATH 527, MATH 528, MATH 645.

MATH 770 - Foundations of Number Theory**Credits:** 4

Factorization and prime numbers, arithmetic functions, congruences, reciprocity laws, quadratic forms, Diophantine equations, computational number theory. Prereq: MATH 531. Offered in alternate years.

MATH 772 - Combinatorics**Credits:** 4

Graph theory (including planar graphs, graph coloring, Hamiltonian circuits, trees); counting principles (including permutations, combinations, pigeonhole principle, inclusion-exclusion principle); and related topics. Prereq: MATH 531.

MATH 776 - Logic**Credits:** 4

Examination of the basic notions of soundness and completeness, first for sentential and then for propositional logic. Turning to the question of decision procedures for logical formulae, the concept of recursive function, which emerges in the work of Church and Turing, provides the essential link between logic and theory of computation. The course culminates with Godel's Incompleteness Theorems, which demonstrate the intrinsic limitations of the logical method. Prereq: MATH 531. Offered in alternate years.

MATH #783 - Set Theory**Credits:** 4

Axiomatic set theory, including its history. Cantor's theory of infinite cardinal and ordinal numbers seemed laden with contradictions and paradoxes. A satisfactory treatment of these difficulties came with the axiomatic set theory of Zermelo and Fraenkel. This course develops the Zermelo-Fraenkel axioms and examines cardinal and ordinal arithmetic in the context they provide. The course then investigates the consequences of various additional axioms extending Zermelo-Fraenkel, such as the Axiom of Choice, the Continuum Hypothesis, large cardinal axioms of determinacy. Prereq: MATH 531. Offered in alternate years.

MATH 784 - Topology**Credits:** 4

Open sets, closure, base, and continuous functions; connectedness, compactness, separation axioms, and metrizable. Prereq: MATH 531. Writing intensive.

Attributes: Writing Intensive Course**MATH 788 - Complex Analysis****Credits:** 4

Complex functions, sequences, limits, differentiation and Cauchy-Riemann equations, elementary functions, Cauchy's theorem and formula, Taylor's and Laurent's series, residues, conformal mapping. Prereq: MATH 767. Not offered for credit if credit is received for MATH 647.

MATH 790 - Historical Foundations of Mathematics**Credits:** 4

Historical development of number theory, geometry, probability, algebra, and analysis. Study of the significant mathematical contributions to these topics made by prominent mathematicians spanning several historical periods. Prereq: MATH 531 or MATH 545. Writing intensive.

Attributes: Writing Intensive Course**MATH 796 - Topics****Credits:** 1-4

New or specialized courses not covered in regular course offerings. Prereq: permission of instructor. May be repeated.

MATH 797 - Senior Seminar**Credits:** 4

Exploration of mathematical topics beyond the student's previous coursework in the seminar format. The course focus is on independent research, collaborative work and classroom engagement; oral presentations and written work are required. Prereq: senior standing.

MATH 798 - Senior Project**Credits:** 4

Students work either individually or as a group under the direction of a faculty sponsor to plan and carry out an independent research project resulting in a written report and presentation to the department. Prereq: Senior standing in the department; a written proposal approved by a faculty sponsor and by the department chairperson (or designee).

MATH 799 - Senior Thesis**Credits:** 2 or 4

Students work under the direction of a faculty sponsor to plan and carry out independent research resulting in a written thesis. Required for honors-in-major. Prereq: senior standing; a written proposal endorsed by a faculty sponsor and approved by the department chairperson (or designee). May be repeated up to 4 credits. Writing intensive.

Attributes: Writing Intensive Course**Faculty**Visit <http://ceps.unh.edu/faculty/mathematics-statistics> for faculty.