MATHEMATICAL SCIENCES

Undergraduate Program Information

In addition to meeting University and College requirements, students earning a Bachelor of Science in Mathematics must fulfill the core departmental requirements and choose from one of five emphases:

- General,
- Applied Mathematics,
- Actuarial Science and Insurance,
- Foundations or
- Secondary Mathematics Education.

Students must earn a grade of C- or better in all departmental and nondepartmental courses for any degree in the Department of Mathematical Sciences.

Math Sequence Information and Recommendations

Some students may be able to bypass one or more courses in the calculus sequence MATH 1511G Calculus and Analytic Geometry I - MATH 1521G Calculus and Analytic Geometry II - MATH 2530G Calculus III. The calculus sequence, Introduction to Higher Mathematics, and Linear Algebra provide knowledge that is basic to further work, and students are advised to complete them or their equivalent as early as possible.

Students planning to enter a graduate program in Mathematics should select the General Emphasis. In any case, such students are strongly advised to take both MATH 331 Introduction to Modern Algebra and MATH 332 Introduction to Analysis, since these courses are required by most programs, and should take as many as possible of the following courses

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Title</th>
<th>Credits</th>
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<tr>
<td>MATH 456</td>
<td>Abstract Algebra I: Groups and Rings</td>
<td>3</td>
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<tr>
<td>MATH 481</td>
<td>Advanced Linear Algebra</td>
<td>3</td>
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<tr>
<td>MATH 491</td>
<td>Introduction to Real Analysis I</td>
<td>3</td>
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<tr>
<td>MATH 492</td>
<td>Introduction to Real Analysis II</td>
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Graduate Program Information

The Department of Mathematical Sciences offers graduate instruction leading to the Master of Science degree, and Doctor of Philosophy degree. Possible areas of study are various topics in pure mathematics and applied mathematics, statistics and mathematics education. Students may also pursue an interdisciplinary program of study. Most graduate students in Mathematical Sciences are supported either through teaching assistantships, research assistantships, fellowships, or job opportunities at nearby teaching or research units.

For more information on our programs and facilities, and to learn more about the research interests of the faculty, please see our web site at www.math.nmsu.edu, phone us at (575) 646-3901, or write to:

Graduate Secretary
Department of Mathematical Sciences
NMSU
Las Cruces, NM 88003-8001
Email: gradcomm@nmsu.edu

Students applying for regular admission to graduate study in mathematics are expected to have 24 credits of upper-division courses in mathematics and statistics, including three-credit proof based courses in modern analysis and in modern algebra. Students who do not meet these requirements may be admitted with deficiencies and allowed to complete the requirements at New Mexico State University.

Applications must be submitted online, see http://prospective.nmsu.edu/graduate/apply/. The minimum application to be submitted as a regular graduate student in mathematics includes:

1. a completed Graduate School admission application
2. complete transcripts of all undergraduate and graduate work
3. application fee
4. three letters of recommendation from professors, employers, or others who are qualified to judge potential for graduate work in mathematics
5. a one-page statement of educational objectives

Although GRE subject test scores are not required for admission, applicants are encouraged to submit them, if available. The test scores may be used to help allocate available teaching assistantships among entering students.

To ensure full consideration for admission, candidates should submit their applications by the following deadlines.

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<tr>
<th>Semester</th>
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<th>Admission/Financial Aid</th>
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<td>Fall</td>
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Application Deadlines-International Applicants

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Degrees for the Department

Bachelor Degree(s)

- Mathematics (Actuarial Science and Insurance) - Bachelor of Science
- Mathematics (Applied Mathematics) - Bachelor of Science
- Mathematics (Foundations) - Bachelor of Science
- Mathematics (General Mathematics) - Bachelor of Science
- Mathematics (Secondary Mathematics Education) - Bachelor of Science

Supplemental Major(s)

- Applied Mathematics - Supplemental Major

Master Degree(s)

- Mathematics - Master of Science

Doctoral Degree(s)

- Mathematics - Doctor of Philosophy
Minors for the Department
Mathematics - Undergraduate Minor

Professor, John Harding, Department Head

Professors Baggett, Barany, Bezhanishvili, DeBlassie, Giorgi, Harding, Lakey, Lodder, Olberding, Smits, Wang; Associate Professors Ballyk, Fouli, Stanford, Tian; Assistant Professors Cahill, Chen, Contreras, Montaño; College Professors Fulte, Zimmerman; College Associate Professors White-Hosford; College Assistant Professors Ausbrooks, Villaverde; College Instructors Reece

J. Harding Department Head, Ph.D. D. (McMaster) — applications of topological methods to ordered structures; P. Baggett, Ph.D. (Colorado) — mathematics education; M. Ballyk, Ph.D. (McMaster) — mathematical biology and ecology; E. Barany, Ph.D. (Ohio State) — mathematical physics; G. Bezhanishvili, Ph.D. (Tokyo Institute of Technology) — topology, algebra, and categories in logic; J. Cahill, Ph.D. (Missouri) — applied harmonic analysis; A. Contreras, Ph.D. (Indiana) — analysis and applied mathematics; D. DeBlassie, Ph.D. (MIT) — probability; L. Fouli, Ph.D. (Purdue) — commutative algebra; T. Giorgi, Ph.D. (Purdue) — applied mathematics; J. Lakey, (Maryland) — applied harmonic analysis; G. Lodder, Ph.D. (Stanford) — topology, geometry, history of mathematics; J. Montaño, Ph.D. (Purdue) — commutative algebra; B. Olberding, Ph.D. (Wesleyan) — commutative algebra, valuation theory and module theory; R. Smits, Ph.D. (Purdue) — probability, harmonic analysis; T. Stanford, Ph.D. (Columbia) — math education; J. Tian, Ph.D. (California—Riverside) — applied mathematics, mathematical biology, and biostatistics; T. Wang, Ph.D. (Windsor) — mathematical statistics. Associated Faculty: Annie Selden, Ph.D. (Clarkson) — mathematics education; John Selden, Ph.D. (Georgia) — mathematics education.

Mathematics Courses

MATH 1130G. Survey of Mathematics
3 Credits (3)
This course will develop students’ ability to work with and interpret numerical data, to apply logical and symbolic analysis to a variety of problems, and/or to model phenomena with mathematical or logical reasoning. Topics include financial mathematics used in everyday life situations, statistics, and optional topics from a wide array of authentic contexts. Prerequisite(s): adequate scoring on the Mathematics Placement Exam, or any ACT/SAT and GPA combination that is considered equivalent, or a C- or better in CCDM 113 N or CCDM 114 N or A S 103 or higher

MATH 1134. Fundamentals of Elementary Mathematics I
3 Credits (3)
Numbers and the four operations of arithmetic. Understanding and comparing multiple representations of numbers and operations, in particular how these representations build from whole numbers to integers to fractions and decimals. Applying properties of numbers and operations in contextual situations. Reasoning, communicating, and problem solving with numbers and operations. Applications to ratio, and connections with algebra. Taught primarily through student activities and investigations. Restricted to: EDUC, EPAR, E EDECEC majors. Prerequisite(s): adequate scoring on the Mathematics Placement Exam, or any ACT/SAT and GPA combination that is considered equivalent, or a C- or better in MATH 1215 or higher

MATH 1215. Intermediate Algebra
3 Credits (3)
A study of linear and quadratic functions, and an introduction to polynomial, absolute value, rational, radical, exponential, and logarithmic functions. A development of strategies for solving single-variable equations and contextual problems. Prerequisite(s): adequate scoring on the Mathematics Placement Exam, or any ACT/SAT and GPA combination that is considered equivalent, or a C- or better in CCDM 113 N or CCDM 114 N or A S 103 or higher

MATH 1217. General Supplemental Instruction I
1 Credit (2P)

MATH 1220G. College Algebra
3 Credits (3)
The study of equations, functions and graphs, reviewing linear and quadratic functions, and concentrating on polynomial, rational, exponential and logarithmic functions. Emphasizes algebraic problem solving skills and graphical representation of functions. Prerequisite(s): adequate scoring on the Mathematics Placement Exam, or any ACT/SAT and GPA combination that is considered equivalent, or a C- or better in MATH 1215 or higher

MATH 1221. General Supplemental Instruction II
1 Credit (1+2P)
Collaborative workshop for students enrolled in College Algebra. Graded: S/U Grading (S/U, Audit). Corequisite(s): MATH 1220G.

MATH 1250G. Trigonometry & Pre-Calculus
4 Credits (3+2P)
Trigonometry & Pre-Calculus includes the study of functions in general with emphasis on the elementary functions: algebraic, exponential, logarithmic, trigonometric and inverse trigonometric functions. Topics include rates of change, limits, systems of equations, conic sections, sequences and series, trigonometric equations and identities, complex number, vectors, and applications. Prerequisite(s): adequate scoring on the Mathematics Placement Exam, or any ACT/SAT and GPA combination that is considered equivalent, or a C- or better in MATH 1220G or higher

MATH 1350G. Introduction to Statistics
3 Credits (3)
This course discusses the fundamentals of descriptive and inferential statistics. Students will gain introductions to topics such as descriptive statistics, probability and basic probability models used in statistics, sampling and statistical inference, and techniques for the visual presentation of numerical data. These concepts will be illustrated by examples from a variety of fields. Prerequisite(s): adequate scoring on the Mathematics Placement Exam, or any ACT/SAT and GPA combination that is considered equivalent, or a C- or better in MATH 1215 or higher

MATH 1430G. Applications of Calculus I
3 Credits (2+2P)
An algebraic and graphical study of derivatives and integrals, with an emphasis on applications to business, social science, economics and the sciences. Prerequisite(s): adequate scoring on the Mathematics Placement Exam, or any ACT/SAT and GPA combination that is considered equivalent, or a C- or better in MATH 1220G or higher

MATH 1435. Applications of Calculus I
3 Credits (3)
Intuitive differential calculus with applications to engineering. Prerequisite(s): C- or better in MATH 1250G.
MATH 1440. Applications of Calculus II
3 Credits (3)
Topics in this second course of Applications of Calculus include functions of several variables, techniques of integration, an introduction to basic differential equations, and other applications.
**Prerequisites:** C or better in MATH 1430G or in MATH 1521G, or in MATH 1521H.

MATH 1511G. Calculus and Analytic Geometry I
4 Credits (4)
Limits and continuity, theory and computation of derivatives, applications of derivatives, extreme values, critical points, derivative tests, L'Hopital's Rule. Prerequisite(s): adequate scoring on the Mathematics Placement Exam, or any ACT/SAT and GPA combination that is considered equivalent, or a C- or better in MATH 1250G or higher.

MATH 1521G. Calculus and Analytic Geometry II
4 Credits (4)
Riemann sums, the definite integral, antiderivatives, fundamental theorems, techniques of integration, applications of integrals, improper integrals, Taylor polynomials, sequences and series, power series and Taylor series.
**Prerequisite(s):** C or better in MATH 1511G.

MATH 1521H. Calculus and Analytic Geometry II Honors
4 Credits (3+1P)
A more advanced treatment of the material of MATH 1521G with additional topics. Consent of Instructor required. Restricted to Las Cruces campus only. Consent of Department.

MATH 1531. Introduction to Higher Mathematics
3 Credits (3)
Logic; sets, relations, and functions; introduction to mathematical proofs.
**Prerequisite(s):** C or better in MATH 1521G or MATH 1521H.

MATH 1996. Topics in Mathematics
1-3 Credits
Topics to be announced in the Schedule of Classes. Maximum of 3 credits per semester. Total credit not to exceed 6 credits. Community Colleges only.
**Prerequisite:** consent of instructor.

MATH 2134G. Fundamentals of Elementary Math II
3 Credits (3)
Geometry and measurement. Multiple approaches to solving problems and understanding concepts in geometry. Analyzing and constructing two- and three-dimensional shapes. Measurable attributes, including angle, length, area, and volume. Understanding and applying units and unit conversions. Transformations, congruence, and symmetry. Scale factor and similarity. Coordinate geometry and connections with algebra. Reasoning and communicating about geometric concepts. Taught primarily through student activities and investigations.
**Prerequisite(s):** C or better in MATH 1134.

MATH 2234. Fundamentals of Elementary Mathematics III
3 Credits (3)
Probability, statistics, ratios, and proportional relationships. Experimental and theoretical probability. Collecting, analyzing, and displaying data, including measurement data. Multiple approaches to solving problems involving proportional relationships, with connections to number and operation, geometry and measurement, and algebra. Understanding data in professional contexts of teaching. Taught primarily through student activities and investigations.
**Prerequisite(s):** C or better in MATH 2134G.

MATH 2350G. Statistical Methods
3 Credits (3)
Exploratory data analysis. Introduction to probability, random variables and probability distributions. Concepts of Central Limit Theorem and Sampling Distributions such as sample mean and sample proportion. Estimation and hypothesis testing single population parameter for means and proportions and difference of two population parameters for means and proportions. Analysis categorical data for goodness of fit. Fitting simple linear regression model and inference for regression parameters. Analysis of variance for several population means. Techniques in data analysis using statistical packages. Prerequisite(s): adequate scoring on the Mathematics Placement Exam, or any ACT/SAT and GPA combination that is considered equivalent, or a C- or better in MATH 1215 or higher.

MATH 2415. Introduction to Linear Algebra
3 Credits (3)
Systems of equations, matrices, vector spaces and linear transformations. Applications to computer science.
**Prerequisite(s):** Grade of C- or better in MATH 1521G or MATH 1521H.

MATH 2530G. Calculus III
3 Credits (3)
The purpose of this course, which is a continuation of Calculus II, is to study the methods of calculus in more detail. The course will cover the material in the textbook from Chapters 10-14. Vectors in the plane and 3-space, vector calculus in two-dimensions, partial differentiation, multiple integration, topics in vector calculus, and complex numbers and functions.
**Prerequisite(s):** Grade of C- or better in MATH 1521G or MATH 1521H.

MATH 2992. Directed Study
1-3 Credits
May be repeated for a maximum of 6 credits. Graded S/U.
**Prerequisite:** consent of the instructor.

MATH 300. Readings
1-3 Credits
A selection of readings and reports in the mathematical sciences, the breadth and depth of which is deemed to fit the needs of the student. Graded S/U.
**Prerequisite:** consent of instructor.

MATH 313. Fundamentals of Algebra and Geometry I
3 Credits (3+1P)
Covers algebra combined with geometry based on measurements of distance (metric geometry). Secondary mathematics education majors may take course as a math elective. MATH 313 does not substitute for other required math courses. Does not fulfill requirements for major in mathematics.
**Prerequisites:** MATH 1134 and MATH 2134G.

MATH 316. Calculus with Hands-on Applications
3 Credits (3)
This course, primarily for prospective teachers, is taught in an interactive laboratory format. Students design and construct physical objects for which the planning stage requires calculus techniques. All numerical computations are carried out on graphing calculators. Meets simultaneously with MATH 516, primarily for practicing teachers. Secondary math education majors may take course as a math elective. MATH 316 does not fulfill requirements for majors in mathematics. Consent of instructor required.

MATH 319. Introduction to Modern Algebra
3 Credits (3)
Elements of abstract algebra, including groups, rings and fields.
**Prerequisite:** C or better in MATH 1531 and MATH 2415.
MATH 332. Introduction to Analysis
3 Credits (3)
Development of the real numbers, a rigorous treatment of sequences, limits, continuity, differentiation, and integration.
Prerequisite: C or better in MATH 1521G or MATH 1521H and MATH 1531.

MATH 377. Introduction to Numerical Methods
3 Credits (3)
Basic numerical methods for interpolation, approximation, locating zeros of functions, integration, and solution of linear equations. Computer-oriented methods will be emphasized.
Prerequisites: grade of C or better in MATH 1521G or MATH 1521H and some programming experience.

MATH 391. Vector Analysis
3 Credits (3)
Calculus of vector valued functions, Green's and Stokes' theorems and applications.
Prerequisite: grade of C or better in MATH 2530G.

MATH 392. Introduction to Ordinary Differential Equations
3 Credits (3)
Introduction to differential equations and dynamical systems with emphasis on modeling and applications. Basic analytic, qualitative and numerical methods. Equilibria and bifurcations. Linear systems with matrix methods, real and complex solutions.
Prerequisite: C or better in MATH 1521G or MATH 1521H or B or better in MATH 1440.

MATH 400. Undergraduate Research
1-3 Credits
May be repeated for a maximum of 6 credits. Graded S/U.
Prerequisite: consent of faculty member.

MATH 401. Special Topics
1-3 Credits (1-3)
Specific subjects to be announced in the Schedule of Classes. May be used to fulfill a course requirement for the mathematics major. Consent of Instructor required.

MATH 411V. Great Theorems: The Art of Mathematics
3 Credits (3)
Adopts the view of mathematics as art, using original sources displaying the creation of mathematical masterpieces from antiquity to the modern era. Original sources are supplemented by cultural, biographical, and mathematical history placing mathematics in a broad human context.
Prerequisites: Grades of B or better in MATH 1521G or MATH 1521H and any upper division MATH course, with overall GPA of 3.2 or better, or consent of instructor.

MATH 454. Logic and Set Theory
3 Credits (3)
Prerequisite(s): C- or better in MATH 331 or MATH 332, or consent of instructor.

MATH 455. Elementary Number Theory
3 Credits (3)
Covers primes, congruences and related topics.
Prerequisite: grade of C or better in MATH 331 or consent of instructor.

MATH 456. Abstract Algebra I: Groups and Rings
3 Credits (3)
Group theory, including cyclic groups, homomorphisms, cosets, quotient groups and Lagrange's theorem. Introduction to rings: ring homomorphisms, ideals, quotient rings, polynomial rings, and principal ideal domains. Crosslisted with: MATH 526.
Prerequisite(s): MATH 331 or consent of instructor.

MATH 459. Survey of Geometry
3 Credits (3)
Basic concepts of Euclidean geometry, ruler and compass constructions. May include topics in non-Euclidean geometry. For non-math majors. Restricted to: Main campus only.
Prerequisite(s): C- or better in MATH 331 or MATH 332.

MATH 471. Complex Variables
3 Credits (3)
A first course in complex function theory, with emphasis on applications.
Prerequisite(s): C- or better in MATH 391 or C- or better in both MATH 392 and MATH 2530G.

MATH 472. Fourier Series and Boundary Value Problems
3 Credits (3)
Fourier series and methods of solution of the boundary value problems of applied mathematics.
Prerequisite(s): C- or better in MATH 392.

MATH 473. Calculus of Variations and Optimal Control
3 Credits (3)
Euler's equations, conditions for extrema, direct methods, dynamic programming, and the Pontryagin maximal principle.
Prerequisite(s): C- or better in MATH 392.

MATH 477. Introduction to Numerical Methods
3 Credits (3)
Basic numerical methods for interpolation, approximation, locating zeros of functions, integration, and solution of linear equations. Computer-oriented methods will be emphasized.
Prerequisites: grade of C or better in MATH 1521G or MATH 1521H and some programming experience.

MATH 480. Matrix Theory and Applied Linear Algebra
3 Credits (3)
An application driven course, whose topics include rectangular systems, matrix algebra, vector spaces and linear transformations, inner products, and eigenvalues and eigenvectors. Applications may include LU factorization, least squares, data compression, QR factorization, singular value decomposition, and search engines.
Prerequisite(s): C or better in any 300-level course with a MATH prefix.
MATH 481. Advanced Linear Algebra
3 Credits (3)
Rigorous treatment of vector spaces and linear transformations including canonical forms, spectral theory, inner product spaces and related topics.
Prerequisite: grade of C or better in MATH 331.

MATH 491. Introduction to Real Analysis I
3 Credits (3)
Rigorous discussion of the topics introduced in calculus. Sequences, series, limits, continuity, differentiation.
Prerequisite: grade of C or better in MATH 332 or consent of instructor.

MATH 492. Introduction to Real Analysis II
3 Credits (3)
Continuation of MATH 491. Integration, metric spaces and selected topics.
Prerequisite(s): C- or better in MATH 491 or consent of instructor.

MATH 498. Directed Reading
1-6 Credits
May be repeated for a maximum of 6 credits. Graded S/U.

MATH 499. Complex Analysis
3 Credits (3)
Rigorous treatment of complex differentiation and integration, properties of analytic functions, series and Cauchy's integral representations. Crosslisted with: MATH 529.
Prerequisite(s): MATH 332.

MATH 501. Introduction to Differential Geometry
3 Credits (3)
Same as MATH 451 with additional work for graduate students.

MATH 502. Foundations of Geometry
3 Credits (3)
Same as MATH 452 with additional assignments for graduate students.

MATH 505. Elementary Number Theory
3 Credits (3)
Same as MATH 455 with additional assignments for graduate students.

MATH 511. Fundamentals of Elementary Mathematics I
3 Credits (3+1P)
Topics from real numbers, geometry, measurement, and algorithms, incorporating calculator technology. Intended for K-8 teachers. As part of course students mentor MATH 1134 undergraduates. Does not fulfill degree requirements for M.S. in mathematics.

MATH 512. Fundamentals of Elementary Mathematics II
3 Credits (3+1P)
Real numbers, geometry, and statistics, incorporating calculator technology. Intended for K-8 teachers. Students serve as mentors to MATH 2134G undergraduates. Does not fulfill degree requirements for M.S. in mathematics.

MATH 513. Fundamentals of Algebra and Geometry I
3 Credits (3+1P)
Algebra and metric geometry, incorporating appropriate calculator technology. Intended for K-8 teachers. Students serve as mentors to MATH 313 undergraduates. Does not fulfill degree requirements for M.S. in mathematics.

MATH 516. Calculus with Hands-on Application
3 Credits (3)
This course, primarily for in-service teachers, is taught in an interactive laboratory format. Students design and construct physical objects for which the planning stage requires calculus techniques. All numerical computations are carried out on graphing calculators. Meets simultaneously with Math 316, primarily for prospective teachers. Does not fulfill degree requirements for M.S. in Mathematics.
Prerequisite(s): MATH 511 and MATH 512 or consent of instructor.

MATH 517. Complex Variables
3 Credits (3)
Same as MATH 471 with additional work for graduate students.

MATH 518. Fourier Series and Boundary Value Problems
3 Credits (3)
Same as MATH 472 with additional work for graduate students.

MATH 519. Calculus of Variations and Optimal Control
3 Credits (3)
Same as MATH 473 with additional work for graduate students.

MATH 520. Introduction to Topology
3 Credits (3)
Same as MATH 450 with additional work for graduate students. Crosslisted with: MATH 450.

MATH 524. Logic and Set Theory
3 Credits (3)
Same as MATH 454 with additional assignments for graduate students. Crosslisted with: MATH 454.
Prerequisite(s): consent of instructor.

MATH 525. Advanced Linear Algebra
3 Credits (3)
Same as MATH 481 with additional work for graduate students. May be repeated up to 3 credits.

MATH 526. Abstract Algebra I: Groups and Rings
3 Credits (3)
Same as MATH 456 with additional work for graduate students. Crosslisted with: MATH 456.
Prerequisite(s): MATH 525 or consent of instructor.

MATH 527. Introduction to Real Analysis I
3 Credits (3)
Same as MATH 491 with additional work for graduate students.

MATH 528. Introduction to Real Analysis II
3 Credits (3)
Same as MATH 492 with additional work for graduate students.

MATH 529. Complex Analysis
3 Credits (3)
Same as Math 499 with additional work for graduate students.
Prerequisite(s): MATH 528.

MATH 530. Special Topics
1-3 Credits
Specific subjects to be announced in the Schedule of Classes. May be for unlimited credit with approval of the department.
MATH 531. Ordinary Differential Equations
3 Credits (3)
Linear algebra and linear ordinary differential equations, existence and uniqueness of solution, smooth dependence on initial conditions, flows, introduction to smooth dynamical systems. May be repeated up to 3 credits.
Prerequisite(s): MATH 527, or consent of instructor.

MATH 532. Nonlinear Dynamics
3 Credits (3)
Introduction to nonlinear dynamics and deterministic chaos. Core topics include stability and bifurcations; chaos in one dimensional maps; universality and re-normalization group. Further topics include symbolic dynamics, fractals, sensitive dependence on initial data, self-organization and complexity and cellular automata. Knowledge of differential equations and linear algebra is desired.

MATH 540. Directed Reading
1-6 Credits
May be repeated for a maximum of 6 credits. Consent of instructor required. Graded: S/U.

MATH 541. Topology I
3 Credits (3)
Connectedness and compactness of topological spaces, introduction to the quotient topology, elementary homotopy theory, the fundamental group, the Seifert-van Kampen theorem.
Prerequisite(s): MATH 525 and MATH 528, or consent of instructor.

MATH 542. Topology II
3 Credits (3)
Covering spaces and their classification, singular homology, degree theory, Brouwer’s fixed point theorem, CW-complexes and cellular homology, and other applications.
Prerequisite(s): MATH 541 or consent of instructor.

MATH 550. Mathematical Structures in Logic
3 Credits (3)
Prerequisite(s): MATH 524.

MATH 551. Mathematical Structures in Logic
3 Credits (3)
Prerequisite(s): MATH 524.

MATH 552. Universal Algebra and Model Theory
3 Credits (3)
Prerequisite(s): MATH 524.

MATH 555. Differentiable Manifolds
3 Credits (3)
Differentiable structures, tangent bundles, vector fields and differential equations. Additional topics may include differential forms, De Rham cohomology, Riemannian geometry, and topics chosen by the instructor. May be repeated for a maximum of 9 credits. Consent of instructor required.
Prerequisite(s): MATH 525 and MATH 528, or consent of instructor.

MATH 562. History and Theories of Mathematics Education
3 Credits (3)
A study of the history of the mathematics taught in American schools, including an examination of authentic original textbooks and the changes in their content and the approach to the subject over time, together with writings of people who have influenced the development and changes of mathematics education. Theories of learning mathematics, and current issues in mathematics education.
Prerequisite(s): Restricted to graduate students.

MATH 563. Algebra with Connections
3 Credits (3)
Connections between Algebra and other K-12 curriculum strands, especially Geometry and Probability / Data Analysis. Apply algebraic modeling and reasoning to a variety of mathematical problem solving situations. Does not fulfill requirements for degrees in mathematics. Consent of instructor required.
Prerequisite(s): Admittance into the MC2-LIFT program.

MATH 564. From Number to Algebra
3 Credits (3)
The progression from Number to Algebra in the K-12 curriculum as a concrete-to-abstract progression. Key concepts considered across the grade levels include the different uses of variables, equivalence in different contexts, patterns, and ratios. Does not fulfill requirements for degrees in mathematics. Consent of instructor required.
Prerequisite(s): Admittance into the MC2-LIFT program.

MATH 565. Number to Algebra
3 Credits (3)
The progression from Number to Algebra in the K-12 curriculum as a concrete-to-abstract progression. Key concepts considered across the grade levels include the different uses of variables, equivalence in different contexts, patterns, and ratios. Does not fulfill requirements for degrees in mathematics. Consent of instructor required.
Prerequisite(s): Admittance into the MC2-LIFT program.

MATH 566. Data Analysis with Applications
3 Credits (3)
Statistical concepts and terminology in professional uses of data by teachers, such as standardized test score reports and educational research; visual displays of data; measures of variation and central tendency; consideration of how K-12 topics in Data Analysis are developed from one grade level to the next. Does not fulfill requirements for degrees in mathematics. Consent of instructor required.
Prerequisite(s): Admittance into the MC2-LIFT program.

MATH 567. From Measurement to Geometry
3 Credits (3)
The progression from Measurement to Geometry in the K-12 curriculum as a concrete-to-abstract progression. Important concepts such as angle, length, and area progress from concrete, measurable situations to more abstract problems which require reasoning and proof. Does not fulfill requirements for degrees in mathematics. Consent of instructor required.
Prerequisite(s): Admittance into the MC2-LIFT program.

MATH 568. Using Number Throughout the Curriculum
3 Credits (3)
Understand number concepts more deeply by seeing many examples of those concepts applied in other content strands. Develop mathematical knowledge and understanding to build a repertoire of ways for students to practice and review basic number skills and concepts as part of later, more advanced courses. Does not fulfill requirements for degrees in mathematics. Consent of instructor required.
Prerequisite(s): Admittance into the MC2-LIFT program.

MATH 569. Geometry with Connections
3 Credits (3)
Connections between Geometry and other K-12 curriculum strands, especially Algebra and Probability / Data Analysis. Address key attributes of geometric concepts by considering their connections within and across grade levels. Does not fulfill requirements for degrees in mathematics. Consent of instructor required.
Prerequisite(s): Admittance into the MC2-LIFT program.
MATH 517. Partial Differential Equations I  
3 Credits (3)  
The basic equations of mathematical physics. Laplace, Heat and Wave Equations. The method of characteristics, introduction to conservation laws, special solutions.  
Prerequisite(s): MATH 518 and MATH 528 or consent of instructor.

MATH 517. Partial Differential Equations II  
3 Credits (3)  
Sobolev spaces theory: basic definitions and properties, embedding theorems, weak solutions of boundary value problems and variational methods for partial differential equations.  
Prerequisite(s): MATH 593 or consent of instructor.

MATH 581. Abstract Algebra II: Fields, Rings and Modules  
3 Credits (3)  
Topics covered include field extensions; algebraic closure; polynomials rings; irreducibility criteria; Noetherian rings; algebraic sets; Nullstellensatz; modules; applications to linear algebra.  
Prerequisite(s): MATH 526 or consent of instructor.

MATH 582. Module Theory and Homological Algebra  
3 Credits (3)  
Introductory concepts of homological algebra, including projective, injective and flat modules; projective and injective resolutions; exactness of functors; homology of chain complexes; derived functors.  
Prerequisite(s): MATH 581 or consent of instructor.

MATH 583. Introduction to Commutative Algebra and Algebraic Geometry  
3 Credits (3)  
Introduction to the basic notions and techniques of modern algebraic geometry, including the necessary commutative algebra foundation. Topics likely to include algebraic and projective varieties, Nullstellensatz, morphisms, rational and regular functions, local properties. Other topics may include Noether normalization, dimension theory, singularities, sheaves, schemes, Grobner bases.  
Prerequisite(s): MATH 581 or consent of instructor.

MATH 593. Measure and Integration  
3 Credits (3)  
Measure spaces, measurable functions, extension and decomposition theorems for measures, integration on measure spaces, absolute continuity, iterated integrals.  
Prerequisite: MATH 528 or consent of instructor.

MATH 594. Real Analysis  
3 Credits (3)  
Differentiation, Lp spaces, Banach spaces, measure and topology, other selected topics.  
Prerequisite: MATH 593.

MATH 595. Introduction to Functional Analysis  
3 Credits (3)  
Banach spaces. The three basic principles: uniform boundedness principle, closed graph/open mapping theorems, Hahn-Banach theorem.  
Prerequisite(s): MATH 594, or consent of instructor.

MATH 599. Master's Thesis  
1-15 Credits  
Thesis.  

MATH 600. Doctoral Research  
1-15 Credits  
Research.  

MATH 698. Selected Topics  
1-15 Credits  
Selected topics.  

MATH 700. Doctoral Dissertation  
1-15 Credits  
Dissertation.  

Statistics Courses  
STAT 371. Statistics for Engineers and Scientists I  
3 Credits (3)  
Modern probability and statistics with applications to the engineering sciences.  
Prerequisite(s): C- or better in MATH 1521G or MATH 1521H.

STAT 400. Undergraduate Research  
1-3 Credits  
Arrangements must be made with supervising professor before registration. May be repeated for a maximum of 6 credits.

STAT 470. Probability: Theory and Applications  
3 Credits (3)  
Basic probability distributions including binomial, normal; random variables, expectation; laws of large numbers; central limit theorem.  
Prerequisite(s): C- or better in MATH 2530G and C- or better in at least one-300 level Math course.

STAT 480. Statistics: Theory and Applications  
3 Credits (3)  
Point and interval estimation; sufficiency; hypothesis testing; regression; analysis of variance; chi-square tests.  
Prerequisite(s): C- or better in STAT 470.

STAT 515. Probability: Theory and Applications  
3 Credits (3)  
Same as STAT 470 with additional work for graduate students.

STAT 525. Statistics: Theory and Applications  
3 Credits (3)  
Same as STAT 480 with additional work for graduate students.

STAT 535. Elementary Stochastic Processes  
3 Credits (3)  
Markov chains, Poisson processes, Brownian motion, branching processes, and queuing processes, with applications to the physical, biological, and social sciences.  
Prerequisite: STAT 515 or consent of instructor.

STAT 540. Directed Reading  
1-6 Credits  
May be repeated for a maximum of 6 credits. Graded S/U.  
Prerequisite: consent of instructor and graduate committee.

STAT 562. Foundations of Probability  
3 Credits (3)  
Probability spaces, expectation and conditional expectation, limit theorems and laws of large numbers.  
Prerequisite: MATH 593.

STAT 563. Advanced Topics in Stochastic Processes  
3 Credits (3)  
Markov processes, martingales, Brownian motion, the Ito calculus, stochastic differential equations.  
Prerequisite(s): STAT 562.

STAT 571. Continuous Multivariate Analysis  
3 Credits (3)  
Theory and applications of the multivariate normal distribution. May be repeated up to 3 credits. Consent of Instructor required.  
Prerequisite(s): STAT 525, or consent of instructor.
STAT 572. Linear Models
3 Credits (3)
Core topics include distribution of quadratic forms, theory of regression, analysis of variance and covariance in linear models. Advanced topics chosen from random and mixed linear models, generalized linear, growth curve, and nonlinear models, quartile and copula regression. May be repeated up to 6 credits.
Prerequisite(s): STAT 571.

STAT 581. Advanced Theory of Statistics I
3 Credits (3)
Testing hypotheses, probability and sufficiency, uniformly most powerful tests, unbiasedness, invariance, and minimax principle.
Prerequisite: STAT 525 or consent of instructor.

STAT 582. Advanced Theory of Statistics II
3 Credits (3)
Estimation of parameters; unbiased estimators; equivariance; Bayes properties; large sample theory and optimality.
Prerequisite: STAT 581 or consent of instructor.

STAT 598. Special Research Problems
1-3 Credits
Individual investigations or consulting programs. Maximum of 3 credits.

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