DEPARTMENT OF MATHEMATICS

Programs

Undergraduate

Major

- Mathematics Major (https://catalog.tulane.edu/science-engineering/mathematics/mathematics-major/)

Minor

- Mathematics Minor (https://catalog.tulane.edu/science-engineering/mathematics/mathematics-minor/)

Graduate

- Applied Mathematics, MS (https://catalog.tulane.edu/science-engineering/mathematics/applied-mathematics-ms/)
- Data Science, MS (https://catalog.tulane.edu/science-engineering/mathematics/data-science-ms/)
- Mathematics, MS (https://catalog.tulane.edu/science-engineering/mathematics/mathematics-ms/)
- Mathematics, PhD (https://catalog.tulane.edu/science-engineering/mathematics/mathematics-phd/)
- Statistics, MS (https://catalog.tulane.edu/science-engineering/mathematics/statistics-ms/)

Courses

Mathematics (MATH)

MATH 1001 College Mathematics Prep (1)
A five week review of algebra, trigonometry and other pre-calculus concepts relevant to success in calculus and statistics using an artificially intelligent assessment and learning system. This course is open only to students participating in the Newcomb-Tulane College Summer Experience program.

MATH 1005 Explore Experiment Math (3)
An introduction to selected topics in mathematics through inquiry-based discovery. Students will make novel calculations, search for patterns, formulate conjectures, and ultimately prove theorems based on their exploration. The emphasis of the course is on the search for structures in mathematics through guided discovery. This course is open only to high school students participating in the Tulane Science Scholars program.

MATH 1110 Probability & Statistics I (3)
Elementary probability theory with applications; random variables; distributions including a thorough discussion of the binomial, and normal distributions; central limit theorem; histograms; sampling distributions; confidence intervals; tests of hypotheses; linear models; regression and correlation; chi-square test; non-parametric statistics. 1110 is a prerequisite for 1120. These courses do not count toward the Mathematics B.S. requirement in SSE. MATH 1110 is mutually exclusive with MATH 1230. Students may receive credit for only one of MATH 1110 or 1230 in the undergraduate degree.

Corequisite(s): MATH 1111.

MATH 1111 Recitation for Prob & Stats (0)
This is a co-requisite recitation course for MATH 1110.

MATH 1150 Long Calculus I (3)
The material of Calculus 1210 is covered in two semesters, with diversions for topics in algebra, trigonometry, complex numbers as the need for these topics arises. Mathematics 1150 is a prerequisite for 1160. Students finishing the course sequence 1150-1160 may continue with 1220 or any other course having Calculus 1201 as a prerequisite. The combination of 1150 and 1160 may count as one course toward the B.S. degree requirement.

MATH 1160 Long Calculus II (3)
The material of Calculus 1210 is covered in two semesters, with diversions for topics in algebra, trigonometry, complex numbers as the need for these topics arises. Mathematics 1150 is a prerequisite for 1160. Students finishing the course sequence 1150-1160 may continue with 1220 or any other course having Calculus 1201 as a prerequisite. The combination of 1150 and 1160 may count as one course toward the B.S. degree requirement.

Prerequisite(s): MATH 1150.

MATH 1210 Calculus I (4)
Functions and their graphs, limits and continuity, derivatives and applications of derivatives, and introduction to the integral.

Corequisite(s): MATH 1211.

MATH 1211 Calculus I Recitation (0)
This is a co-requisite recitation course for MATH 1210.

MATH 1220 Calculus II (4)
Integration; exponential, logarithmic, and trigonometric functions; techniques of integration; mean value theorem; Taylor's Theorem and Taylor series; and infinite series. MATH 1220 is mutually exclusive with MATH 1310. Students may receive credit for only one of MATH 1220 or MATH 1310 in the undergraduate degree.

Prerequisite(s): MATH 1160 or 1210.
Corequisite(s): MATH 1221.

MATH 1221 Recitation for Calculus II (0)
This is a co-requisite recitation course for MATH 1220.

MATH 1230 Statistics For Scientists (4)
The objective of this course is to provide a thorough introduction to the statistical methods most likely to be encountered by scientists in practical research applications. Specific topics that will be covered in this course include probability axioms and counting techniques, discrete and continuous distributions, sampling methods and descriptive statistics, the Central Limit Theorem and its applications, confidence intervals, hypothesis testing, and linear regression. MATH 1230 is mutually exclusive with MATH 1110. Students may receive credit for only one of MATH 1110 or 1230 in the undergraduate degree. Only MATH 1230 counts towards the B.S. degree.

Prerequisite(s): (MATH 1210) or (MATH 1150 and 1160) or (MATH 1310).
Corequisite(s): MATH 1231.

MATH 1231 Stats for Scientists Recitation (0)
This is a co-requisite recitation course for MATH 1230.

MATH 1310 Consolidated Calculus (4)
A combined course in Calculus I and II for students with a background in Calculus I. Students receive credit for both this course and 1210 if they receive a B- or higher. MATH 1310 is mutually exclusive with MATH 1220. Students may receive credit for only one of MATH 1220 or MATH 1310 in the undergraduate degree.

Corequisite(s): MATH 1311.

MATH 1311 Consolidated Calculus 1 Rec. (0)
This is a co-requisite recitation course for MATH 1310.

MATH 1940 Transfer Coursework (0-20)
Transfer Coursework at the 1000 level. Department approval may be required.

Maximum Hours: 99

MATH 2010 Math Modeling of World (3)
This course exposes students to the process of mathematical modeling as a way to describe, explain, understand, or predict situations arising in everyday life. Examples of such situations might include: the design of handicap ramps, estimating the number of sand bags needed to raise a levee a few feet, understanding and predicting the number of daylight hours at different places in the world, analyzing the consequences of child support payment adjustment formulas used by the states, etc. The modeling process emphasizes making assumptions, translating the empirical situation into mathematical language, drawing conclusions from the mathematical solution, interpreting and validating those conclusions in the context of the original situation and revising assumptions if necessary.

Prerequisite(s): MATH 1150, 1210, 1220, 1310 or 2210.

MATH 2170 Intro To Discrete Math (3)
This course is an introduction to several areas of mathematics that are particularly useful in computer science. The topics include an introduction to predicate and propositional logic, mathematical induction, combinatorics and counting, and discrete probability theory. In lieu of prerequisites please contact instructor for consideration.

Prerequisite(s): MATH 1210, 1310, 1150 or 1110.
Corequisite(s): CMPS 2171.

MATH 2171 Intro To Discrete Math Lab (0)
Co-requisite lab for MATH 2170.

Corequisite(s): MATH 2170.

MATH 2210 Calculus III (4)
A basic course in differential and integral calculus of several variables. Vectors in the plane and space. Vector functions, derivatives, arc length, curvature. Functions of several variables: continuity, partial derivatives, chain rule, gradient, optimization, Lagrange multipliers. Double and triple integrals: change of variables, polar coordinates, cylindrical and spherical coordinates, surface area. Vector fields: gradient, curl, divergence, line and surface integrals, Green's, Stokes', and Divergence theorems.

Prerequisite(s): MATH 1220 or 1310.
Corequisite(s): MATH 2211.

MATH 2211 Recitation for Calculus III (0)
This is a co-requisite recitation course for MATH 2210.

MATH 2240 Intro To Applied Math (4)
An introduction to the techniques of applied mathematics. The course combines an introduction to ordinary differential equations with linear algebra. Numerical and graphical techniques for finding both quantitative and qualitative information about solutions will be discussed and implemented on the computer. No programming experience is assumed. Note: MATH 2240 is mutually exclusive with MATH 4240. Students may receive credit for only one of MATH 2240 or MATH 4240 in the undergraduate degree.

Prerequisite(s): MATH 1220 or 1310.
Corequisite(s): MATH 2241.

MATH 2241 Recitation for Intro App Math (0)
This is a co-requisite recitation course for MATH 2240.

Corequisite(s): MATH 2240.

MATH 2890 Service Learning (0-1)
Students complete a service activity in the community in conjunction with the content of a three-credit co-requisite course. Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 2940 Transfer Coursework (0-20)
Transfer Coursework at the 2000 level. Department approval may be required.

Maximum Hours: 99

MATH 3050 Real Analysis I (3)
Introduction to analysis. Real numbers, limits, continuity, uniform continuity, sequences and series, compactness, convergence, Riemann integration. An in-depth treatment of the concepts underlying calculus.

Prerequisite(s): MATH 2210.
Corequisite(s): MATH 3051.

MATH 3051 Recitations for Real Analysis (0)
This is a co-requisite recitation course for MATH 3050.

MATH 3070 Intro To Probability (3)
An introduction to probability theory. Counting methods, conditional probability and independence. Discrete and continuous distributions, expected value, joint distributions and limit theorems. Prepares student for future work in probability and statistics.

Corequisite(s): MATH 3071.

MATH 3071 Intro to Probability Rec. (0)
Corequisite(s): MATH 3070.

MATH 3080 Intro to Statistical Inference (3)
Basics of statistical inference. Sampling distributions, parameter estimation, hypothesis testing, optimal estimates and tests. Maximum likelihood estimates and likelihood ratio tests. Data summary methods and categorical data analysis. Analysis of variance and introduction to linear regression.

Prerequisite(s): MATH 2210 and 3070.
Corequisite(s): MATH 3081.

MATH 3081 Recitations for Intro to Stat (0)
This is a co-requisite recitation course for MATH 3080.

MATH 3090 Linear Algebra (4)
An introduction to linear algebra emphasizing matrices and their applications. Gaussian elimination, determinants, vector spaces and linear transformations, orthogonality and projections, eigenvector problems, diagonalizability, Spectral Theorem, quadratic forms, applications. MATLAB is used as a computational tool.

Prerequisite(s): MATH 2210.
Corequisite(s): MATH 3091.

MATH 3091 Recitations for Linear Algebra (0)
This is a co-requisite recitation course for MATH 3090.

MATH 3110 Abstract Algebra I (3)
An introduction to abstract algebra. Elementary number theory and congruences. Basic group theory: groups, subgroups, normality, quotient groups, permutation groups. Ring theory: polynomial rings, unique factorization domains, elementary ideal theory. Introduction to field theory. Prerequisite(s): MATH 2210.

Prerequisite(s): MATH 2210.

MATH 3140 Experimental Mathematics (3)
The exploration of Mathematical tools in Symbolic Languages. Examples are taken from calculus, differential equations, and linear algebra. Prerequisite(s): MATH 1210, 1220 and 2210.

Prerequisite(s): MATH 1210, 1220 and 2210.

MATH 3200 Combinatorics (3)
Basics of combinatorics with emphasis on problem solving. Provability, pigeonhole principle, mathematical induction. Counting techniques, generating functions, recurrence relations, Polya's counting formula, a theorem of Ramsey. Prerequisite(s): (MATH 1210) and (MATH 1220) and (MATH 2210) or (MATH 3090) or (MATH 1310).

Prerequisite(s): (MATH 1210) and (MATH 1220) and (MATH 2210) or (MATH 3090) or (MATH 1310).

MATH 3280 Information Theory (3)
This introduction to information theory will address fundamental concepts, such as information, entropy, relative entropy, and mutual information. In addition to giving precise definitions of these concepts, the course will include a probabilistic approach based on equipartitions. Many of the applications of information will be discussed, including Shannon's basic theorems on channel capacity and related coding theorems. In addition to channels and channel capacity, the course will discuss applications of information theory to mathematics, statistics, and computer science. Prerequisite(s): MATH 3050, 3090 or 6090.

Prerequisite(s): MATH 3050, 3090 or 6090.

MATH 3310 Scientific Computing I (3)
Errors. Curve fitting and function approximation, least squares approximation, orthogonal polynomials, trigonometric polynomial approximation. Direct methods for linear equations. Iterative methods for nonlinear equations and systems of nonlinear equations. Interpolation by polynomials and piecewise polynomials. Numerical integration. Single-step and multi-step methods for initial-value problems for ordinary differential equations, variable step size. Current algorithms and software.

Prerequisite(s): (MATH 2210) and (MATH 2240) or (MATH 4240).

MATH 3650 Number Theory (3)
The subject of number theory is one of the oldest in mathematics. The course will cover some basic material and describe interesting applications. One of the recurrent themes is the realization that mathematics that was developed usually for its own sake, has found applications in many unexpected problems. Some of the topics covered in the class are Pythagorean triples, prime numbers, divisibility and the highest common divisor, linear diophantine equations, congruences, round-robin tournaments and perpetual calendars, multiple functions, perfect numbers, primitive roots, pseudo-random numbers, decimal fractions and continued fractions, quadratic reciprocity.

MATH 3660 Special Topics (1-3)
Special Topics. Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 3890 Service Learning (0-1)
Students complete a service activity in the community in conjunction with the content of a three-credit co-requisite course. Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 3940 Transfer Coursework (0-20)
Transfer Coursework at the 3000 level. Department approval may be required.

Maximum Hours: 99

MATH 3980 Senior Seminar (1)
Under faculty guidance, students will select a topic in current mathematical research, write an expository article on that topic, and give an oral presentation. This seminar is required of all mathematics majors who are not doing an Honors Project within the department.

MATH 3990 Senior Seminar (3)
Under faculty guidance, students will select a topic in current mathematical research, write an expository article on that topic, and give an oral presentation. This seminar is required of all mathematics majors who are not doing an Honors Project within the department.

MATH 4060 Real Analysis II (3)
An in-depth treatment of multivariable calculus. Extends the material covered in Mathematics 2210. Chain rule, inverse and implicit function theorems, Riemann integration in Euclidean n-space, Gauss-Green-Stokes theorems, applications.

Prerequisite(s): MATH 3050.

MATH 4120 Abstract Algebra II (3)
Abstract vector spaces, quotient spaces, linear transformations, dual spaces, determinants. Solvable groups. Field extensions, Galois theory, solvability of equations by radicals. Prerequisite(s): MATH 3090 and 3110.

Prerequisite(s): MATH 3090 and 3110.

MATH 4210 Differential Geometry (3)
Theory of plane and space curves including arc length, curvature, torsion, Frenet equations, surfaces in three-dimensional space. First and second fundamental forms, Gaussian and mean curvature, differentiable mappings of surfaces, curves on a surface, special surfaces. Prerequisite(s): MATH 3050 and 3090.

Prerequisite(s): MATH 3050 and 3090.

MATH 4240 Ordinary Differentl Equa (3)
Review of linear algebra, first-order equations (models, existence, uniqueness, Euler method, phase line, stability of equilibria), higher-order linear equations, Laplace transforms and applications, power series of solutions, linear first-order, systems (autonomous systems, phase plane), application of matrix normal forms, linearization and stability of nonlinear systems, bifurcation, Hopf bifurcation, limit cycles, Poincare-Bendixson theorem, partial differential equations (symmetric boundary-value problems on an interval, eigenvalue problems, eigenfunction expansion, initial-value problems in 1D). Note: MATH 4240 is mutually exclusive with MATH 2240. Students may receive credit for only one of MATH 2240 or MATH 4240 in the undergraduate degree.

Prerequisite(s): MATH 2210 and 3090.

MATH 4300 Complex Analysis (3)
The complex number system, complex integration and differentiation, conformal mapping, Cauchy's theorem, calculus of residues.

MATH 4410 Topology (3)
An introduction to topology. Elementary point set topology: topological spaces, compactness, connectedness, continuity, homeomorphisms, product and quotient spaces. Classification of surfaces and other geometric applications. Prerequisite(s): MATH 3050.

Prerequisite(s): MATH 3050.

MATH 4470 Analyt Method Appl Math (3)
Derivations of transport, heat/reaction-diffusion, wave, Poisson's equations; well-posedness; characteristics methods for first order PDE's; D'Alembert formula and conservation of energy for wave equations; propagation of waves; Fourier transforms; heat kernel, smoothing effect; maximum principles; Fourier series and Sturm-Liouville eigen-expansions; method of separation of variables, frequencies of wave equations, stable and unstable modes, long time behavior of heat equations; delta-function, fundamental solution of Laplace equation, Newton potential; Green's function and Poisson formula; Dirichlet Principle.

MATH 4560 Internship (1-3)
Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 4660 Special Topics (1-3)
Special Topics. Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 4900 Advanced Topics In Math (3)
This course covers a variety of advanced topics in mathematics and exposes students to recent developments not available in other parts of the mathematics curriculum. Topics covered will vary from semester to semester. Recent topics offered include Knot Theory and 3-Manifolds, Algebraic Combinatorics, Cardiac Modeling, Number Theory.

MATH 4910 Independent Study (1-3)
No more than four hours of 4910-4920 may be counted toward satisfying the major requirements. Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 4920 Independent Study (1-3)
No more than four hours of 4910-4920 may be counted toward satisfying the major requirements. Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 4940 Transfer Coursework (0-20)
Transfer coursework at the 4000 level. Departmental approval required.

Maximum Hours: 99

MATH 4990 Honors Thesis (3)
Honors thesis research, first semester. Register in department.

MATH 5000 Honors Thesis (4)
For especially qualified seniors with approval of the faculty director and the Office of Academic Enrichment. Students must have a minimum of a 3.400 overall grade-point average and a 3.500 grade-point average in the major.

Prerequisite(s): MATH 4990.

MATH 5380 Study Abroad (1-20)
Courses taught abroad by non-Tulane faculty. Does not count toward Tulane GPA. Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 5390 Study Abroad (1-20)
Courses taught abroad by non-Tulane faculty. Does not count toward Tulane GPA. Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 6020 Mathematical Statistics (3)
Thorough review of key distributions for probability and statistics, including the multivariate calculus needed to develop them. Full derivation of sampling distribution. Classical principles of inference including best tests and estimations. Methods of finding tests and estimators. Introduction to Bayesian estimators. Prerequisite(s): MATH 6070, 6080 and 7150.

Prerequisite(s): (MATH 6070 or 6070) and (MATH 6080 or 6080) and (MATH 7150 or 7150).

MATH 6030 Stochastic Processes (3)
Markov processes, Poisson processes, queueing models, introduction to Brownian Motion.

Prerequisite(s): MATH 3070.

MATH 6040 Linear Models (3)
Overview of multivariate analysis, theory of least squares linear regression, regression diagnostics, analysis of variance. Includes data modeling using statistical software.

Prerequisite(s): MATH 6090 and (MATH 6080 or 6020).

MATH 6050 Real Analysis I (3)
Introduction to analysis. Real numbers, limits, continuity, uniform continuity, sequences and series, compactness, convergence, Riemann integration. An in-depth treatment of the concepts underlying calculus.

Prerequisite(s): MATH 2210.
Corequisite(s): MATH 6051.

MATH 6051 Recitations for Real Analysis (0)
This is a co-requisite recitation course for MATH 6050.

Corequisite(s): MATH 6050.

MATH 6060 Real Analysis II (3)
An in-depth treatment of multivariable calculus. Extends the material covered in Mathematics 2210. Chain rule, inverse and implicit function theorems, Riemann integration in Euclidean n-space, Gauss-Green-Stokes theorems, applications.

MATH 6070 Intro To Probability (3)
An introduction to probability theory. Counting methods, conditional probability and independence. Discrete and continuous distributions, expected value, joint distributions and limit theorems. Prepares student for future work in probability and statistic

Corequisite(s): MATH 6071.

MATH 6071 Intro to Probability Rec (0)
Corequisite(s): MATH 6070.

MATH 6080 Intro to Statistical Inference (3)
Basics of Statistical inference. Sampling distributions, parameter estimation, hypothesis testing, optimal estimates and tests. Maximum likelihood estimates and likelihood ratio tests. Data summary methods, categorical data analysis. Analysis of variance and introduction to linear regression.

Corequisite(s): MATH 6081.

MATH 6081 Recitations for Intro to Stat (0)
This is a co-requisite recitation course for MATH 6080.

MATH 6090 Linear Algebra (3)
An introduction to linear algebra emphasizing matrices and their applications. Gaussian elimination, determinants, vector spaces and linear transformations, orthogonality and projections, eigenvector problems, diagonalizability, Spectral Theorem, quadrati

Corequisite(s): MATH 6091.

MATH 6091 Recitations for Linear Algebra (0)
This is a co-requisite recitation course for MATH 6090.

Corequisite(s): MATH 6090.

MATH 6110 Abstract Algebra I (3)
An introduction to abstract algebra. Elementary number theory and congruences. Basic group theory: groups, subgroups, normality, quotient groups, permutation groups. Ring theory: polynomial rings, unique factorization domains, elementary ideal theory. Int

MATH 6120 Abstract Algebra II (3)
Abstract vector spaces, quotient spaces, linear transformations, dual spaces, determinants. Solvable groups. Field extensions, Galois theory, solvability of equations by radicals.

MATH 6200 Combinatorics (3)
Basics of combinatorics with emphasis on problem solving. Provability, pigeonhole principle, mathematical induction. Counting techniques, generating functions, recurrence relations, Polya's counting formula, a theorem of Ramsey.

MATH 6210 Differential Geometry (3)
Theory of plane and space curves including arc length, curvature, torsion, Frenet equations, surfaces in three-dimensional space. First and second fundamental forms, Gaussian and mean curvature, differentiable mappings of surfaces, curves on a surface, sp

MATH 6240 Ordinary Differentl Equa (3)
Review of linear algebra, first-order equations (models, existence, uniqueness, Euler method, phase line, stability of equilibria), higher-order linear equations, Laplace transforms and applications, power series of solutions, linear first-order, systems (autonomous systems, phase plane), application of matrix normal forms, linearization and stability of nonlinearsystems, bifurcation, Hopf bifurcation, limit cycles, Poincare-Bendixson theorem, partial differential equations (symmetric boundary-value problems on an interval, eigenvalue problems, eigenfunction expansion, initial-value problems in 1D). Students may not receive credit for both 2240 and 4240.

MATH 6280 Information Theory (3)
This introduction to information theory will address fundamental concepts, such as information, entropy, relative entropy, and mutual information. In addition to giving precise definitions of these concepts, the course will include a probabilistic approac

MATH 6300 Complex Analysis I (3)
The complex number system, complex integration and differentiation, conformal mapping, Cauchy's theorem, calculus of residues.

MATH 6310 Scientific Computing I (3)
Errors. Curve fitting and function approximation, least squares approximation, orthogonal polynomials, trigonometric polynomial approximation. Direct methods for linear equations. Iterative methods for nonlinear equations and systems of nonlinear equation

MATH 6350 Optimization (3)
Constrained and unconstrained non-linear optimization; Linear programming, combinatorial optimization as time allows. Emphasis is on realistic problems whose solution requires computers, using Maple or Mathematica.

MATH 6370 Time Series Analysis (3)
This course provides an introduction to time series analysis at the graduate level. The course is about modeling based on three main families of techniques: (i) the classical decomposition into trend, seasonal and noise components; (ii) ARIMA processes and the Box and Jenkins methodology; (iii) Fourier analysis. If time permits, other possible topics include state space modeling and fractional processes. The course is focused on the theory, but some key examples and applications are also covered and implemented in the software package R.

Prerequisite(s): MATH 6070 and 6080 and (MATH 6040 or 7260).

MATH 6470 Analy Methods Appl Math (3)

MATH 6510 Topology I (3)
Point set topology. Connectedness, product and quotient spaces, separation properties, metric spaces. Classification of compact connected surfaces. Homotopy. Fundamental group and covering spaces. Singular and simplicial homology. Eilenberg-Steenrod axioms. Computational techniques, including long exact sequences. Mayer-Vietoris sequences, excision, and cellular chain complexes. Introduction to singular cohomology.

MATH 6520 Topology II (3)
Point set topology. Connectedness, product and quotient spaces, separation properties, metric spaces. Classification of compact connected surfaces. Homotopy. Fundamental group and covering spaces. Singular and simplicial homology. Eilenberg-Steenrod axioms. Computational techniques, including long exact sequences. Mayer-Vietoris sequences, excision, and cellular chain complexes. Introduction to singular cohomology.

Prerequisite(s): MATH 3050 and 4060.

MATH 6550 Differential Geometry I (3)
Differentiable manifolds. Vector fields and flows. Tangent bundles. Frobenius theorem. Tensor fields. Differential forms, Lie derivatives. Integration and deRham's theorem. Riemannian metrics, connections, curvature, parallel translation, geodesics, and submanifolds, including surfaces. First and second variation formulas, Jacobi fields, Lie groups. The Maurer-Cartan equation. Isometries, principal bundles, symmetric spaces, K&aumlhler geometry.

MATH 6560 Differential Geometry II (3)
Differentiable manifolds. Vector fields and flows. Tangent bundles. Frobenius theorem. Tensor fields. Differential forms, Lie derivatives. Integration and deRham's theorem. Riemannian metrics, connections, curvature, parallel translation, geodesics, and submanifolds, including surfaces. First and second variation formulas, Jacobi fields, Lie groups. The Maurer-Cartan equation. Isometries, principal bundles, symmetric spaces, Kähler geometry.

MATH 6610 Algebra I (3)
Vector spaces: matrices, eigenvalues, Jordan canonical form. Elementary number theory: primes, congruences, function, linear Diophantine equations, Pythagorean triples. Group theory: cosets, normal subgroups, homomorphisms, permutation groups, theorems of Lagrange, Cayley, Jordan-Hölder, Sylow. Finite abelian groups, free groups, presentations. Ring theory: prime and maximal ideals, fields of quotients, matrix and Noetherian rings. Fields: algebraic and transcendental extensions, survey of Galois theory. Modules and algebras: exact sequences, projective and injective and free modules, hom and tensor products, group algebras, finite dimensional algebras. Categories: axioms, subobjects, kernels, limits and colimits, functors and adjoint functors.

MATH 6620 Algebra II (3)
Vector spaces: matrices, eigenvalues, Jordan canonical form. Elementary number theory: primes, congruences, function, linear Diophantine equations, Pythagorean triples. Group theory: cosets, normal subgroups, homomorphisms, permutation groups, theorems of Lagrange, Cayley, Jordan-Hölder Sylow. Finite abelian groups, free groups, presentations. Ring theory: prime and maximal ideals, fields of quotients, matrix and Noetherian rings. Fields: algebraic and transcendental extensions, survey of Galois theory. Modules and algebras: exact sequences, projective and injective and free modules, hom and tensor products, group algebras, finite dimensional algebras. Categories: axioms, subobjects, kernels, limits and colimits, functors and adjoint functors.

Prerequisite(s): MATH 3090 and 3110.

MATH 6660 Special Topics (1-3)
Special Topics. Can be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 6710 Analysis I (3)
Lebesgue measure on R. Measurable functions (including Lusin's and Egoroff's theorems). The Lebesgue integral. Monotone and dominated convergence theorems. Radon-Nikodym Theorem. Differentiation: bounded variation, absolute continuity, and the fundamental theorem of calculus. Measure spaces and the general Lebesgue integral (including summation and topics in Rn such as the Lebesgue differentiation theorem). Lp spaces and Banach spaces. Hahn-Banach, open mapping, and uniform boundedness theorems. Hilbert space. Representation of linear functionals. Completeness and compactness. Compact operators, integral equations, applications to differential equations, self-adjoint operators, unbounded operators.

MATH 6720 Analysis II (3)
Lebesgue measure on R. Measurable functions (including Lusin's and Egoroff's theorems). The Lebesgue integral. Monotone and dominated convergence theorems. Radon-Nikodym Theorem. Differentiation: bounded variation, absolute continuity, and the fundamental theorem of calculus. Measure spaces and the general Lebesgue integral (including summation and topics in Rn such as the Lebesgue differentiation theorem). Lp spaces and Banach spaces. Hahn-Banach, open mapping, and uniform boundedness theorems. Hilbert space. Representation of linear functionals. Completeness and compactness. Compact operators, integral equations, applications to differential equations, self-adjoint operators, unbounded operators.

Prerequisite(s): MATH 3050, 3090 and 4060.

MATH 6810 Applied Math I (3)
Formulating mathematical models. Introduction to differential equations and integral equations. Fourier series and transforms, Laplace transforms. Generating functions. Dimensional analysis and scaling. Regular and singular perturbations. Asymptotic expansions. Boundary layers. The calculus of variations and optimization theory. Similarity solutions. Difference equations. Stability and bifurcation. Introduction to probability and statistics, and applications.

MATH 6820 Applied Math II (3)
Formulating mathematical models. Introduction to differential equations and integral equations. Fourier series and transforms, Laplace transforms. Generating functions. Dimensional analysis and scaling. Regular and singular perturbations. Asymptotic expansions. Boundary layers. The calculus of variations and optimization theory. Similarity solutions. Difference equations. Stability and bifurcation. Introduction to probability and statistics, and applications.

MATH 6940 Transfer Coursework (0-20)
Transfer coursework at the 6000 level. Departmental approval required.

Maximum Hours: 99

MATH 7001 Math Teaching Training (1)
An interactive seminar to prepare students to teach mathematics at the college level. Topics covered will include discussion of practical issues such as how to keep a class engaged, how to prepare and grade assessments, how to prepare for class meetings, as well as discussion of theoretical issues such as what a teacher should be trying to achieve in the classroom, current understanding of how students learn best, and evaluating the effectiveness of assessments of student performance.

MATH 7010 Topology I (3)
Point set topology. Connectedness, product and quotient spaces, separation properties, metric spaces. Classification of compact connected surfaces. Homotopy. Fundamental group and covering spaces. Singular and simplicial homology. Eilenberg-Steenrod axioms. Computational techniques, including long exact sequences. Mayer-Vietoris sequences, excision, and cellular chain complexes. Introduction to singular cohomology.

MATH 7020 Topology II (3)
Point set topology. Connectedness, product and quotient spaces, separation properties, metric spaces. Classification of compact connected surfaces. Homotopy. Fundamental group and covering spaces. Singular and simplicial homology. Eilenberg-Steenrod axioms. Computational techniques, including long exact sequences. Mayer-Vietoris sequences, excision, and cellular chain complexes. Introduction to singular cohomology.

MATH 7030 Stochastic Processes (3)
Markov processes, Poisson processes, queueing models, introduction to Brownian Motion.

MATH 7110 Algebra I (3)
Vector spaces: matrices, eigenvalues, Jordan canonical form. Elementary number theory: primes, congruences, function, linear Diophantine equations, Pythagorean triples. Group theory: cosets, normal subgroups, homomorphisms, permutation groups, theorems of Lagrange, Cayley, Jordan-Hölder , Sylow. Finite abelian groups, free groups, presentations. Ring theory: prime and maximal ideals, fields of quotients, matrix and Noetherian rings. Fields: algebraic and transcendental extensions, survey of Galois theory. Modules and algebras: exact sequences, projective and injective and free modules, hom and tensor products, group algebras, finite dimensional algebras. Categories: axioms, subobjects, kernels, limits and colimits, functors and adjoint functors.

MATH 7120 Algebra II (3)
Vector spaces: matrices, eigenvalues, Jordan canonical form. Elementary number theory: primes, congruences, function, linear Diophantine equations, Pythagorean triples. Group theory: cosets, normal subgroups, homomorphisms, permutation groups, theorems of Lagrange, Cayley, Jordan-Hölder , Sylow. Finite abelian groups, free groups, presentations. Ring theory: prime and maximal ideals, fields of quotients, matrix and Noetherian rings. Fields: algebraic and transcendental extensions, survey of Galois theory. Modules and algebras: exact sequences, projective and injective and free modules, hom and tensor products, group algebras, finite dimensional algebras. Categories: axioms, subobjects, kernels, limits and colimits, functors and adjoint functors.

MATH 7150 Probability Theory I (3)

MATH 7210 Analysis I (3)
Lebesgue measure on R. Measurable functions (including Lusin's and Egoroff's theorems). The Lebesgue integral. Monotone and dominated convergence theorems. Radon-Nikodym Theorem. Differentiation: bounded variation, absolute continuity, and the fundamental

MATH 7220 Analysis II (3)
Lebesgue measure on R. Measurable functions (including Lusin's and Egoroff's theorems). The Lebesgue integral. Monotone and dominated convergence theorems. Radon-Nikodym Theorem. Differentiation: bounded variation, absolute continuity, and the fundamental

MATH 7240 Mathematical Statistics (3)
Consists of Math 6020 and additional meetings and readings to cover advanced limit theorems and foundations of mathematical statistics. Prerequisite(s): MATH 6070, 6080 and 7150.

Prerequisite(s): (MATH 6070 or 6070) and (MATH 6080 or 6080) and (MATH 7150 or 7150).

MATH 7260 Linear Models (3)
Overview of multivariate analysis, theory of least squares linear regression, regression diagnostics, analysis of variance. Includes data modeling using statistical software.

MATH 7291 Algebraic Geometry I (3)
This is the first semester of a second year course for graduate students with research interest in Algebraic Geometry and related areas. The course will give students a necessary background preparation for research in Algebraic Geometry or to read and understand papers in this area. Topics in this course include: affine and projective varieties, morphisms of varieties, nonsingular varieties, and category theory.

MATH 7292 Algebraic Geometry II (3)
This is the second semester of a second year course for graduate students with research interest in Algebraic Geometry and related areas. The course will give students a necessary background preparation for research in Algebraic Geometry or to read and understand papers in this area. Topics in this course include: sheaves and schemes, line bundles and divisors, projective morphisms, and applications in toric geometry, homogeneous spaces, and algebraic group embeddings.

MATH 7310 Applied Mathematics I (3)
This is a first year graduate course in Applied Mathematics. A solid working knowledge of linear algebra and advanced calculus is the necessary background for this class. The topics covered include a mix of analytical and numerical methods that are used to understand models described by differential equations. We will emphasize applications from science and engineering, as they are the driving force behind each of the topics addressed.

MATH 7320 Applied Math II (3)
This is a first year graduate course in Applied Mathematics. A solid working knowledge of linear algebra and advanced calculus is the necessary background for this class. The topics covered include a mix of analytical and numerical methods that are used to understand models described by differential equations. We will emphasize applications from science and engineering, as they are the driving force behind each of the topics addressed.

MATH 7350 Scientific Computing I (3)
Introduction to numerical analysis: well-posedness and condition number, stability and convergence of numerical methods, a priori and a-posteriori analysis, source of error in computational models, machine representation of numbers. Linear operators on normed spaces. Root finding for nonlinear equations. Polynomial interpolation. Numerical integration. Orthogonal polynomials in approximation theory. Numerical solution of ordinary differential equations.

MATH 7360 Data Analysis (3)
This course covers the statistical analysis of datasets using R software package. The R environment, which is an Open Source system based on the S Language, is one of the most versatile and powerful tools available for statistical data analysis, and is widely used in both academic and industrial research. Key topics include graphical methods, generalized linear models, clustering, classification, time series analysis and spatial statistics. No prior knowledge of R is required.

Prerequisite(s): MATH 6020 and 6080.

MATH 7370 Time Series Analysis (3)
This course provides an introduction to time series analysis at the graduate level. The course is about modeling based on three main families of techniques: (i) the classical decomposition into trend, seasonal and noise components; (ii) ARIMA processes and the Box and Jenkins methodology; (iii) Fourier analysis. If time permits, other possible topics include state space modeling and fractional processes. The course is focused on the theory, but some key examples and applications are also covered and implemented in the software package R.

MATH 7510 Differential Geometry I (3)
Differential manifolds. Vector fields and flows. Tangent bundles. Frobenius theorem. Tensor fields. Differential forms, Lie derivatives. Integration and deRham's theorem. Riemannian metrics, connections, curvature, parallel translation, geodesics, and submanifolds, including surfaces. First and second variation formulas, Jacobi fields, Lie groups. The Maurer-Cartan equation. Isometries, principal bundles, symmetric spaces, Kähler geometry.

MATH 7520 Differential Geometry II (3)
Differential manifolds. Vector fields and flows. Tangent bundles. Frobenius theorem. Tensor fields. Differential forms, Lie derivatives. Integration and deRham's theorem. Riemannian metrics, connections, curvature, parallel translation, geodesics, and submanifolds, including surfaces. First and second variation formulas, Jacobi fields, Lie groups. The Maurer-Cartan equation. Isometries, principal bundles, symmetric spaces, Kähler geometry.

MATH 7530 Partial Diff Equations I (3)
Classical weak and strong maximum principles for 2nd order elliptic and parabolic equations, Hopf boundary point lemma, and their applications. Sobolev spaces, weak derivatives, approximation, density theorem, Sobolev inequalities, Kondrachov compact imbedding. L2 theory for second order elliptic equations, existence via Lax-Milgram Theorem, Fredholm alternative, a brief introduction to L2 estimates, Harnack inequality, eigenexpansion. L2 theory for second order parabolic and hyperbolic equations, existence via Galerkin method, uniqueness and regularity via energy method. Semigroup theory applied to second order parabolic and hyperbolic equations. A brief introduction to elliptic and parabolic regularity theory, the Lp and Schauder estimates. Nonlinear elliptic equations, variational methods, method of upper and lower solutions, fixed point method, bifurcation method. Nonlinear parabolic equations, global existence, stability of steady states, traveling wave solutions. Conservation laws, Rankine-Hugoniot jump condition, uniqueness issue, entropy condition, Riemann problem for Burger's equation, p-systems.

MATH 7540 Partial Diff Equitns II (3)
A brief introduction to elliptic and parabolic regularity theory, the L^p and Schauder estimates. Nonlinear elliptic equations, variational methods, methods of upper and lower solutions, fixed point method, bifurcation method. Nonlinear parabolic equations, global existence, stability of steady states, traveling wave solutions. Conservation laws, Rankine-Hugonoit jump condition, uniqueness issue,, entropy condition, Reimann problem for Burger's equation and p-systems.

MATH 7550 Probability Theory II (3)
Various types of convergence, independent increments, stable laws, central limit problem. Central limit theorems, x^2 distribution, contingency tables. Sampling distributions for normal populations (t, x^2, F). Estimation of parameters: minimum variance, maximum likelihood, sufficiency, nonparametric estimation. Hypothesis testing: Neyman-Pearson lemmas, general linear models, analysis of variances and covariance, regression. Introduction to time series, sampling design, and Bayesian theory.

MATH 7570 Scientific Computatn II (3)
Floating point arithmetic (limitations and pitfalls). Numerical linear algebra, solving linear system by direct and iterative methods, eigenvalue problems, singular value decompositions, numerical integrations, interpolations. Unconstrained optimization.

MATH 7580 Scientific Computing III (3)
Numerical ODE, both initial and boundary value problems. Numerical PDE. Introduction to fluid dynamics and other areas of application.

Prerequisite(s): MATH 7570.

MATH 7710 Topics In Algebra (3)
Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 7711 Topics in Algebra (3)
Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 7712 Topics in Algebra (3)
Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 7713 Topics in Algebra (3)
Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 7714 Topics in Algebra (3)
Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 7715 Topics in Algebra (3)
Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 7720 Topics In Analysis (3)

MATH 7730 Topics In Applied Math (3)
Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 7731 Topics in Applied Math (3)
Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 7732 Topics in Applied Math (3)

MATH 7740 Topics In Computation (3)
Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 7750 Topics/Differential Equa (3)
Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 7760 Topics In Geometry (3)
Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 7770 Topics/Probability&Stats (3)
Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 7780 Topics/Theoret. Comp Sci (3)
Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 7790 Topics In Topology (3)
Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 7940 Transfer Credit-Grad (1-12)
Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 7980 Reading and Research (1-9)
Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 7990 Advanced Math (1-9)

MATH 9980 Masters Research (3)
Research toward completion of a masters degree. Course may be repeated up to unlimited credit hours.

Maximum Hours: 99

MATH 9990 Dissertation Research (3)
Research toward completion of a doctoral degree. Course may be repeated up to unlimited credit hours.

Maximum Hours: 99