Prerequisites and Course Descriptions for our math courses are in the Undergraduate Catalog. The following course descriptions supplement and expand on those in the Graduate Catalog. For additional information about mathematics courses, please see our Course Information page or call the Mathematics Department at 532-6750.

**MATH 010 Intermediate Algebra**
This course is a review of basic algebra for those who have been away from algebra for a long while as well as for those who have had little or no algebra. The areas of study include arithmetic (of fractions, integers, irrationals, polynomials, algebraic fractions and exponents), solving equations (linear, fractional, quadratic, polynomial and radical) and linear systems, graphing (lines and simple parabolas), and applications of these ideas to other fields.

- **Courses for Undergraduate Credit: MATH 100 - 499**
- **Courses for Undergraduate Credit or Graduate Credit in Minor Field: MATH 500 - 599**
- **Courses for Undergraduate Credit or Graduate Credit: MATH 600 - 799**
- **Courses for Graduate Credit: MATH 800 - 999**

**MATH 100 College Algebra**
The purpose of college algebra is to provide concepts and skills necessary to translate problems from a variety of fields into the appropriate mathematical symbols and to operate on or manipulate these symbols to obtain an answer to the problem. The topics covered in college algebra include numbers, algebraic symbols, equivalent algebraic expressions, coordinate systems, functions, polynomial functions, zeros of polynomials, exponential functions and systems of equations and inequalities. The traditional version of the course is taught in two fifty-minute lectures and one fifty-minute recitation per week. The studio version has one lecture, one recitation, and one fifty-minute session in a microcomputer laboratory per week. The recitation instructor is responsible for assigning grades. There are three evening hour exams and a comprehensive final exam. Students from every college and every class enroll in the course. For many students college algebra fulfills a three-hour mathematics requirement with no additional mathematics courses planned. For others, such as Business majors, college algebra is a prerequisite to statistics and other mathematics courses.

**MATH 150 Plane Trigonometry**
This is a traditional course in plane trigonometry. The six trigonometric functions and their graphs are introduced. A unit on trigonometric identities and equations follows. Word problems involving right triangles and illustrating the law of sines and the law of cosines are emphasized. The inverse trigonometric functions are introduced. The course has two large lectures and one small discussion class each week. It is assumed that the students are proficient in college algebra and in the use of a scientific calculator. They must be able to manipulate algebraic expressions and solve quadratic equations.

**MATH 160 Introduction to Contemporary Mathematics**
This course provides an introduction to some contemporary uses of mathematics and meets the general education requirement mandated by the Board of Regents for education majors. This course explores ways in which mathematics is used to understand the contemporary world and make decisions. Topics include: combinatorics and probability; descriptions of data; graph theory; and various additional topics selected by the individual instructors.
MATH 199 Undergraduate Mathematics Seminar
The Undergraduate Lecture Series in Mathematics features weekly presentations in the fall by alumni, faculty, and business and government representatives. Math alumni have described: their experiences and success factors; the value of mathematical thinking and training; interesting problems and the math in their work. Faculty have described: how to be the best math student you can be; career planning; undergraduate research; off campus research experiences; and graduate studies. Business and government representatives have described career and internship opportunities. New students interested in the Undergraduate Lecture Series should enroll in MATH 199 A-REC Undergraduate Mathematics Seminar which meets every Monday (except Labor Day and Thanksgiving break) during the fall semester from 1:30 to 2:20 p.m. in 122 Cardwell Hall. All students are welcome to attend individual presentations that interest them. Students attending the lectures can visit with the lecturers and have refreshments afterwards in the Department of Mathematics Commons Room, 121 Cardwell Hall.

MATH 205 General Calculus and Linear Algebra
Students in this course will study the differential and integral calculus needed for the applications which they will encounter in business and economics. The calculus of polynomials and algebraic, logarithmic and exponential functions together with the elementary algebra of matrices will be stressed. Applications to problems arising in business and economics will be emphasized. Students enrolling in this course should have a solid working knowledge of high school or college algebra. Students who enroll in this course are from the College of Business Administration or are agricultural economics or economics majors.

MATH 220 Analytic Geometry and Calculus I
This course covers the elementary ideas of analytic geometry and introduces the basic concepts of the differential and integral calculus of algebraic functions. The course begins with a brief review of the algebra and geometry of straight lines in the plane and with a thorough description of the algebra of functions. The concept of limit is introduced and considered in detail. One-sided limits and limits involving infinity are discussed, horizontal and vertical asymptotes are studied, and the concept of continuity for functions is defined. The idea of the derivative is introduced, motivated by considering rates of change and tangent lines, and the differentiation of algebraic functions is covered. Numerous problems involving applications of the derivative are assigned and explained in detail. These include a study of extrema of functions, graphing, related rates of change, and applications to physics, engineering and economics. The concept of the definite integral is introduced, and its basic properties are considered. The motivation for the integral and its relationship to the concept of the area under a curve are discussed, and the Fundamental Theorem of Calculus is proved. Finally, applications of the integral are considered and its relationship to the concepts of volume, work and other physical concepts is described. The course is intended for students in engineering, mathematics and the natural sciences. Emphasis is on problem solving, and a thorough knowledge of algebra is assumed.

MATH 221 Analytic Geometry and Calculus II
This course is a continuation of MATH 220 and introduces the differential and integral calculus in relationship to the transcendental functions and plane analytic geometry. Logarithmic, exponential and trigonometric functions are defined, and their differential and integral properties are studied in detail. A considerable amount of time is devoted to the development of techniques of integration, such as trigonometric substitution, integration by parts and partial fractions. The theory of plane analytic geometry is introduced. The relationship between Cartesian and polar coordinates is discussed, the conic sections are described. Indeterminate forms and many versions of L'Hôpital's rule are considered, and improper integrals are introduced. Consideration is given to Taylor's formula and the theory of infinite series. Tests for convergence of an infinite series are developed, and the power series representation of elementary functions is studied.
MATH 222 Analytic Geometry and Calculus III
This course develops calculus for functions of many variables together with vector analysis in two and three dimensional space. These topics are basic for applied mathematics and geometry for we live in three spatial dimensions, not just one. Mechanics of particle motion is developed in detail including curvature and normal and tangential components of acceleration. A beautiful application is the derivation of Kepler's Laws of planetary motion from Newton's Law of gravitational attraction. The three dimensional geometry of surfaces, lines and tangent planes is included. The calculus of several variables, partial derivatives, chain rules and directional derivatives using the gradient are studied. Max-min problems and the method of Lagrange multipliers for extreme problems with constraint are considered. An extensive development and application of multiple integration is presented. Finally, line integrals of a vector field along a curve, conservative force fields and Green's Theorem are studied.

MATH 312 Finite Applications of Mathematics
This course is an introduction to finite mathematics and its applications to business and social sciences. The course emphasizes linear algebra including solving systems of linear equations, Gauss-Jordan elimination, matrix algebra, inverses of matrices, Euclidean 3-space, the Leontief open model for economics, linear programming, linear production models, the simplex algorithm and the duality of linear programming. Topics will be chosen from graph theory such as Dijkstra's Algorithm, Eulerian graphs, spanning trees and Kruskal's Algorithm. Topics also will be chosen from Probability theory such as permutations, combinations, Bayes' formula, expected value, standard deviation and normal distributions.

MATH 320 Mathematics for Elementary School Teachers
This three credit course provides a mathematics background for school teachers of grades K through 8. The course begins with some of the basic recurring themes; namely, problem solving, sets and functions. This is followed by a study of the whole numbers and their arithmetic including the idea of place value, the various algorithms for arithmetic, the whole numbers as a formal structure and various applications of whole numbers. Elements of number theory are studied next including factorization, primes and divisibility tests. Next, ideas about whole numbers are generalized to include the integers, rational numbers and decimals. These are treated both informally and as formal systems. Special attention is given to concrete representations of these numbers and to their applications. Basic ideas of probability and statistics and the elements of informal geometry and measurement conclude the course. Individual instructors may chose to omit some of the above topics and may chose to include others such as an introduction to algebra or computers.

MATH 330 Intuitive Geometry
This course is intended to prepare prospective K through 8 teachers for the teaching of geometry. The course consists of a series of activities done in a small group setting with minimal lectures. For example, students use blocks to develop spatial visualization, geoboards to explore a variety of questions in plane geometry, paper folding, graph paper and tracing paper to investigate transformations and tessellations, ruler and compass constructions to investigate regular polygons, protractors and rulers as well as computers to determine the properties of triangles, quadrilaterals and circles, and various materials to construct solid figures. In addition, several papers related to the teaching and uses of geometry are required.

MATH 340 Elementary Differential Equations
In this course a variety of problems from science and engineering and their formulation in terms of differential equations are studied. Techniques are developed for solving a number of important types of equations with emphasis on first and second order equations. Higher order equations are treated briefly. For second order equations the constant coefficient case is treated in detail. The Laplace transform is introduced as a technique for solving constant coefficient initial value problems with possibly discontinuous external forcing terms. Series methods are used for solving variable coefficient problems. An introduction is given to solutions of systems of constant coefficient linear equations using differential operators. The course meets once a week in a microcomputer laboratory where students use the mathematical software Derive to solve problems involving differential equations.
MATH 499A Undergraduate Topics in Mathematics
A student who wants to take a reading course in advanced undergraduate math should select a faculty member whose Faculty Areas of Research include the topics the student wants to study. The student then needs to get the faculty member to agree to direct the study, and the student and the faculty member need to agree on the number of credit hours, course requirements, and meeting times. After obtaining an instructor's permission, an undergraduate should see the Undergraduate Programs Secretary to enroll in a topics course.

MATH 499B Putnam Seminar
The Putnam Seminar will introduce students to topics and problem solving strategies in algebra, analysis, combinatorics, geometry, number theory and probability theory and will prepare students for the William Lowell Putnam Mathematical Competition.
Interested students may enroll in MATH 499 B Top/Putnam Seminar for 0 or 1 credit using the credit option when enrolling in KSIS. Students may switch from 1 to 0 credit or from 0 to 1 credit up to the 15th day of classes. Taking the Putnam Seminar three times for 1 credit would help fulfill the upper level math requirement for a math major. Students who complete the Putnam Seminar will have it noted on their transcript.
Students enrolled in the Putnam Seminar are required to take the Putnam Exam which is given on the first Saturday in December. K-State students who are not enrolled in the Putnam Seminar can arrange to take the Putnam Exam by contacting ugmath@math.ksu.edu.

MATH 499C Mathematical Modeling Seminar
Are you interested in learning how mathematics is applied in business, government, or industry? Then enroll in the Mathematical Modeling Seminar and participate in the Mathematical Contest in Modeling! The Mathematical Modeling Seminar (Math 499 C) is a one-credit class which meets on during Spring semesters (at a time arranged to accommodate all interested students. The seminar introduces students to techniques and ideas from modeling and applied mathematics and helps prepare K-State teams for the Mathematical Contest in Modeling (visit http://www.comap.com/undergraduate/contests/mcm/). For more information about this class or the MCM contact Professor David Auckly

MATH 499C GRE Math Subject Test Preparation Seminar
This seminar will prepare students for the GRE Math Subject Test which covers:
Calculus - 50%
Material learned in the usual sequence of elementary calculus courses - differential and integral calculus of one and of several variables - includes calculus-based applications and connections with coordinate geometry, trigonometry, differential equations and other branches of mathematics.
Algebra - 25%
- Elementary algebra: basic algebraic techniques and manipulations acquired in high school and used throughout mathematics;
- Linear algebra: matrix algebra, systems of linear equations, vector spaces, linear transformations, characteristic polynomials and eigenvalues and eigenvectors;
- Abstract algebra and number theory: elementary topics from group theory, theory of rings and modules, field theory and number theory.
Additional Topics - 25%
- Introductory real analysis: sequences and series of numbers and functions, continuity, differentiability and integrability, and elementary topology of R and R^n;
- Discrete mathematics: logic, set theory, combinatorics, graph theory and algorithms;
- Other topics: general topology, geometry, complex variables, probability and statistics, and numerical analysis.
The prerequisite for MATH 499C is MATH 340 Elementary Differential Equations.

Courses for Undergraduate Credit or Graduate Credit in Minor Field: MATH 500 - 599
MATH 500 Mathematical Theory of Interest
This course provides an extensive introduction to the mathematical theory of interest. Actuaries are expected to complete a sequence of Professional Examinations covering subjects necessary to their work. This course will prepare students to take the second professional examination administered by the Society of Actuaries and the Casualty Actuarial Society. The prerequisite is MATH 221 Analytic Geometry and Calculus II.

MATH 501 Mathematical Foundations of Actuarial Science
This course provides an introduction to calculus-based applications and models with an emphasis on applications to insurance. Actuaries are expected to complete a sequence of Professional Examinations covering subjects necessary to their work. This course will prepare students to take the first professional examination administered by the Society of Actuaries and the Casualty Actuarial Society. The prerequisites are MATH 222 Analytic Geometry and Calculus III and STAT 510 Introduction to Probability and Statistics I or concurrent enrollment in STAT 510.

MATH 506 Introduction to Number Theory
Number theory is the study of the natural numbers 1, 2, 3, .... It is one of the oldest branches of mathematics and is rich with intriguing theorems and unsolved problems. This course will cover the divisibility properties of integers, primes, unique factorization of integers, congruences, the Chinese Remainder Theorem and arithmetic functions. Also topics will be chosen from diophantine equations, continued fractions, perfect numbers and cryptography.

MATH 510 Discrete Mathematics
This course is an introduction to the basic techniques and modes of reasoning of combinatorial problem solving. Many combinatorial problems have quite simple solutions, and, while problem solving is an important aspect of the course, the means for achieving solutions are of more concern here than the ends. The course is roughly divided into two parts: combinatorics and graph theory. Preliminary material is reviewed, including mathematical induction, probability and the pigeon hole principle. General counting methods are discussed in detail, along with generating functions, recurrence relations, the inclusion-exclusion principle and Polya's enumeration formula. Graph theory and its many applications are considered and various types of circuits are described. Trees and tree searching are examined, and numerous network algorithms are considered.

MATH 511 Introduction to Algebraic Systems
This course was designed to give secondary mathematics education majors an introduction to the fundamental concepts of modern algebra. The course covers elements of set theory, basic properties of functions, the integers including unique factorization, induction and congruences, groups, cyclic groups, permutation groups, rings, integral domains, fields and ideals. Special attention is given to concrete examples such as subsets of the complex numbers, symmetries of regular polygons and polynomial rings.

MATH 512 Introduction to Modern Algebra
The student is to be introduced to the basic concepts of elementary modern algebra. A minimal set of topics to be covered in this course would include the following: sets, mappings, equivalence relations, binary operations, rings (including the ring of integers, the ring of integers modulo n, and rings of matrices), subrings, integral domains, the field of integers modulo a prime and polynomial rings. The format of the subject matter is axiomatic. Consequently, the student will be expected to learn fundamental skills in proving theorems.

MATH 515 Introduction to Linear Algebra
The basic objects of study in this course are the vector spaces and their linear transformations. The most elementary examples of these objects arise from systems of homogeneous linear equations. The logical development, then, is that of abstracting the properties of the set of solutions to such a system of equations, which leads naturally to the definition of an abstract vector space. For the most part, only finite dimensional vector spaces are discussed. Since the algebraic structure of an abstract vector space is rather trivial, the course turns, as early as possible, to the study of linear transformations on vector spaces. The notion of a matrix representation of a linear transformation is treated in some detail. A more detailed investigation of linear transformations can include discussions of invariant subspaces,
eigenvalues, eigenvectors, canonical forms and Sylvester's law of inertia. Finally, an abstract treatment of determinants may be included.

MATH 520 Foundations of Analysis
This course was designed to give secondary mathematics education majors an introduction to the fundamental concepts of analysis. The course covers elements of set theory, sequences, neighborhoods, limit points, convergence, open and closed sets in the real line and in the plane and the concept of continuous function.

MATH 521 The Real Number System
The purpose of this course is to build up in a careful, consistent and rigorous way the various number systems used in mathematics the natural numbers, the integers, and the rational, real and complex numbers. Students' knowledge of these systems is reviewed, and the need for rigorous development of concepts is explored. In order to build the number systems, a number of important mathematical ideas are introduced: the language and symbolism of set theory, notions of equivalence and order relations, bijective functions and binary operations and standards and techniques of mathematical logic and proof. With these tools the student is shown how to build the natural numbers from the Peano axioms, making heavy use of mathematical induction. Then extensions are made to the integers and rational numbers, in both cases using ordered pairs. The real numbers then are developed as equivalence classes of Cauchy sequences. The uniqueness, up to isomorphism, of each of these systems is explored. Finally, the complex numbers, as ordered pairs of real numbers, are developed.

MATH 540 Advanced Ordinary Differential Equations
The objectives of this course are to give a rigorous foundation for the basic qualitative as well as quantitative results and methods of the theory of ordinary differential equations and show the meaning and importance of those results in various applications. The course is intended primarily for junior and senior undergraduate students.
The following are the major topics included in the course: (scalar) first order equations; systems of first order linear equations; second order linear equations: the initial value problem; second order linear equations: the boundary value problems; introduction to nonlinear equations. Most of the subjects included in the course are treated reasonably in W. E. Boyce and R. C. DiPrima, Elementary Differential Equations, John Wiley & Sons, that will serve as a textbook for the course. For the few of the subjects that are missing in that book, the lecturer will provide notes.
MATH 340 is a prerequisite for this course. Hence, less time will be spend on practicing in standard methods of solving differential equations. However, most of the topics covered in MATH 340 will be reviewed and reconsidered from the point of view of the general qualitative results, providing an explanation for the specific methods and techniques used for solving differential equations.
In addition to theoretical considerations, many of the subjects considered in the course will be illustrated by examples taken from natural sciences and engineering (depending on what the interests of the students are). Some of the classes will take place in the Computer Lab, where the students will use Maple to solve the equations and analyze the solutions, using the book Differential Equations with Maple by Coombes, John Wiley & Sons.

MATH 551 Applied Matrix Theory
This course starts from a study of matrix algebra and elementary row operations to find solutions for systems of linear equations. This technique is used in the discussion of vector spaces, the eigenvalue problem, least squares, quadratic forms and linear programming. The course is taught from the perspective of imparting skill in the use of the basic concepts of matrix theory.
The course meets once a week in a microcomputer laboratory where students use the mathematical software MatLab to solve problems involving matrices. It requires only a knowledge of college algebra and the maturity of an advanced undergraduate. This course is intended for computer science and engineering students and others who need linear algebra as a tool.
MATH 560 Introduction to Topology
This course is an introduction to the basic topological concepts at the undergraduate level. Topics include: Topological spaces, metric spaces, closure, interior, and frontier operators, subspaces, separation and countability properties, bases, subbases, convergence, continuity, homeomorphisms, compactness, connectedness, quotients and products. The course will include a brief introduction to proof techniques and set theory.

MATH 570 History of Mathematics
This course provides a survey of the development of mathematics from ancient to modern times. Beginning with the first written records of mathematics of the ancient Egyptians and Babylonians, the course considers the contributions of the Greek, Chinese, Indian, Islamic and European mathematicians. This chronological framework provides a structure in which individual biographies, evolution of particular topics, and social and philosophical aspects of mathematics can be discussed. Students are usually allowed to investigate in depth topics which are of individual interest to them.

MATH 572 Foundations of Geometry
This course, designed for students planning to teach secondary school mathematics, concentrates on topics related to the logical and axiomatic structure of geometry. Euclidean, non-Euclidean, and finite geometries are studied and transformation, analytic, and synthetic approaches to geometry are discussed. In addition, topics of special interest to prospective teachers are discussed.

MATH 591 Topics in Mathematics for Teachers
This course covers topics of importance for teachers of mathematics.

MATH 599 Introduction to Time Series Analysis in Actuarial Science
This course provides an introduction to the terminology and underlying assumptions of time series models and how to apply and analyze an appropriately selected model when solving insurance related problems. Topics include deterministic and stochastic time series models; stationary time series; autocorrelation functions; random walk models; AR, MA, ARMA and ARIMA models. Students pursuing a career in actuarial science will get a working knowledge of time series models and analysis from this course and then should be able to obtain VEE credit from both the SOA and CAS.

Courses for Undergraduate Credit or Graduate Credit: MATH 600 - 799

MATH 615 Introduction to Digital Image Processing
The basic ideas and techniques in digital image processing stem from mathematics, engineering, and computer science. This course will focus on such ideas and techniques including intensity transformations, spatial filtering, filtering in the frequency domain, image restoration and reconstruction, color image processing, and image compression standards (JPEG and JPEG2000). The course will be essentially self-contained and will equally emphasize the mathematical ideas and their MATLAB implementation. This course is suitable for undergraduate and graduate students from physics, engineering, chemistry, computer science, mathematics and geography. It is also an excellent starting point for related undergraduate research projects and potential interaction with other disciplines such as Chemistry, Medicine, Engineering, Physics, and Geography.

MATH 630 Introduction to Complex Analysis
The goals of this introductory course are to study the underlying mathematical structure of Complex Analysis and also to cover some of its many applications. The answers we seek in subjecting physical models to mathematical analysis are most frequently real, but to arrive at these answers we often invoke the powerful theory of analytic functions. The arithmetic of Complex numbers, the Cauchy-Riemann equations, Contour integrals, Cauchy's Integral Theorems, power series expansions, the applications of harmonic functions and of simple conformal mappings to the Laplace equations and the theory of residues are covered. Units on Laplace transforms and on conformal mappings are also covered when time permits. Most of the students enrolling in this course are upper division or beginning graduate students in engineering, mathematics, or one of the physical sciences. Definitions and important theorems are emphasized, whereas proofs of the theorems are de-emphasized. Students must be proficient in simplifying algebraic expressions and in
computing partial derivatives. Most of the assigned exercises are computational. The conceptually difficult part of the course deals with infinite series. The better a student understands infinite series the better will be the student's appreciation for the meta-principle of complex analysis: an analytic function is essentially a polynomial of infinite degree.

MATH 632 Elementary Partial Differential Equations
This course is designed for advanced undergraduates and beginning graduate students in mathematics, engineering and the physical sciences. It is an introduction to boundary value problems for the classical PDE's - the modeling of physical problems, the heat, wave and potential equations - with an emphasis on mathematical method and physical interpretation rather than on formal proof. Separation of variables, which provides a uniform approach to many of these problems, leads to the study of Fourier series and integrals, orthogonal functions, Sturm Liouville problems and Bessel and Legendre functions. Some of the following topics will be included: integral transforms, numerical methods, Green's functions, variational methods and Duhamel's principle.

MATH 633 Advanced Calculus I
This course is taken by students in mathematics, physics, engineering and statistics. Most of the topics are ones that students have met in previous calculus courses, but the emphasis is on a more thorough treatment. Learning how to read and how to write proofs is an important part of this course. The course begins with a brief discussion of foundations, (the real number system) and various proof techniques, including induction. This is followed by the study of limits of both sequences and functions and then continuity and uniform continuity. Various important theorems about continuous functions are proved. For differentiable functions, the Mean-Value Theorem and Taylor's Theorem are discussed. Riemann-Stieltjes integration is introduced as a generalization of Riemann integration. Next, we switch gears to study infinite series and various tests for convergence. This is then extended to series of functions and the various consequences of uniform convergence are explored. Finally power series (Taylor series) are studied and operations with power series are explained.

MATH 634 Advanced Calculus II
This is a continuation of MATH 633 but here we study functions from $\mathbb{R}^m$ to $\mathbb{R}^n$. The course begins with a short introduction to linear algebra and the point-set topology of $\mathbb{R}^n$. The concept of the derivative as a linear transformation is then introduced and its relationship with various partial derivatives is explored. After suitable generalizations of one-variable topics, the study of derivatives culminates with the inverse and implicit function theorems. The next part of the course generalized Riemann integration to cover real-valued functions of several variables. Measure zero sets are studied and Lebesgue's Theorem is proven. Fubini's Theorem and the change-of-variables formula are also discussed. Finally, we investigate a part of the circle of ideas surrounding Stokes Theorem: differential forms, integrals over curves and surfaces, Green's Theorem and the Divergence Theorem.

MATH 635 Dynamics, Chaos and Fractals
The course will be an introduction to discrete dynamical systems. Dynamics studies the long term behavior of nonlinear systems (e.g. planetary motion, motion of fluids and particles in them, population growth, billiards and many more). In this course we will study the dynamics of some of the easiest systems – the quadratic functions $y=x^2 + c$. We will see that even this seemingly simple systems often exhibit very complicated behavior such as sensitive dependence on initial conditions (the “butterfly effect”) and chaos. All of this can be seen in the bifurcation diagram above and most of the semester we will spend trying to understand it. Time permitting we will also study the complex (i.e. 2-dimenssional) counterpart of the bifurcation diagram - the famous Mandelbrot set.

MATH 655 Elementary Numerical Analysis
These courses are for students who want to learn computational methods and the ideas behind the methods. Topics include basic concepts like numbers in computing, error and its propagation, stability, solutions of equations of one variables, direct and iterative method for solving linear systems, interpolation, numerical differentiation and integration, approximation theory, approximating eigenvalues, numerical solution of nonlinear systems of equations and numerical solution for ordinary and partial differential equations.
MATH 670 Mathematical Modeling
This course introduces students to the process of solving problems from inside and outside mathematics by constructing and applying mathematical models. After an introduction to the modeling process, students will work on problems selected from the physical, biological, or social sciences. To find out exactly what topics will be treated and what background is expected, one should consult the course instructor. Mathematical modeling is the process of creating mathematical descriptions of reality. It is an art as well as a science, and involves relating formulae and equations to real objects and behaviors. Every model is an approximation which becomes increasingly complicated as more detail and generality are required. After an introduction, which includes the methods of dissection and description, and the reduction of dimensionality, students will work on problems selected from their own fields of interest with the consent and guidance of the instructor.

MATH 700 Set Theory and Logic
This course is an introduction to set theory and logic. Topics include relations, partitions, functions, cartesian products, disjoint unions, orders, the natural numbers, ordinal and cardinal numbers and their arithmetic, transfinite induction, recursion theorems, well ordering theorems, the Axiom of Choice and Zorn's Lemma.

MATH 704 Introduction to the Theory of Groups
This course expands upon the material on group theory in MATH 730-731. Topics include the theory of simple groups, groups and their geometries, free groups, homological algebra and computational group theory using the Cayley computer software.

MATH 706 Theory of Numbers
This course is designed to give the student an exposure to many of the important topics from elementary number theory. Many classical results on primes, divisibility, and congruences are proven. Also several number theoretic functions are investigated. The appeal of the subject is that most of results are easy to understand (although not necessarily easy to prove) and many have historical importance.

MATH 710 Introduction to Category Theory
Categories, functors, natural transformations, duality, special morphisms, limits and colimits. Both abstract and concrete categories are studied. Applications of the theory are stressed.

MATH 711 Category Theory
Factorization structures in categories; adjoint functors and adjoint situations; algebraic, topological, and cartesian closed categories; categorical completions.

MATH 713 Advanced Applied Matrix Theory
This course will develop the concept of eigenvalues by considering applications in differential equations and quadratic forms and estimation problems. The course will cover Jordan canonical form, functions of matrices, vector and matrix norms, convex sets, simplex algorithm, Markov chains, Leslie population models and Leontieff input-output models. The background required is either MATH 515 or MATH 551. The course is intended for advanced students who need linear algebra techniques.

MATH 715 Applied Mathematics I
This course will provide an analysis of numerical methods for linear algebra. The course will cover perturbation theory and error analysis, matrix factorizations, solutions to linear systems, least-squares, problems, techniques for special matrix structures, symmetric and nonsymmetric eigenvalue problems, iterative and direct methods.

MATH 716 Applied Mathematics II
This course will present linear operator theory applied to matrix, integral and differential equations. The course will cover spectral theory, the Fredholm Alternative, least-squares and pseudo-inverses. Banach and Hilbert space techniques, Fourier series and wavelets, theory of distributions, Green's functions.
MATH 721 and 722 Introduction to Real Analysis and Functions of Several Variables
An uncompromisingly rigorous treatment of elementary analysis. The emphasis is on clear statements of definitions, theorems, and proofs. In addition to the theorems of differential and integral calculus, the topics include inequalities, complex power series, limits and continuity on topological spaces, uniform convergence, uniform approximation (Stone-Weierstrass Theorems), interchanging limiting operations, and either Riemann-Stieltjes integration or an introduction to Lebesgue measure and integration. The prerequisites are calculus and mathematical maturity.

MATH 725 and 726 The Mathematics of Data and Networks I and II
"Big Data" describes the mathematics necessary to tackle and analyze massive data sets. Often data comes interconnected with a network structure, and other times a natural network structure can be superimposed on a raw data-set. The goal in this class is to explain the mathematics behind the use of graphs and networks in applied sciences such as Engineering, Biology, Ecology, Political Science and beyond.
We begin with a quick review of matrix theory, mathematical probability, and graph theory. We then combine these subjects and discuss random graphs, the Erdos-Renyi model, the preferential attachment model, and other models for "expected" graphs. Random walks and branching processes such Galton-Watson will be crucial for the analysis of these random graphs. We will also describe dynamical processes on the graph, such as modeled epidemics.
We will then build on the theory of Markov chains which underlies the notion of random walks and show how these processes interact with fundamental properties of graphs, such as the spectrum, and clustering methods used to split graphs into "communities". We will also introduce the basic principles of Data Mining and Algorithms such as the Johnson-Lindenstrauss Lemma, k-means, and graph sparsification.

MATH 730 and 731 Abstract Algebra I and II
The subject matter includes much of what is already in MATH 512, but from a deeper and more sophisticated point of view. Topics would include the following: groups, subgroups, normal subgroups, quotient groups, group homomorphisms, automorphisms, group actions, Sylow's theorem and finitely generated Abelian groups; rings, subrings, ideals, quotient rings, ring homomorphisms, integral domains, fraction fields, Euclidean rings and polynomial rings; vector spaces, bases and dimension of a vector space, dual spaces, inner product spaces, linear transformations, matrices, canonical forms and spectral decomposition of normal transformations; fields, subfields, extension fields, polynomials and roots, Galois theory and extension by radicals.

MATH 740 Calculus of Variations
The Calculus of variations is concerned with the optimization of variable quantities called functionals over certain admissible classes of competing objects and applications to physics, engineering, biology and to analysis of dynamic modeling. This course is designed for advanced undergraduates and beginning graduate students in mathematics, engineering and the physical sciences. This course will strike a balance between theoretical backgrounds and the applications of extremal problems. The necessary conditions for extremal, Euler-Lagrange equations, Fermat's principle of least time, Hamilton-Jacobi theory, sufficient conditions and Hilbert's Theorem, and elementary convex analysis are covered. The topics including optimal control (Pontryagin principles), Lie group and conservation laws, and direct methods are selected as additional materials when time permits.
MATH 745 Ordinary Differential Equations
This course is taken by many engineering, mathematics, and science majors. Topics include a brief review of the material from the introductory course of ODE, first and second order equations and applications, existence and uniqueness theorems, oscillation theorems, series solutions, Sturm-Liouville problems, special functions, Laplace transformation, linear and non-linear systems, stability via first and second Liapunov's method and asymptotic methods. Applications are made to many areas, including biology, population dynamics, electric circuits, physics, and engineering. Elements of Hamiltonian mechanics including the Hamilton-Jacobi method will be studied. The contents of the course can vary according to the needs of the students enrolled in the course.

MATH 755 Dynamic Modeling Processes
This application-oriented course is designed for those in mathematics, physics, engineering and related majors who wish to make contact with this rapidly growing area in applied mathematics. Along with the presentation of the concepts and techniques for setting up models, a self-contained theoretical background will be provided for analyzing the mathematical behavior of dynamic systems - both the deterministic nature and the chaotic behavior. Models for investigation will include algae blooms, pollution in rivers, highway traffic, tidal dynamics, Canadian budworm, population dynamics, spread of gonorrhea, harvesting dynamics, stock market catastrophes and chaotic phenomena in mechanical systems. The topics on the theoretic side will cover dynamical systems, stability and instability, equilibrium, bifurcations, chaos, castrophes, Hopf bifurcation, Thom's Theorem in topology and strange attractors.

MATH 757 Mathematical Control Theory
This course is designed for students from mathematics, computer science, and electrical and mechanical engineering. Topics include linear and nonlinear systems, transfer functions, input/output methods, Lyapunov stability, dynamic feedback, time optimal control, Pontryagin maximum principles, ultrastable and multistable systems, and Winer, Kolmogorof and Kalman filtering theories.

MATH 760 Probability Theory
An introduction to the mathematical theory of probability. Material covered includes combinatorial probability, random variables, independence, expectations, limit theorems, Markov chains, random walks and martingales.

MATH 770 and MATH 771 - Introduction to Topology/Geometry I & II
This two course sequence is an introduction to topology at a graduate level. Topics include definitions and examples of topological spaces, simplicial complexes, topological and smooth manifolds, quotient spaces, CW complexes, projective spaces and knots. Topological properties will be covered, such as separation axioms, compactness, and connectedness. Further topics include homotopy theory and the fundamental group, covering spaces, Euler characteristics, classification of closed surfaces, differential forms, integration, Stokes' Theorem, and de Rham cohomology.

MATH 772 Elementary Differential Geometry
This course will cover curves and surfaces in Euclidean spaces, differential forms, exterior differentiation, differential invariants, frame fields, geodesics and the uniqueness theorem for curves and surfaces. The course also will provide an introduction to Riemannian geometry, cover some global theorems and study minimal surfaces.

MATH 789 Combinatorial Analysis
In combinatorics there are problems of enumeration (which involve counting the number of ways in which certain combinations can be formed), and problems involving relationships among a fixed number of terms. The two sorts of problems call for analytic methods on the one hand and geometric methods on the other. The course will offer an introduction to both viewpoints. Thus some topics will be:
analytic - generating functions, inversion formulas, inclusion exclusion, recurrence relations.
geometric - finite graphs, networks, trees and finite geometries arising from linear algebra.
Of course there is no clear-cut division between these two areas. One topic which uses both approaches in coding theory, and if time permits, the course will provide an introduction to that subject as well. In different years other special topics may be chosen.
MATH 791 Topics in Mathematics for Secondary School Teachers
This course covers topics of importance in the preparation of secondary school teachers to teach mathematics.
Courses for Graduate Credit: MATH 800 - 999

Here are Course Descriptions for MATH 800-999. The topics covered in these courses depend on the instructor. The names of the instructors of these courses are listed in the Course Schedule. In exceptional circumstances, highly qualified undergraduate students may enroll in courses numbered 800 and above after obtaining permission from the instructor of the course, the Head of the Mathematics Department, and the Dean of the Graduate School.