

impact of those choices on the political, cultural, educational and socioeconomic domains.

Prerequisite: MLL 230, LING 290, 360 or permission of the instructor.

LING 450
Workshop in Applied Linguistics. [3]

A practical investigation of the structure of an uncommonly taught language such as Czech, Gascon, Lithuanian, Mapudungun and Wolof. **Prerequisite:** LING 210 and another LING course.

LING 470
Language and Cognition. [3]

This course examines the implications of current linguistic theory and research for first- and second-language acquisition, language disorders, aphasia studies and speech therapy.

Prerequisites: LING 310 and 320 or permission of the instructor.

LING 480
Advanced Studies in Theoretical Linguistics. [3]

This course provides an in-depth examination of specific issues in either general or sub-field-specific linguistic theory, with special reference to various linguistic phenomena observable in different languages, including English. A theory-significant and original term paper is required. **Note:** Repeatable once for credit with permission of instructor and LING major/minor advisor. **Prerequisite:** Two LING courses at the 300- or 400-level and permission of the instructor.

LING 490
Seminar in Applied Linguistics. [3]

This course is centered around advanced research on a particular applied linguistics topic. Students are expected to give frequent oral reports and complete work on a theory-significant and original term paper.

Prerequisite: Two LING courses at the 300- or 400-level.

LING 499
Honors Paper in Linguistics. [3]

Original research on a linguistics topic, under the supervi-

sion of a linguistics faculty member. The research will result in an extended paper, to be presented orally before an examining committee that includes the student's research advisor and another linguistics faculty member. Students who earn a grade of "A" and have a GPA of at least 3.5 will graduate with Departmental Honors. Students should consult with their linguistics advisor regarding eligibility and details. **Prerequisites:** Senior standing and permission of a faculty member in linguistics.

Management of Aging Services

See AGNG for course descriptions.

Mathematics

All mathematics courses up to MATH 140, 150, 151 or 155 require suitable placement scores on the placement examination administered by the Learning Resources Center unless appropriate college-level prerequisite courses have been passed with a grade of "C" or better. Placement examination also is recommended for students whose last mathematics course was taken several years ago.

MATH 099
Introductory Algebra. [0]

Designed for the student with little or no knowledge of algebra. Topics include properties of integers and real numbers, linear equations and inequalities, operations on monomials and simple polynomials, factoring second-degree polynomials, rational expressions, properties of exponents and square roots, and graphing inequalities. **Note:** Three "institutional credits" (not applicable to the degree) are awarded. **NOTE:** This course is usually given as LRC 099. **Prerequisite:** A qualifying score on the mathematics placement test.

MATH 100
Introduction to Contemporary Mathematics (MS). [3]

Students will be introduced to many topics from contemporary mathematics. These are especially of interest to students in the social and information sciences. Topics include networks and graphs, the traveling salesman problem, scheduling linear programming, social choice, voting systems game theory, fair division, patterns, tilings form, similarity and symmetry. **Prerequisite:** A suitable score on LRC algebra placement exam.

MATH 106
Algebra and Elementary Functions. [3]

An introduction to the basic techniques and functions of mathematics. This course is especially recommended for those students who need to brush up due to a shaky high school preparation or for those who haven't had a mathematics course in several years. Topics include linear equations and inequalities; quadratic equations; polynomials; and rational functions and their inverses, including the exponential and the logarithm. **Note:** Not open to students who have passed MATH 150 or above. Not transferrable to other Maryland public institutions for college-level credit. **Prerequisite:** Qualifying score on LRC algebra placement exam.

MATH 115
Finite Mathematics (MS). [3]

An introduction to linear algebra, matrices, set theory, combinatorial analysis and probability theory. Appropriate for students desiring a knowledge of elementary linear algebra and probability theory. **Note:** Not open to students who have passed MATH 221, STAT 350, 351, 355 or 451. **Prerequisite:** A qualifying score on the LRC Algebra placement test.

MATH 131
Mathematics for Elementary School Teachers I (MS). [4]

Intended primarily for prospective elementary school teachers. Structural aspects of mathematics and the "why" of arithmetical computations. Topics include sets, functions, logic,

numbers and number systems, numeration systems, properties of mathematical operations, techniques for computation, decimals, elementary number theory, metric and non-metric geometry, elements of probability and statistics. (Fall) **Note:** Enrollment is restricted to students pursuing certification in elementary or secondary education. **Prerequisites:** A suitable score on LRC algebra placement exam.

MATH 132
Mathematics for Elementary School Teachers II (MS). [4]

Continuation of MATH 131. (Spring) **Prerequisite:** MATH 131.

MATH 140
Differential Calculus (MS). [3]

This course covers the fundamentals of differential calculus with review of notions of analytic geometry and trigonometry as needed. Content includes limits; rate of change and velocity; derivatives and rules of differentiation; differentiation of polynomial, algebraic and trigonometric functions; curve sketching and optimization problems; and differentiation of inverse functions, anti-derivatives and indefinite integrals. **Note:** MATH 140 does not cover all the material of MATH 151. It is equivalent to the first quarter of calculus at institutions on a quarter system. **Prerequisite:** MATH 150.

MATH 141
Integral Calculus. [3]

Topics of this course include: computation of areas, definition of the definite integral, integrals of algebraic and trigonometric functions, applications of integrals, the calculus of exponential and logarithmic functions, basic and advanced techniques of integration, numerical integration and improper integrals. **Note:** The combination of MATH 140 and 141 includes all material in MATH 151 and can serve as a prerequisite to MATH 152. MATH 141 is equivalent to the second quarter of calculus at institutions on quarter system. **Prerequisite:** MATH 140 or 155B.

MATH 142
Calculus Applications and Infinite Series. [3]

Topics of this course include: first introduction to differential equations; further applications of the differential and integral calculus; infinite sequences and series; Taylor and Maclaurin series for functions, including the trigonometric, logarithmic and exponential functions.

Note: Completion of this course is equivalent to completion of MATH 152. This is equivalent to the third quarter of calculus at institutions on a quarter system. **Prerequisite:** MATH 141.

MATH 150
Pre-Calculus Mathematics (MS). [4]

This course provides the mathematical preparation necessary for success in calculus. It also provides preparation for basic physics, computer science and engineering science courses. Topics covered include review of functions and graphing techniques; logarithmic and exponential functions; review of basic right-angle trigonometry followed by an extensive treatment of trigonometric functions, identities and applications to the analytic geometry of the conic sections, applications to two-dimensional vectors and to the geometry of complex numbers. **Prerequisites:** A suitable score on LRC algebra placement exam or MATH 106.

MATH 151
Calculus and Analytic Geometry I (MS). [4]

Topics of this course include limits, continuity, the rate of change, derivatives, differentiations formulas for algebraic and trigonometric functions, maxima and minima, integration and computation of areas. Areas and volumes of solids of revolution, applications. **Note:** Non-science-oriented students interested in calculus should consider MATH 155. Credit will not be given for both MATH 151 and 155. **Prerequisite:** MATH 150 or a qualifying score on the LRC calculus readiness placement test.

MATH 152
Calculus and Analytic Geometry II. [4]

Topics of this course include logarithmic and exponential functions, inverse functions, methods of integration, improper integrals, hyperbolic functions, sequences and infinite series, power series, Taylor series, applications, conic sections and polar coordinates.

Prerequisites: MATH 151, 141 or 155B.

MATH 155
Elementary Calculus I (MS). [3]

Basic ideas of differential and integral calculus, with emphasis on elementary techniques of differentiation and integration with applications are treated in this course. Not recommended for students majoring in mathematics, computer science, engineering, biological or physical sciences. **Note:** Credit will not be given for both MATH 151 and 155. **Prerequisite:** A suitable score on the LRC algebra placement test or MATH 106.

MATH 155B
Calculus of Trigonometric Functions. [1]

The main topics of this course are the differentiation and integration of trigonometric functions, together with a treatment in greater depth of topics in MATH 155. **Note:** MATH 155B is a prerequisite to MATH 152. **Prerequisite:** MATH 155.

MATH 215
Finite Mathematics for Information Sciences.

This course focuses on the area of mathematics of particular use in the information sciences. The basic linear algebra of matrices used for solutions of large scale systems of linear equations is treated. Applications of matrices such as Leontieff models of multi-sector economics and the basics of the simplex method for solving linear economic optimization problems are discussed. Fundamental concepts of probability including basic combinatorial methods for probabilistic computations are studied. An introduction is given to decision theory. This treatment is in the context of Bayesian or statisti-

cal decision theory, though game theoretic versions may be discussed. Possible optional topics may include elementary Markov chains or the matrix algebra of spreadsheet operations. This course is intended for IFSM majors only. **Prerequisite:** MATH 141, 151, 155 or 380.

MATH 221
Introduction to Linear Algebra. [3]

Topics of this course include: linear equations, Gauss-Jordan reduction, matrices and determinants and their properties, vector spaces and subspaces, basis and dimension, linear transformations, kernel and range, eigenvalues and eigenvectors, and matrix diagonalization. **Prerequisites:** MATH 141, 151, 155 or 380.

MATH 225
Introduction to Differential Equations. [3]

Topics of this course include: solutions of first- and second-order linear differential equations, non-linear exact and separable equations, integrating factors, homogeneous equations, higher-order linear equations. initial and boundary value problems, solutions as functions of the equation parameters, Laplace transforms, power series solutions for Bessel and Legendre equations, difference equations and numerical methods. **Note:** Recommended for science majors who need a basic knowledge of differential equations. **Recommended:** MATH 251. **Prerequisite:** MATH 142 or 152.

MATH 233
Fundamentals of Geometry. [3]

In this course, the student will learn and apply the principles of geometry as well as recognize and understand their relevance to the real world. Topics include fundamental concepts and patterns; geometric reasoning and proof; parallel and perpendicular lines as they relate to Euclidean, hyperbolic and elliptical geometry; triangle relationships and triangle congruence; exploring quadrilaterals; transformations and similarity; investigating right triangles, poly-

gons, surface area and volume, and circles. Throughout the course, special emphasis is given to problem-solving techniques. **Prerequisite:** MATH 132 or 150 or placement into MATH 140 or 151.

MATH 251
Multivariable Calculus. [4]

Topics of this course include: vectors, lines, planes and surfaces in three dimensions. Vector functions and their derivatives. Partial derivatives, gradients, directional derivatives, maxima, minima and Lagrange multipliers. Multiple integrals, area, volume, surface area, integration in different coordinate systems. Line integral, Green's theorem, Stokes' theorem and divergence theorem. **Prerequisite:** MATH 142 or 152.

MATH 290
Special Topics in Mathematics. [1-4]**MATH 299**
Independent Study in Mathematics. [1-4]

Prerequisite: Permission of instructor.

MATH 301
Introduction to Mathematical Analysis I. [4]

This course is a systematic study of basic analysis with an emphasis on formal proofs, examples and counter examples. Topics include properties of the real line, sequences, series, limits, continuity and differentiation of functions, and Riemann Integration. **Highly recommended:** CMSC 203. **Prerequisite:** MATH 142 or 152 and 221.

MATH 302
Introduction to Mathematical Analysis II. [3]

Topics of this course include: continuity, differentiation of functions of several variables, uniform convergence of sequences of functions, multiple integration, contraction mapping principle, and implicit and inverse function theorems. **Note:** Credit will not be given for both MATH 302 and 401. **Prerequisites:** MATH 251 and 301.

MATH 306**Geometry. [3]**

Topics of this course are to be selected from foundations of geometry, modern Euclidean geometry, non-Euclidean geometry, projective geometry and its subgeometries. **Prerequisite:** MATH 301.

MATH 341**Computational Methods. [3]**

Basic computational methods for interpolation, systems of linear equations, least squares approximation, numerical quadrature, numerical solution of polynomial and transcendental equations. Emphasis on the methods and their computational properties, rather than on their analytic aspects. **Prerequisites:** MATH 142 or 152, 221, CMSC 201 or permission of instructor.

MATH 380**Introduction to Operations Research (MS). [3]**

Linear programming, including the simplex method. Transportation, assignment and trans-shipment problems. Network problems. Not recommended for mathematics/statistics or computer science majors. **Note:** Credit will not be given for both MATH 380 and 381. **Prerequisite:** MATH 115 or 150.

MATH 381**Linear Methods in Operations Research. [3]**

Introduction to convex sets. Theory of linear programming. Applications to transportation and assignment problems. Introduction to graphs with applications to network problems, including shortest route and maximum flow problems. Introduction to game theory. **Note:** Credit will not be given for both MATH 380 and 381. **Prerequisite:** MATH 221.

MATH 385**Introduction to Mathematical Modeling. [3]**

This is a project-oriented course offering the opportunity to discover how various real-world problems can be described and analyzed with the aid of simple mathematical models and computer simulations. Possible project topics include operation of

a fuse, spread of pollutants in a river, propagation of an infectious disease, traffic flow on a highway, oscillating chemical reactions, etc. Specific selection of problems will depend on the background and interests of the students enrolled in the course. Students seeking elementary teacher certification in science or math are particularly welcome. This course incorporates constructivist principles and has been designed as an MCTP course for students in the Maryland Collaborative for Teacher Preparation Program. **Prerequisite:** MATH 225.

MATH 390**Special Topics in Mathematics. [1-4]****MATH 401****Mathematical Analysis. [3]**

Topics of this course include: elementary metric space topology, sequences, series, continuity, differentiation, Riemann integral, sequences and series of functions, and implicit and inverse function theorems. **Note:** Credit will not be given for both MATH 302 and 401. **Prerequisite:** MATH 301 or equivalent.

MATH 404**Introduction to Partial Differential Equations I. [3]**

Quasi-linear and non-linear first-order equations, calculus of variations, linear second-order equations and their classification, self-adjoint operators, Sturm Liouville problems and eigenfunction expansions, fundamental solutions and Green's functions, distributions, boundary and initial value problem for potential, wave and heat equations, integral transforms and asymptotic expansions. **Prerequisites:** MATH 251 and 225.

MATH 407**Introduction to Modern Algebra and Number Theory. [3]**

The basic abstract algebraic structures (rings, integral domains, division rings, fields and Boolean algebra) will be introduced, and the fundamental concepts of number theory will be examined from an algebraic perspective. This will be

done by examining the construction of the natural numbers from the Peano postulates, the construction of the integers from the natural numbers, the rationals as the field of quotients of the integers, the reals as the ordered field completion of the rationals and the complex numbers as the algebraic completion of the reals. The basic concepts of number theory lead to modular arithmetic; ideals in rings; and to examples of integral domains, division rings and fields as quotient rings. The concept of primes yields the algebraic concepts of unique factorization domains, Euclidean rings, and prime and maximal ideals of rings. Examples of symmetries in number theory and geometry lead to the concept of groups whose fundamental properties and applications will be explored. **Prerequisite:** MATH 301 or permission of instructor.

MATH 408**Abstract Algebra. [3]**

Topics of this course include a deeper examination of the structure of groups, including Sylow theorems and the fundamental theorem of abelian groups; a further study of rings, including modules and linear algebra over rings; polynomial and matrix rings; field theory, including Galois theory; and applications such as non-solubility of quintic polynomials by radicals and geometric non-constructibility. **Prerequisite:** MATH 407.

MATH 409**Introduction to Mathematical Logic.**

Propositional and first-order logic are developed. The basic framework of formal languages, logical structures and their models is given. Formal deductive systems for logical proofs is set in an algorithmic framework. The completeness and compactness theorems for consistent axiom systems are proven, including the Lowenheim-Skolem theorems. The last half of the course focuses on the work of Goedel. Using Goedel's numbering of number theoretic formulae and proofs, his theorem asserting the incompleteness (inability to prove all true statements) of

any consistent axiomatization of the natural numbers that is recursively given are proven. Related results of Tarski and Rosser, his second incompleteness theorem; the impossibility of Peano arithmetic, if consistent, to prove its own consistency are also proven. Time permitting, the course will introduce Goedel's proof of the consistency of Cantor's continuum hypothesis and axiom of choice with the usual axioms of set theory. **Note:** Credit cannot be given for both MATH 409 and CMSC 452. **Prerequisite:** MATH 301, CMSC 441, PHIL 346 or permission of instructor.

MATH 410**Introduction to Complex Analysis. [3]**

Complex number plane and functions of a complex variable, differentiability and analyticity. Cauchy-Riemann equations, integration in the complex plane, Cauchy's theorem, power series, analytic continuation, Laurent series, improper integrals, gamma function, calculus of residues, evaluation of real integrals, argument principle, meromorphic functions and entire functions. **Recommended:** MATH 301. **Prerequisite:** MATH 251.

MATH 411**Linear Algebra. [3]**

Topics of this course include finite-dimensional vector spaces, subspaces, basis, dimension, linear transformations, matrices, linear functionals, dual space, dual-basis theorem, direct sum, quotient space, determinants, eigenvalues, minimal polynomial, characteristic polynomial, Cayley-Hamilton theorem, companion matrices, invariant subspaces, similarity, diagonalization, rational and Jordan canonical forms, nilpotent operators, inner product spaces, Gram-Schmidt orthogonalization, orthogonal matrices and spectral theorem. **Prerequisite:** MATH 301.

MATH 413**Number Theory. [3]**

Following a review of elementary number theory through Fermat's little theorem, the course treats: unique factorization, element orders, Euler's function and Carmichael's lambda functions, primitive elements, quadratic reciprocity, the prime-number theorem and elementary analytic number theory, and quadratic number fields. Optional topics may include: computational number theory, finite fields, cyclotomic fields and Fermat's last theorem. **Prerequisite:** MATH 407.

MATH 421**Introduction to Topology. [3]**

Topics of this course include metric spaces, topological spaces, derived topological spaces, separation axioms, closure and continuity, covering properties and compactness, connectedness, metrizable, complete metric spaces, and introduction to homotopy theory. **Prerequisite or Corequisite:** MATH 302 or 401.

MATH 423**Differential Geometry. [3]**

The differential geometry of curves and surfaces, curvature and torsion, moving frames, the fundamental differential forms, and intrinsic geometry of a surface. **Recommended:** MATH 301. **Prerequisites:** MATH 221 and 251.

MATH 426**Introduction to Mathematical Software Packages: MATLAB. [2]**

The student will become familiar with the usage of Matlab, an advanced numerical linear algebra package that is widely used in teaching and research. Matlab is an interactive tool for high-performance numerical computations, visualization and programming. Matlab performs complex matrix algebra, computes matrix factorizations (such as LU, QR and SVD) and eigenvalues, solves linear systems of equations, provides extensive 2-D and 3-D visualization tools, and possesses programming tools used in scripts and functions. **Prerequisites:** MATH 152, 221 and CMSC 201, or permission of instructor.

MATH 427**Introduction to Mathematical Software Packages: Maple. [1]**

The student will become familiar with the usage of Maple, an advanced computer algebra package that is widely used in teaching and research. Maple performs symbolic computations such as integration, differentiation, factoring and simplifying algebraic expressions, solving linear and non-linear systems, solving differential equations exactly or in power series, complex algebra, matrix algebra, plotting in 2-D and 3-D, and animated plots. **Prerequisites:** MATH 152, 221 and CMSC 201, or permission of instructor.

MATH 430**Matrix Analysis. [3]**

Topics in this course will include a review of basic matrix operations, determinants, rank, matrix inverse and solving linear equations. The course then will study partitioned matrices, eigenvalues and eigenvectors, spectral decomposition, singular-value decomposition, orthogonal projections, idempotent matrices, quadratic forms, extrema of quadratic forms, non-negative definite and positive definite matrices, and matrix derivatives. **Prerequisite:** MATH 251 and 301 or permission of instructor.

MATH 432**History of Mathematics. [3]**

An examination of the conceptual development of mathematics and the roles played by the people central to its development. Key periods of focus will be the Greco-Roman classical era, the development of mathematics from the Renaissance through the birth of the calculus, the rise of mathematical rigor and abstraction in the 18th and 19th centuries, and the continuing evolution of mathematics and its impact on modern society in the 20th century. Ancillary topics such as ethno-mathematics and humanistic-mathematics may be addressed. **Note:** This course does not qualify as an upper-division mathematics/statistics elective for majors or minors, but it does qualify as a supplementary elective. **Prerequisite:** MATH 301 or permission of instructor.

MATH 441**Introduction to Numerical Analysis. [3]**

Topics of this course include: numerical linear algebra, interpolation, numerical differentiation and integration, solution of non-linear equations, acceleration of convergence and numerical treatment of differential equations. **Prerequisites:** MATH 225, 251, 301 and CMSC 201, or permission of instructor.

MATH 452**Introduction to Stochastic Processes. [3]**

This is a non-measure theoretic course. Topics include general Markov chains (branching process, queuing processes, birth and death processes, and Poisson processes), second-order processes (Gaussian processes and Wiener processes) and an introduction to stochastic differential equations. **Prerequisite:** STAT 451 or 355.

MATH 456**Mathematical Methods for Science and Engineering. [3]**

Vector analysis and tensors, Sturm-Liouville problems and Fourier series, complex analysis, integral transforms and variational calculus. **Prerequisites:** MATH 221, 225 and 251.

MATH 465**Introduction to Artificial Neural Networks.**

This course gives a systematic introduction to artificial neural networks, which represent a rather new and fundamentally different approach to computing and information processing. Providing parsimonious universal approximators for static and dynamic mappings, synthetic methodologies for building models and/or solutions, abilities to learn from and adapt to environments, and massively parallel computation paradigms, the artificial neural networks have formed a powerful approach to solving non-linear or complex problems in a broad spectrum of areas including signal speech/image processing, system control, pattern recognition, robotics, financial management, digital communication, etc. This course will cover multi-layer perceptrons, recurrent neural nets,

global minimization for training, adaptive and robust neural nets, neural filtering, identification and control, support vector machines, self-organizing maps, etc. **Prerequisites:** MATH 221, 251, 301 and STAT 451, or permission of instructor.

MATH 470**Introduction to Actuarial Mathematics. [2]**

This course is intended to prepare students for Society of Actuaries Exam Course I Mathematical Foundations of Actuarial Science. **Prerequisites:** MATH 251 and STAT 451.

MATH 475**Combinatorics and Graph Theory. [3]**

General enumeration methods, difference equations, generating functions. Elements of graph theory, including transport networks, matching theory and graph algorithms. Introduction to finite geometries and block designs. **Prerequisites:** MATH 301 or permission of instructor.

MATH 476**Introduction to Game Theory.**

Purely non-cooperative or zero-sum games between two players are introduced. In simple cases, solutions of such games use techniques of saddle points or other geometric means. VonNeumann's Min-Max theorem assures optimal mixed strategies. In general, linear programming techniques must be employed. Study of convex sets in Euclidean spaces, in particular of polyhedra, and polytopes is necessary for full understanding of the general case. In non-zero sum situations with two or more players, the fundamental results of John Nash assuring equilibria in mixed strategies and on arbitration or bargaining schemes are studied. For cooperative games with many players, several solution concepts are studied, including Shapley values and core allocations. Diverse applications are considered. Purely non-cooperative or zero-sum games between two players are introduced. Solutions of such entail techniques of finding saddle points or geometric means in simple cases. **Prerequisites:** Math 221 and Math 251.

MATH 479**Mathematics****Problem-Solving Seminar. [1]**

Mathematical problem-solving techniques, mathematical communication skills. Problem sessions with problems ranging from pre-calculus to analysis, algebra, geometry, combinatorics and probability. Problems ranging from quickies to mini research problems. Students will develop and reinforce skills from previous mathematics courses and will be introduced to topics from more advanced courses. **Note:** Repeatable for credit. **Prerequisite:** Permission of instructor.

MATH 480**Senior Seminar. [1]**

Note: Repeatable for credit.

MATH 481**Mathematical Modeling. [3]**

Derivation and analysis of mathematical models of phenomena from physics, engineering and other exact sciences. Topics include stability of equilibria of dynamical systems with emphasis on the qualitative aspects of solutions, phase plane analysis and linearization of non-linear systems. Additional topics from catastrophe theory, bifurcation, optimization and chaos will be covered as time permits. Examples will be drawn from population dynamics, flywheel governor, a model for heartbeat, bang-bang controls, self-sustained oscillations and morphogenesis. **Prerequisites:** MATH 221, 225 and 251.

MATH 482**Non-linear Optimization. [3]**

Introduction to convex analysis. One-dimensional minimization. Unconstrained optimization in algorithms, global convergence and rates of convergence. Quasi-Newton techniques. Convex programming: optimality conditions and duality. Penalty and Barrier methods. **Prerequisite:** MATH 251. **Corequisite:** MATH 301.

MATH 483**Linear and Combinatorial Optimization. [3]**

Integer programming. The traveling salesman problem. Advanced linear programming techniques. Complexity. Projec-

tive methods in linear programming. The Karmarkar method.

Prerequisite: MATH 381.

MATH 484**Stochastic Methods in Operations Research. [3]**

Topics of this course include: introduction to Markov chains, Poisson processes, introduction to queuing theory, Stochastic programming, introduction to deterministic and Stochastic dynamic programming. **Prerequisite:** STAT 355 or 451.

MATH 485**Introduction to the Calculus of Variations. [3]**

This course will provide a modern introduction to basic results of the classical calculus of variations. Special emphasis will be given to the theory of second-order conditions. Considerable attention will be devoted to physical applications of variational methods. **Prerequisites:** MATH 221, 225, 251 and 301.

MATH 486**Introduction to Dynamical Systems.**

The course will address ideas from discrete dynamical systems, including fixed points, periodic points, bifurcations, and an explanation of period 3 implied chaos. Fractals such as Sierpinski's gasket, Julia sets and Mandelbrot sets also will be introduced. **Prerequisite:** MATH 221 and 225 and some programming experience; Math 301 or permission of instructor.

MATH 490**Special Topics in Mathematics. [1-4]****MATH 495****Topics in Mathematics of Operations Research. [3]**

Introduction to recent and advanced techniques of optimization and operations research. The course will be redefined from time to time and will reflect the instructor's interests. **Prerequisite:** Permission of instructor.

MATH 496**Mathematics Practicum. [1-4]**

Under faculty direction, students will write a report dealing with mathematical concepts or techniques utilized or implemented in internships or cooperative education or in the workplace. **Note:** This course is repeatable up to four times.

Prerequisite: Permission of instructor.

MATH 497**Senior Thesis. [3]**

The student will be required to prepare an exposition of either a significant area of mathematics or of the results of a student research project. Typically, the former will be in connection with an upper-division course the student has completed or independent study (MATH 499).

MATH 499**Independent Study in Mathematics. [1-4]**

Under this heading, a student may agree to a course with a particular faculty member on a topic not covered in the regular curriculum. The arrangements with the faculty member must be made before the student registers for the course.

Modern Languages and Linguistics**MLL 110****Composition for ESL Students. [3]**

See ENGL 110.

MLL 190**The World of Language I (AH or C). [3]**

Language as a distinctive characteristic of the human species. In this course, we examine the structure of both written and spoken forms of language across cultures, comparing them with animal communication and human gestural systems. We explore language's neurological basis, theories of origin, and first- and second-language learning. **Note:** MLL 190 is required for the MLL major. Also listed as ENGL and LING 190. **Highly recommended:** MLL 191.

MLL 191**The World of Language II (AH or C). [3]**

Language as both a reflection and a determiner of social relationships. In this course, we examine the varying idioms of the scientist, the politician, the media, the poet, the child and the magician, and we investigate how language changes and how it marks social groups. Communication strategies and social taboos reflected in language are discussed for various cultures. **Note:** Although this course continues work begun in The World of Language I, it is designed so that students can easily enter MLL 191 without having taken MLL 190. **Note:** Also listed as ENGL 191. **Highly recommended:** MLL majors take the two course sequence.

MLL 203**Inter-Cultural Communication: Community Issues in Maryland/D.C. (C). [4]**

Immigration and social adjustment to a new environment could be analyzed from different theoretical perspectives. By doing service learning, students will learn to combine the analysis of immigration — generally studied as a social and economic process — and the perspective of intercultural communication. Difficulties in the process of adjustment faced by new immigrants and other members of local heritage communities in the Maryland/D.C. region will allow students to explore the ways in which the development of intercultural competence can help resolve cultural conflicts in a multicultural society. Guest speakers from local immigrant/heritage communities will be invited to participate in the seminars. The course will entail spending three hours per week in immigrant/heritage communities doing service learning related to intercultural communication. **Prerequisites:** A language course above the 201 level, MLL 305, or an equivalent course in cultural diversity or intercultural communication.