Mathematics

Nakhle Asmar, Chair
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Faculty

Associate Professor C. Chindris**, A. Harcharras**, C. Morpurgo**, J. Segert*, D. T. Weston**
Assistant Professor P. Pivovarov**, S. Walsh**, S. Takeda**, J. Tu**
Business Mathematics Coordinator S. Goldschmidt
Calculus Coordinator A. Clayton
College Algebra Coordinator T. E. Christiansen

* Graduate Faculty Member - membership is required to teach graduate-level courses, chair master's thesis committees, and serve on doctoral examination and dissertation committees.
** Doctoral Faculty Member - membership is required to chair doctoral examination or dissertation committees. Graduate faculty membership is a prerequisite for Doctoral faculty membership.

Undergraduate

• Department Level Requirements (http://catalog.missouri.edu/undergraduategraduate/collegeofartsandscience/mathematics/department-level-requirements)
• BA in Mathematics (http://catalog.missouri.edu/undergraduategraduate/collegeofartsandscience/mathematics/ba-mathematics)
• BS in Mathematics (http://catalog.missouri.edu/undergraduategraduate/collegeofartsandscience/mathematics-bs-mathematics)
  • with emphasis in Actuarial Science and Mathematical Finance (http://catalog.missouri.edu/undergraduategraduate/collegeofartsandscience/mathematics-bs-mathematics-emphasis-actuarial-science-mathematical-finance)
• Minor in Mathematics (http://catalog.missouri.edu/undergraduategraduate/collegeofartsandscience/mathematics/minor-mathematics)

The Department of Mathematics offers a major with either a Bachelor of Arts or a Bachelor of Science degree. Within the BS degree, an emphasis in Actuarial Science and Financial Mathematics is available. Both the BA and BS degrees will prepare a student for a graduate program in Mathematics.

Preparation for Graduate Study in Mathematics

Students satisfying the requirements for either the BA or the “traditional” BS will have the basic preparation for a graduate program in Mathematics. A student considering graduate work, however, should take additional coursework. Because of this, a BS degree would be considered preferable. Those students in the Actuarial Science area considering graduate work should take MATH 4720 as part of their program. Those students getting a dual degree in Mathematics and Mathematics Education considering graduate work in mathematics should choose to take both MATH 4700 and MATH 4720 as part of their program.

Courses recommended for students planning to pursue graduate studies in pure mathematics: MATH 4400, MATH 4500, MATH 4900, MATH 4920, and MATH 4940.

Courses recommended for students planning to pursue graduate studies in applied mathematics: MATH 4300, MATH 4310, MATH 4315, MATH 4320, MATH 4500, MATH 4540, MATH 4940.

Departmental Honors

Eligibility

To become a candidate for the BA or BS degree with a major in Mathematics with departmental honors, a student must have a cumulative grade point average that meets the Honors College standards. At present, students with a GPA of 3.30 or higher are automatically eligible to enter the departmental honors programs.

Requirements

To graduate with departmental honors in mathematics, a student must satisfy the regular BA or BS degree requirements and must have a GPA of 3.5 or higher in all Mathematics Department courses. In addition, the student must have at least 26 credits in mathematics courses numbered 4000 or above. Furthermore, the student must complete one of the two options listed below.

Option 1: Honors Thesis

The student must write an honors thesis in conjunction with a mentorship or in conjunction with MATH 4996. This option requires that the student enroll in MATH 4996.

Option 2:

The student’s program of study must include MATH 4700, MATH 4900, MATH 4720 and MATH 4920.

Graduate

• MA in Mathematics (http://catalog.missouri.edu/undergraduategraduate/collegeofartsandscience/mathematics/ma-mathematics)
• MS in Applied Mathematics (http://catalog.missouri.edu/undergraduategraduate/collegeofartsandscience/mathematics/ms-applied-mathematics)
• MST in Mathematics (http://catalog.missouri.edu/undergraduategraduate/collegeofartsandscience/mathematics/mst-mathematics)
• PhD in Mathematics (http://catalog.missouri.edu/undergraduate/collegeofartsandscience/mathematics/phd-mathematics)

College of Arts and Science
202 Mathematical Sciences Building
(573) 882-6221
https://www.math.missouri.edu/grad/index

Director of Graduate Studies: Stephen Montgomery-Smith

About Mathematics

The Graduate Program in Mathematics is large enough to encompass research and courses in many areas, yet small enough to remain responsive to the needs of individual students. There are approximately 80 graduate students, 40 professors, and 15 postdoctoral and visiting researchers. The active areas of research include: algebraic geometry, analysis (real, complex, functional and harmonic), analytic functions, applied mathematics, financial mathematics and mathematics of insurance, commutative rings, scattering theory, differential equations (ordinary and partial), differential geometry, dynamical systems, general relativity, mathematical physics, number theory, probabilistic analysis and topology.

The Mathematical Sciences Building houses a library with more than 34,000 volumes and 430 journal titles. MU students have access to an extensive array of computing resources.

Admission Notice

Applicants for any graduate degree in mathematics should submit an application for graduate study. Admission to the graduate program does NOT guarantee admission to the Ph.D. program. International Applicants applying from outside North America who seek financial support from the Department will only be considered for the PhD program.

Financial Aid from the Program

All domestic applications for admission are automatically considered for financial support, in most cases by Teaching Assistantships. Virtually all current students are supported financially. Scholarships, assistantships, fellowships and other sources of aid are available.

The Department Research Fellowship, the Blumenthal Scholarship and the McFarlan Fellowship are administered by the department, while the Huggins Scholarship, Gregory Fellowship and Ridgel Fellowship are administered by the university.

International applications with TOEFL of 85 or higher (or equivalent) will also be automatically considered for departmental financial support.

MATH _0110: Intermediate Algebra
MATH _0110 is a preparatory course for college algebra that carries no credit towards any baccalaureate degree. However, the grade received in MATH _0110 does count towards a student's overall GPA. The course covers operations with real numbers, graphs of functions, domain and range of functions, linear equations and inequalities, quadratic equations; operations with polynomials, rational expressions, exponents and radicals; equations of lines. Emphasis is also put on problem-solving.

Credit Hours: 3

MATH 1050: Quantitative Reasoning
Promotes mathematical literacy among students. This course will cover important mathematical ideas and problem solving skills in the context of science, technology, and/or society. Topics may include: logic and critical thinking, Venn Diagrams, problem solving, sets, units of measure, percentages and ratios, counting and probability, exponential growth and decay, linear and exponential models. Quantitative Reasoning is designed to stimulate interest in and appreciation of mathematics and quantitative reasoning as valuable tools for comprehending the world in which we live. This course does not satisfy the prerequisite of any other math course.

Credit Hours: 3
Prerequisites: C- or higher in MATH _0110 or a sufficient score on the ALEKS (or MMT) exam

MATH 1100: College Algebra
A review of exponents, order of operations, factoring, and simplifying polynomial, rational, and radical expressions. Topics include: linear, quadratic, polynomial, rational, inverse, exponential, and logarithmic functions and their applications. Students will solve equations involving these functions, and systems of linear equations in two variables, as well as inequalities. See the Math website for specific requirements. A student may receive at most 5.0 credit hours among MATH 1100, MATH 1120, MATH 1140, MATH 1160.

Credit Hours: 3
Prerequisites: C- or higher in MATH _0110 or a sufficient score on the ALEKS exam or MyMathTest Intermediate Algebra score of 70% or higher

MATH 1140: Trigonometry
A student may receive only 5 credits from among MATH 1100, MATH 1140, and MATH 1160. A Student may receive at most 5.0 credit hours from MATH 1100, MATH 1120, MATH 1140, and MATH 1160.

Credit Hours: 2
Prerequisites: C- or higher in MATH 1100 or sufficient ALEKS score or MyMathTest College Algebra score of 70% or higher

MATH 1160: Precalculus Mathematics
Review of elementary algebra. Background material for MATH 1500, including algebraic, trigonometric, logarithmic, exponential functions. A student may receive at most 5 credits from among MATH 1100, MATH 1140, and MATH 1160.

Credit Hours: 5
Prerequisites: B+ or higher in MATH _0110 (at MU), or C- or higher in MATH 1100, or sufficient ALEKS score or MyMathTest College Algebra score of 60% or higher

MATH 1300: Finite Mathematics
A selections of topics in finite mathematics such as: basic financial mathematics, counting methods and basic probability and statistics, systems of linear equations and matrices. Warning: without a College Algebra exemption, a sufficient ALEKS score will not suffice unless it is a proctored exam (for MATH 1100 credit).

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 1100, or MATH 1160, or both a College Algebra exemption and sufficient ALEKS score
MATH 1320: Elements of Calculus
Introductory analytic geometry, derivatives, definite integrals. Primarily for Computer Science BA candidates, Economics majors, and students preparing to enter the College of BUS. No credit for students who have completed a calculus course. A student may receive credit for MATH 1320, or MATH 1400 but not both. A student may receive at most 5 credit hours among MATH 1320 or MATH 1400 or MATH 1500.

Credit Hours: 3
Prerequisites: MATH 1100, or MATH 1160, or sufficient ALEKS score

MATH 1360: Geometric Concepts
This course is primarily for education majors. This course covers topics of Euclidean geometry such as the study of points, lines, angles, polygons, circles, congruence, similarity, transformations, symmetry, area, surface area, arc length, and volume. Polyhedra, spheres, cones, and other solids are discussed. The course includes constructions and proofs, and uses inductive and deductive reasoning throughout. Math Reasoning Proficiency Course.

Credit Hours: 3
Prerequisites: C- or higher in MATH 1100 or sufficient ALEKS exam score or MATH 1160 or equivalent

MATH 1400: Calculus for Social and Life Sciences I
The real number system, functions, analytic geometry, derivatives, integrals, maximum-minimum problems. No credit for students who have completed a calculus course. A student may receive credit for MATH 1320 or MATH 1400 but not both. A student may receive at most 5 units of credit among the MATH 1320 or MATH 1400 and MATH 1500. Math Reasoning Proficiency Course.

Credit Hours: 3
Prerequisites: grade of C- or higher in MATH 1100, or MATH 1160, or sufficient ALEKS score

MATH 1500: Analytic Geometry and Calculus I
Elementary analytic geometry, functions, limits, continuity, derivatives, antiderivatives, definite integrals. A student may receive at most 5 units of credit among the Mathematics courses MATH 1320 or MATH 1400 and MATH 1500. Math Reasoning Proficiency Course.

Credit Hours: 5
Prerequisites: grade of C- or higher in MATH 1160 or C - or higher in both MATH 1100 and MATH 1140 or sufficient ALEKS score or MyMathTest PreCalculus score of 70% or higher

MATH 1500H: Analytic Geometry and Calculus I - Honors
Elementary analytic geometry, functions, limits, continuity, derivatives, antiderivatives, definite integrals. Honors eligibility required. A student may receive at most 5 units of credit among MATH 1320 or MATH 1400 and MATH 1500. Math Reasoning Proficiency course.

Credit Hours: 5
Prerequisites: C- or higher in MATH 1160 or C - in both MATH 1100 and MATH 1140 and sufficient ALEKS score. Honors Eligibility required

MATH 1601: Selected Topics in Mathematics-General
The special topics covered may vary from term to term. This course may be repeated.

Credit Hours: 3
Prerequisites: instructor's consent

MATH 1602: Selected Topics in Mathematics-Biological/Physical/ Math
The special topics covered may vary from term to term. This course may be repeated.

Credit Hours: 1-3
Prerequisites: instructor's consent

MATH 1700: Calculus II
Definite integrals, applications and techniques of integration, elementary transcendental functions, infinite series. Math Proficiency Reasoning course.

Credit Hours: 5
Prerequisites: a grade of C- or better in MATH 1500

MATH 1700H: Calculus II - Honors
Definite integrals, applications and techniques of integration, elementary transcendental functions, infinite series. Math Reasoning Proficiency course.

Credit Hours: 5
Prerequisites: a grade of C- or better in MATH 1500. Honors eligibility required

MATH 1800: Introduction to Analysis I
This course will cover the material taught in a traditional first semester calculus course at a more rigorous level. The focus of this course will be on proofs of basic theorems of differential and integral calculus. The topics to be covered include axioms of arithmetic, mathematical induction, functions, graphs, limits, continuous functions, derivatives and their applications, integrals, the fundamental theorem of calculus and trigonometric functions. Students in this class will be expected to learn to write clear proofs of mathematical assertions. Some previous exposure to calculus is helpful but not required. No credit for MATH 1800 and MATH 1320, MATH 1400 or MATH 1500. Graded on A-F basis only.

Credit Hours: 5
Prerequisites: ACT mathematics score of at least 31 and ACT composite of at least 30 or instructor's consent

MATH 1900: Introduction to Analysis II
This course is a continuation of MATH 1800. In this course we shall cover uniform convergence and uniform continuity, integration, and sequences and series. The topics will be covered in a mathematically rigorous manner. No credit for MATH 1900 and MATH 1700 or MATH 2100. Graded on A/F basis only.

Credit Hours: 5
Prerequisites: MATH 1800 or instructor's consent

MATH 2100: Calculus for Social and Life Sciences II
Riemann integral, transcendental functions, techniques of integration, improper integrals and functions of several variables. No credit for students who have completed two calculus courses. Math Reasoning Proficiency course.

Credit Hours: 5
Prerequisites: MATH 1800 or instructor's consent
**Prerequisites:** C- or higher in MATH 1320 or MATH 1400 or MATH 1500

**MATH 2140: Geometric Axioms and Structures**
Euclidean geometry, axiom systems, spherical geometry, finite geometries, and explorations with technology.

**Credit Hours:** 3

**Prerequisites:** MATH 1340 or MATH 1360

**MATH 2300: Calculus III**
Vectors, solid analytic geometry, calculus of several variables. Math Reasoning Proficiency course.

**Credit Hours:** 3

**Prerequisites:** grade of C- or better in MATH 1700

**MATH 2300H: Calculus III - Honors**
Vectors, solid analytic geometry, calculus of several variables. Math Reasoning Proficiency course.

**Credit Hours:** 3

**Prerequisites:** grade of C- or better in MATH 1700. Honors eligibility required

**MATH 2320: Discrete Mathematical Structures**
Sets, functions, logic, relations, induction, recursion, counting techniques, graphs, trees, algorithms. Math Reasoning Proficiency course.

**Credit Hours:** 3

**Prerequisites:** MATH 1300 and MATH 1320 or instructor's consent

**MATH 3000: Introduction to Advanced Mathematics**
Gateway to theoretical math courses. Focus on reading and writing math proofs/developing background needed in Adv Calc/Abstract Alg. Topics include logic, set theory, properties of functions and integers, the real number system, completeness of the real numbers, sequences of real numbers.

**Credit Hours:** 3

**Prerequisites:** Consent of Department required. Recommended MATH 1700

**MATH 3000W: Introduction to Advanced Mathematics - Writing Intensive**
Gateway to theoretical math courses. Focus on reading and writing math proofs/developing background needed in Adv Calc/Abstract Alg. Topics include logic, set theory, properties of functions and integers, the real number system, completeness of the real numbers, sequences of real numbers.

**Credit Hours:** 3

**Prerequisites:** Consent of Department required. Recommended MATH 1700

**MATH 4001: Topics in Mathematics-General**
Organized study of selected topics. Subjects and earnable credit may vary from semester to semester. May repeat for credit with Departmental consent.

**Credit Hours:** 1-99

**Prerequisites:** Grade of C- or higher in MATH 2300

**MATH 4002: Topics in Mathematics-Biological/Physical/Math**
Organized study of selected topics. Subjects and earnable credit may vary from semester to semester. May repeat for credit with Departmental consent.

**Credit Hours:** 1-99

**Prerequisites:** MATH 2300 and instructor's consent

**MATH 4060: Connecting Geometry to Middle and Secondary Schools**
(cross-leveled with MATH 7060). Euclidean foundations, logic, Euler Characteristic, congruence, area, Pick's Theorem, volume, Cavalieri's Principle, surface area, similarity, symmetry, transformations, matrices, intro to spherical geometry.

**Credit Hours:** 3

**Prerequisites:** Consent of Department required

**Recommended:** MATH 1360 or MATH 1500

**MATH 4070: Connecting Algebra to Middle and Secondary Schools**
A detailed study of integer and rational arithmetic and algebra. Topics include: Binomial Theorem, induction, division algorithm, Euclid's Algorithm, Fundamental Theorem of Arithmetic, Pythagorean triples, modular arithmetic and generalizations to polynomials, matrices and other axiomatic structures.

**Credit Hours:** 3

**Prerequisites:** MATH 1320, enrollment is restricted to Math Education majors

**MATH 4080: Calculus Connections**
Course topics include: sequences, series, functions, limits, continuity, differentiation, optimization, curve sketching, antidifferentiation, areas of plane regions, lengths of plane curves, areas of surfaces of revolution, and volumes of solids.

**Credit Hours:** 3

**Prerequisites:** MATH 1160, enrollment is restricted to Math Education majors

**MATH 4100: Differential Equations**
Traditional introductory course in ordinary differential equations. Includes 1st and 2nd order linear differential equations with numerous applications; Laplace transforms; power series solutions; numerical methods, linear systems.

**Credit Hours:** 3

**Prerequisites:** Grade of C- or above in MATH 2300

**MATH 4110: Advanced Calculus With Applications**
Linear mappings, Jacobian matrices and determinants, change of variables, vector fields, line and surface integrals, theorems of Green, Gauss and
Stokes, sequences and series of functions, uniform convergence, special functions.

Credit Hours: 3
Prerequisites: MATH 2300

MATH 4120: Combinatorics
Study of a variety of topics from combinatorial mathematics, especially graph theory and enumerative combinatorics. Topics include graph coloring, matchings and coverings, generating functions, recurrence relations, Polya's Enumeration Theorem, introduction to Ramsey theory.

Credit Hours: 3
Prerequisites: MATH 2320, or instructor's consent

MATH 4140: Matrix Theory
Basic properties of matrices, determinants, vector spaces, linear transformations, eigenvalues, eigenvectors, and Jordan normal forms. Introduction to writing proofs.

Credit Hours: 3
Prerequisites: Grade of C- or better in MATH 2300 or MATH 2320. Writing intensive sections require ENGLSH 1000

MATH 4140W: Matrix Theory - Writing Intensive
Basic properties of matrices, determinants, vector spaces, linear transformations, eigenvalues, eigenvectors, and Jordan normal forms. Introduction to writing proofs.

Credit Hours: 3
Prerequisites: Grade of C- or better in MATH 2300 or MATH 2320. Writing intensive sections require ENGLSH 1000

MATH 4150: History of Mathematics
This is a history course with mathematics as its subject. Includes topics in the history of mathematics from early civilizations onwards. The growth of mathematics, both as an abstract discipline and as a subject which interacts with others and with practical concerns, is explored. Prerequisites or Corequisite: MATH 2300 or MATH 2340. Writing intensive sections require ENGLSH 1000.

Credit Hours: 3

MATH 4150W: History of Mathematics - Writing Intensive
This is a history course with mathematics as its subject. Includes topics in the history of mathematics from early civilizations onwards. The growth of mathematics, both as an abstract discipline and as a subject which interacts with others and with practical concerns, is explored. Prerequisites or Corequisite: MATH 2300 or MATH 2340. Writing intensive sections require ENGLSH 1000.

Credit Hours: 3

MATH 4300: Numerical Analysis
Machine arithmetic, approximation and interpolation, numerical differentiation and integration, nonlinear equations, linear systems, differential equations, error analysis. Selected algorithms will be programmed for solution on computers.

Credit Hours: 3
Prerequisites: Grade of C- or better in MATH 2300 and MATH 4100

MATH 4310: Numerical Linear Algebra
Solution of linear systems of equations by direct and iterative methods. Calculation of eigenvalues and eigenvectors of matrices. Selected algorithms programmed for solution on computers.

Credit Hours: 3
Prerequisites: MATH 2300 and familiarity with software such as Mathematica, MatLab, Maple, etc

MATH 4315: Introduction to Mathematical Statistics
(same as STAT 4710). Introduction to theory of probability and statistics using concepts and methods of calculus.

Credit Hours: 3
Prerequisites: MATH 2300 or instructor's consent

MATH 4320: Introduction to Probability Theory
(same as STAT 4750). Probability spaces; random variables and their distributions; repeated trials; probability limit theorems.

Credit Hours: 3
Prerequisites: MATH 2300 or instructor's consent

MATH 4325: Linear Programming

Credit Hours: 3
Prerequisites: MATH 4140 or instructor's consent

MATH 4330: Theory of Numbers
Divisibility, factorization, arithmetic functions, means value theorems, distribution of prime numbers, congruences, primitive roots, character theory, Riemann zeta function, and Dirichlet L-functions.

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 2300. Recommended MATH 2320

MATH 4335: College Geometry
Euclidean geometry from an advanced viewpoint. Synthetic and coordinate methods will be used. The Euclidean group of transformations will be studied.

Credit Hours: 3
Prerequisites: MATH 2300

MATH 4340: Projective Geometry
Basic ideas and methods of projective geometry built around the concept of geometry as the study of invariants of a group. Extensive treatment of collineations.

Credit Hours: 3
Prerequisites: MATH 2300
MATH 4345: Foundations of Geometry
Coordination of affine, projective planes by means of various kinds of
algebraic structures: planar ternary rings, Veblen-Wedderburn systems,
divisions rings, skew fields, and fields.
Credit Hours: 3
Prerequisites: MATH 2300

MATH 4350: Introduction to Non-Euclidean Geometry
Account of rise, development of non-Euclidean geometries. Intensive
study of plane hyperbolic geometry.
Credit Hours: 3
Prerequisites: MATH 2300

MATH 4355: Introduction to Financial Derivatives and Options
(cross-leveled with MATH 7355). Long and short positions, forward
contracts, exchange traded index futures, European and American
call and put options, put-call parity, trading and hedging strategies,
synthetic transactions, arbitrage, currency options, fixed income portfolio
management, duration, convexity, interest rate and currency swaps, embedded options.
Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 2300 and either STAT 2500 or STAT 4710 or MATH 4315

MATH 4360: Actuarial Mathematics
(cross-leveled with MATH 7360). Basic actuarial methods, mathematical
population studies and models of population growth. Compound interest
and annuities certain. Values of endowment and annuities, calculation of
 premiums, surrender values. Stochastic models of populations growth.
Credit Hours: 3
Prerequisites: MATH 2300 and either STAT 2500 or STAT 4710 or MATH 4315

MATH 4370: Actuarial Modeling I
This course covers the concepts underlying the theory of interest and
their applications to valuation of various cash flows, annuities certain,
 bonds, and loan repayment. This course is designed to help students
prepare for Society of Actuaries exam FM (Financial Mathematics). It is
oriented towards problem solving techniques applied to real-life situations
and illustrated with previous exam problems.
Credit Hours: 3
Prerequisites: grade of C-or better in MATH 2300

MATH 4371: Actuarial Modeling II
(cross-leveled with MATH 7371). The goal of this course is to teach the
basic theory of life contingent actuarial models and the application of
those models to insurance and other financial risks. The topics covered
are part of the readings for the Society of Actuaries exam MLC (Models
for Life Contingencies) and are illustrated with past exam questions.
Credit Hours: 3
Prerequisites: MATH 4320 or STAT 4750, and MATH 4370

MATH 4400: Introduction to Topology
Topics from topology of Euclidean spaces, generalizations to metric
Credit Hours: 3
Prerequisites: MATH 2300

MATH 4500: Applied Analysis
Solution of the standard partial differential equations (wave, heat,
Laplace's eq.) by separation of variables and transform methods;
including eigenfunction expansions, Fourier and Laplace transform.
Boundary value problems, Sturm-Liouville theory, orthogonality, Fourier,
Bessel, and Legendre series, spherical harmonics.
Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 4100

MATH 4510: Higher Algebra
Introduction to rings, integral domains, fields, groups.
Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 2300 or MATH 2320

MATH 4520: Statistical Inference I
(same as STAT 4760). Sampling; point estimation; sampling distribution;
tests of hypotheses; regression and linear hypotheses.
Credit Hours: 3
Prerequisites: MATH 4320

MATH 4540: Mathematical Modeling I
Solution of problems from industry, physical, social and life sciences,
economics, and engineering using mathematical models.
Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 2300 and MATH 4100
Recommended: Familiarity with software such as MATHEMATICA,
MATLAB, or MAPLE

MATH 4560: Nonlinear Dynamics, Fractals and Chaos
Conceptual introduction to nonlinear dynamics, bifurcation and stability of
steady states, chaos in nonlinear differential equations and maps, fractal
dimension, strange attractors, and applications to physical science.
Credit Hours: 3
Prerequisites: MATH 4100 or MATH 7100, MATH 4140 or MATH 7140,
and familiarity with software such as MATHEMATICA, MATLAB, or
MAPLE

MATH 4570: Fluid Dynamics
Mathematical theory of fluid dynamics and applications. Prerequisites:
MATH 2300
Credit Hours: 3

MATH 4580: Mathematical Modeling II
Solution of problems from industry, physical, social and life sciences,
economics, and engineering using mathematical models. More general
classes of problems than in Mathematics 4540 will be considered.
Credit Hours: 3
Prerequisites: 3 semesters of calculus and some exposure to ordinary
differential equations or instructor's consent. MATH 4540 is not a
prerequisite
MATH 4590: Mathematics of Financial Derivatives
Binomial and Black-Scholes pricing models. Option Greeks, delta and gamma hedging, market maker profit theory. Asian, barrier, compound gap and exchange options. Lognormal and Monte Carlo price simulation. Geometric Brownian Motion and Ito's Lemma. Interest rate models and volatility. Recommended: MATH 4355

Credit Hours: 3
Prerequisites: MATH 2300 and either STAT 2500 or STAT 4710 or MATH 4315

MATH 4700: Advanced Calculus of One Real Variable I
(cross-leveled with MATH 7700). Basic topology of the real line, numerical sequences and series, continuity, differentiability, Riemann integration, uniform convergence, power series.

Credit Hours: 3
Prerequisites: Grade of C - or higher in MATH 3000

MATH 4720: Introduction to Abstract Algebra I
Basic properties of integers, fundamental theorem of arithmetic, introduction to groups, rings and fields.

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 3000

MATH 4800: Advanced Calculus for One Real Variable II
(cross-leveled with MATH 7800). Continuation of Advanced Calculus for functions of a single real variable. Topics include sequences and series of functions, power series and real analytic functions, Fourier series.

Credit Hours: 3
Prerequisites: MATH 4700 or MATH 7700 or permission of the instructor

MATH 4900: Advanced Multivariable Calculus
(cross-leveled with MATH 7900). This is a course in calculus in several variables. The following is core material: Basic topology of n-dimensional Euclidian space; limits and continuity of functions; the derivative as a linear transformation; Taylor's formula with remainder; the Inverse and Implicit Function Theorems, change of coordinates; integration (including transformation of integrals under changes of coordinates); Green's Theorem. Additional material from the calculus of several variables may be included, such as Lagrange multipliers, differential forms, etc.

Credit Hours: 3
Prerequisites: MATH 4700 or MATH 7700 or permission of the instructor

MATH 4920: Introduction to Abstract Linear Algebra
(cross-leveled with MATH 7920). Study of vector spaces over arbitrary fields: topics include linear maps on finite dimensional vector spaces, bilinear and multi-linear forms, invariant subspaces and canonical forms.

Credit Hours: 3
Prerequisites: Grade of C- or higher in MATH 4720

MATH 4940: Introduction to Complex Variables
Complex functions, contour integration, power series, residues and poles, conformal mapping.

Credit Hours: 3
Prerequisites: MATH 4110 or MATH 4700

MATH 4960: Special Readings in Mathematics
Credit Hour: 1-3
Prerequisites: Consent of Department required

MATH 4970: Senior Seminar in Mathematics
Seminar with student presentations, written projects, and problem solving. May be used for the capstone requirement.

Credit Hours: 3

MATH 4980: Mathematics Problem Solving
Creative advanced problem solving bringing together methods such as integration, probability and Euclidean geometry.

Credit Hours: 3
Prerequisites: MATH 4140 and another 4000 level Mathematics course, or instructor's consent

MATH 4996: Honors in Mathematics
Special work for senior B.A. Honors and B.S. Honors candidates.

Credit Hours: 3
Prerequisites: Consent of Department required

MATH 7001: Topics in Mathematics-General
Organized study of selected topics. Subjects and earnable credit may vary from semester to semester.

Credit Hour: 1-99
Prerequisites: graduate standing and MATH 2300 and instructor's consent. Departmental consent for repetition

MATH 7060: Connecting Geometry to Middle and Secondary Schools
Euclidian foundations, basic concepts of symbolic logic, polyhedra, Euler Characteristic, congruence, area, Picks Theorem, volume, Cavalier's Principles, surface area, similarity, reflections, translations, rotations, symmetry, vectors, general transformations, determinants, matrices, transformations using matrices, brief introduction to spherical geometry.

Credit Hours: 3
Prerequisites: MATH 1360 or MATH 1500, enrollment is restricted to Math Education majors

MATH 7070: Connecting Algebra to Middle and Secondary Schools
A detailed study of integer and rational arithmetic and algebra. Topics include: Bionomial Theorem, induction, division algorithm, Euclid's Algorithm, Fundamental Theorem of Arithmetic, Pythagorian triples, modular arithmetic and generalizations to polynomials, matrices and other axiomatic structures. Prerequisites: MATH 1320, enrollment is restricted to Math Education majors

Credit Hours: 3

MATH 7080: Connect Calculus to Middle and Secondary Schools
Course topics include: sequences, series functions, limits, continuity, differentiation, optimization, curve sketching, antidifferentiation, area of
plane regions, lengths of plane curves, areas of surfaces of revolution, and volumes of solids.

**Credit Hours:** 3  
**Prerequisites:** MATH 1160, enrollment is restricted to Math Education majors

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**MATH 7100: Differential Equations**  
Traditional introductory course in ordinary differential equations. Includes 1st and 2nd order linear differential equations with numerous applications; Laplace transforms; power series solutions; numerical methods, linear systems.

**Credit Hours:** 3  
**Prerequisites:** graduate standing and MATH 2300

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**MATH 7110: Advanced Calculus With Applications**  
Linear mappings, Jacobian matrices and determinants, change of variables, vector fields, line and surface integrals, theorems of Green, Gauss and Stokes, sequences and series of functions, uniform convergence, special functions.

**Credit Hours:** 3  
**Prerequisites:** graduate standing and MATH 2300

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**MATH 7140: Matrix Theory**  
Basic properties of matrices, determinants, vector spaces, linear transformations, eigenvalues, eigenvectors, and Jordan normal forms. Introduction to writing proofs.

**Credit Hours:** 3  
**Prerequisites:** graduate standing and one of MATH 2300, MATH 2320, MATH 2120 or MATH 2340

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**MATH 7150: History of Mathematics**  
This is a history course with mathematics as its subject. Includes topics in the history of mathematics from early civilizations onwards. The growth of mathematics, both as an abstract discipline and as a subject which interacts with others and with practical concerns, is explored. Pre- or Co-requisite: MATH 2300 or MATH 2340 and graduate standing.

**Credit Hours:** 3  
**Prerequisites:** graduate standing and one of MATH 2300, MATH 2320, MATH 2120 or MATH 2340

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**MATH 7300: Numerical Analysis**  
Machine arithmetic, approximation and interpolation, numerical differentiation and integration, nonlinear equations, linear systems, differential equations, error analysis. Selected algorithms will be programmed for solution on computers.

**Credit Hours:** 3  
**Prerequisites:** graduate standing and MATH 2300 and MATH 4100 or equivalent

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**MATH 7310: Numerical Linear Algebra**  
Solution of linear systems of equations by direct and iterative methods. Calculation of eigenvalues and eigenvectors of matrices. Selected algorithms programmed for solution on computers.

**Credit Hours:** 3  
**Prerequisites:** MATH 2300 and prior experience writing programs in Mathematica and/or in a computer language such as Fortran, Pascal, or C

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**MATH 7315: Introduction to Mathematical Statistics**  
(same as STAT 7710). Introduction to theory of probability and statistics using concepts and methods of calculus.

**Credit Hours:** 3  
**Prerequisites:** graduate standing and MATH 2300 or instructor's consent

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**MATH 7330: Theory of Numbers**  
Divisibility, factorization, arithmetic functions, means value theorems, distribution of prime numbers, congruences, primitive roots, character theory, Riemann zeta function, and Dirichlet L-functions.

**Credit Hours:** 3  
**Prerequisites:** MATH 2300; recommended MATH 2320 or MATH 2340, and MATH 4940 or MATH 7940

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**MATH 7335: College Geometry**  
Euclidean geometry from an advanced viewpoint. Synthetic and coordinate methods will be used. The Euclidean group of transformations will be studied.

**Credit Hours:** 3  
**Prerequisites:** graduate standing and MATH 2300

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**MATH 7340: Projective Geometry**  
Basic ideas and methods of projective geometry built around the concept of geometry as the study of invariants of a group. Extensive treatment of collineations.

**Credit Hours:** 3  
**Prerequisites:** MATH 2300

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**MATH 7345: Foundations of Geometry**  
Coordination of affine, projective planes by means of various kinds of algebraic structures: planar ternary rings, Veblen-Wedderburn systems, division rings, skew fields, and fields.

**Credit Hours:** 3  
**Prerequisites:** MATH 2300

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**MATH 7350: Introduction to Non-Euclidean Geometry**  
Account of rise, development of non-Euclidean geometries. Intensive study of plane hyperbolic geometry.

**Credit Hours:** 3  
**Prerequisites:** MATH 2300

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**MATH 7355: Introduction to Financial Derivatives and Options**  
(cross-leveled with MATH 4355). Long and short positions, forward contracts, exchange traded index futures, European and American call and put options, put-call parity, trading and hedging strategies, synthetic transactions, arbitrage, currency options, fixed income portfolio
management, duration, convexity, interest rate and currency swaps, embedded options.

**Credit Hours:** 3  
**Prerequisites:** MATH 2300 and STAT 2500 or STAT 4710/ MATH 4315, or instructor's consent

**MATH 7360: Actuarial Mathematics**  
(cross-leveled with MATH 4360). Basic actuarial methods, mathematical population studies and models of population growth. Compound interest and annuities certain. Values of endowment and annuities, calculation of premiums, surrender values. Stochastic models of populations growth.

**Credit Hours:** 3  
**Prerequisites:** MATH 2300 and either STAT 2500 or STAT 4710/ MATH 4315, or instructor's consent

**MATH 7370: Actuarial Modeling I**  
This course covers the main probability tools applied to financial risk modeling, and the financial mathematics concepts used in calculating present and accumulated values for various cash flows. It is a helpful tool in preparing for the Society of Actuaries exams P (Probability) and FM (Financial Mathematics), and it is oriented towards problem solving techniques illustrated with previous exam problems. Students are encouraged to take MATH 4355 prior to this course.

**Credit Hours:** 3  
**Prerequisites:** MATH 2300, MATH 4320/ STAT 4750

**MATH 7371: Actuarial Modeling II**  
(cross-leveled with MATH 4371). The goal of this course is to teach the basic theory of life contingent actuarial models and the application of those models to insurance and other financial risks. The topics covered are part of the readings for the Society of Actuaries exam MLC (Models for Life Contingencies) and are illustrated with past exam questions.

**Credit Hours:** 3  
**Prerequisites:** MATH 4320 or STAT 4750, and MATH 4370

**MATH 7400: Introduction to Topology**  
Topics from topology of Euclidean spaces, generalizations to metric spaces and topological spaces. Fundamentals of point set topology.

**Credit Hours:** 3  
**Prerequisites:** MATH 2300

**MATH 7500: Applied Analysis**  
Solution of the standard partial differential equations (wave, heat, Laplace's eq.) by separation of variables and transform methods; including eigenfunction expansions, Fourier and Laplace transform. Boundary value problems, Sturm-Liouville theory, orthogonality, Fourier, Bessel, and Legendre series, spherical harmonics.

**Credit Hours:** 3  
**Prerequisites:** MATH 4100/ MATH 7100

**MATH 7510: Higher Algebra**  
Introduction to rings, integral domains, fields, groups.

**Credit Hours:** 3  
**Prerequisites:** MATH 2300 OR MATH 2320

**MATH 7520: Statistical Inference I**  
(same as STAT 7760). Sampling; point estimation; sampling distribution; tests of hypotheses; regression and linear hypotheses.

**Credit Hours:** 3  
**Prerequisites:** MATH 4320/ MATH 7320

**MATH 7540: Mathematical Modeling I**  
Solution of problems from industry, physical, social and life sciences, economics, and engineering using mathematical models.

**Credit Hours:** 3  
**Prerequisites:** graduate standing and 3 semesters of calculus and some exposure to ordinary differential equations or instructor's consent

**MATH 7560: Nonlinear Dynamics, Chaos and Fractals**  
Conceptual introduction to nonlinear dynamics, bifurcation and stability of steady states, chaos in nonlinear differential equations and maps, fractal dimension, strange attractors, and applications to physical science.

**Credit Hours:** 3  
**Prerequisites:** graduate standing and MATH 4100/ MATH 7100, MATH 4140/ MATH 7140, and familiarity with software such as MATHEMATICA, MATLAB, or MAPLE

**MATH 7570: Fluid Dynamics and Geophysical Applications**  
Mathematical theory of fluid dynamics and applications to meteorology and oceanography.

**Credit Hours:** 3  
**Prerequisites:** MATH 2300 and instructor's consent

**MATH 7580: Mathematical Modeling II**  
Solution of problems from industry, physical, social and life sciences, economics, and engineering using mathematical models. More general classes of problems than in MATH 7540 will be considered.

**Credit Hours:** 3  
**Prerequisites:** 3 semesters of calculus and some exposure to ordinary differential equations or instructor's consent. MATH 7540 is not a prerequisite

**MATH 7590: Mathematics of Financial Derivatives**  

**Credit Hours:** 3  
**Prerequisites:** MATH 2300 and either STAT 2500 or STAT 4710 or MATH 4315  
**Recommended:** MATH 4355

**MATH 7620: Differential Geometry I**  
Metric properties of restricted portions of curves and surfaces in three-dimensional Euclidean space.

**Credit Hours:** 3  
**Prerequisites:** MATH 2300

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**MATH 7502: Statistical Inference II**  
(same as STAT 7770). Multivariate normal distribution; hypothesis testing in the multivariate normal; confidence regions and hypothesis testing for linear models; analysis of variance, experimental design, and categorical data.

**Credit Hours:** 3  
**Prerequisites:** MATH 7520

**MATH 7512: Modern Algebra II**  
Rings and fields, Galois theory, modules and vector spaces, multilinear algebra, homological algebra, universal algebra.

**Credit Hours:** 3  
**Prerequisites:** MATH 7510

**MATH 7522: Real Analysis II**  
Differentiation, integration, sequences and series of functions, measure theory, sequences of measures, convolution, epsilon-delta calculus, uniform convergence.

**Credit Hours:** 3  
**Prerequisites:** MATH 7500
MATH 7700: Advanced Calculus of One Real Variable I
(cross-leveled with MATH 4700). Series of real numbers, limits of functions, continuity and uniform continuity, differentiability, and Riemann integration.

Credit Hours: 3  
Prerequisites: MATH 2300  
Recommended: MATH 4140 and one other mathematics course number above MATH 2300

MATH 7720: Introduction to Abstract Algebra I
Basic properties of integers, fundamental theorem of arithmetic, introduction to groups, rings and fields.

Credit Hours: 3  
Prerequisites: MATH 2300  
Recommended: MATH 4140 and one other Mathematics course numbered above 2300

MATH 7800: Advanced Calculus of One Real Variable II
(cross-leveled with MATH 4800). Continuation of Advanced Calculus for functions of a single real variable. Topics include sequences and series of functions, power series and real analytic functions, Fourier series.

Credit Hours: 3  
Prerequisites: MATH 4700 or MATH 7700 or permission of the instructor

MATH 7900: Advanced Multivariable Calculus
(cross-leveled with MATH 4900). This is a course in calculus in several variables. The following is core material: Basic topology of n-dimensional Euclidian space; limits and continuity of functions; the derivative as a linear transformation; Taylor's formula with remainder; the Inverse and Implicit Function Theorems, change of coordinates; integration (including transformation of integrals under changes of coordinates); Green's Theorem. Additional material from the calculus of several variables may be included, such as Lagrange multipliers, differential forms, etc.

Credit Hours: 3  
Prerequisites: MATH 4700/ MATH 7700 or permission of the instructor

MATH 7920: Introduction to Abstract Linear Algebra
(cross-leveled with MATH 4920). Study of vector spaces over arbitrary fields: topics include linear maps on finite dimensional vector spaces, bilinear and multi-linear forms, invariant subspaces and canonical forms.

Credit Hours: 3  
Prerequisites: MATH 2300

MATH 7940: Introduction to Complex Variables
Complex functions, contour integration, power series, residues and poles, conformal mapping.

Credit Hours: 3  
Prerequisites: MATH 4110/ MATH 7110 OR MATH 4700/ MATH 7700

MATH 7960: Special Readings in Mathematics
Credit Hour: 1-3  
Prerequisites: MATH 2300 and instructor's consent

MATH 7970: Senior Seminar in Mathematics
Seminar with student presentations, written projects, and problem solving. May be used for the capstone requirement.

Credit Hours: 3  
Prerequisites: 12 hours of mathematics courses numbered 4000 or above

MATH 7980: Mathematics Problem Solving
Creative advanced problem solving bringing together methods such as integration, probability and Euclidean geometry.

Credit Hours: 3  
Prerequisites: MATH 4140 and another 4000 level Mathematics course, or instructor's consent

MATH 8085: Problems in Mathematics
Problems in Mathematics

Credit Hours: 3

MATH 8090: Master's Thesis Research in Mathematics
Students will be required to complete an independent project. Topics are chosen in consultation with a faculty advisor and are subject to departmental consent. Graded on S/U basis only.

Credit Hours: 3

MATH 8102: Topics in Algebra
Advanced topics in algebra.

Credit Hours: 3  
Prerequisites: MATH 8410

MATH 8190: Masters Project in Mathematics
Masters Project in Mathematics

Credit Hours: 3

MATH 8202: Topics in Functional Analysis
Topics in Functional Analysis

Credit Hours: 3

MATH 8210: Basic Algebra
Accelerated problem solving course in linear and abstract algebra. Will prepare students for the algebra qualifying exam.

Credit Hours: 3  
Prerequisites: MATH 4720, MATH 4920, or instructor's consent, or equivalent  
Corequisites: MATH 8220 and MATH 8250

MATH 8220: Basic Analysis
Accelerated problem-solving course in advanced calculus and complex analysis. Will prepare students for the analysis qualifying exam.

Credit Hours: 6  
Prerequisites: MATH 4700, MATH 4900, MATH 4940, instructor's consent or equivalent
MATH 8250: Basic Topology and Geometry
Credit Hours: 3
Prerequisites: MATH 4700, MATH 4900, MATH 4140, or instructor's consent, or equivalent
Corequisites: MATH 8210 and MATH 8220

MATH 8302: Topics in Harmonic Analysis
Topics in Harmonic Analysis
Credit Hours: 3

MATH 8402: Topics in Mathematical Physics
Topics in Mathematical Physics
Credit Hours: 3

MATH 8410: Algebra I
Theory of algebraic structures--groups, rings, fields, algebraic and transcendental extensions of fields.
Credit Hours: 3
Prerequisites: MATH 4720 and MATH 4920, or equivalent

MATH 8411: Algebra II
Theory of modules, Galois theory and additional topics to be selected by the instructor.
Credit Hours: 3
Prerequisites: MATH 8410 or equivalent

MATH 8420: Theory of Functions of Real Variables I
Properties of functions of one real variable. Lebesgue measure and integration on the line.
Credit Hours: 3
Prerequisites: MATH 4700 or MATH 7700 and MATH 4900 or MATH 7900, or equivalent

MATH 8421: Theory of Functions of Real Variables II
Continuation of MATH 8420. General measure and integration theory. Elements of the theory of Hilbert and Banach spaces, linear functions and linear operators.
Credit Hours: 3
Prerequisites: MATH 8410 or equivalent

MATH 8425: Complex Analysis I
Rigorous introduction to the theory of functions of a complex variable.
Credit Hours: 3
Prerequisites: MATH 4940 or MATH 7940 or equivalent

MATH 8426: Complex Analysis II
Analytic continuation, Riemann surfaces, entire and meromorphic functions, selected topics.
Credit Hours: 3
Prerequisites: MATH 8425

MATH 8430: Advanced Ordinary Differential Equations I
Topics from existence and uniqueness theorems, plane autonomous systems, periodicity and boundedness of solutions of second order nonlinear equations, perturbation theory, Sturm-Liouville systems, behavior of solutions at singularities.
Credit Hours: 3
Prerequisites: MATH 4700 or MATH 7700 or equivalent

MATH 8441: Advanced Ordinary Differential Equations II
Continuation of MATH 8440.
Credit Hours: 3

MATH 8442: Calculus of Variations I
Development of necessary conditions and sufficient conditions for nonparametric and parametric problems. Hamilton's principle, related topics.
Credit Hours: 3
Prerequisites: instructor's consent required

MATH 8445: Partial Differential Equations I
Fourier and integral transforms, first and second order partial differential equations, methods of characteristics, Laplace's equation, Dirichlet and Neumann problems, Green's functions and maximum principles.
Credit Hours: 3
Prerequisites: MATH 4700 or MATH 7700 or instructor's consent required
Recommended: MATH 8420

MATH 8446: Partial Differential Equations II
The Cauchy-Kovalevski theorem, the Lewy example, the heat operator, the wave operator, Sobolev spaces, local regularity of elliptic boundary value problems.
Credit Hours: 3
Prerequisites: MATH 8445

MATH 8450: Differential Geometry for Scientists and Engineers
Tensors and multilinear forms. Connections, covariant differentiation, geodesics and curvature on Riemannian and pseudo Riemannian manifolds. Applications to special relativity and general relativity.
Credit Hours: 3
Prerequisites: MATH 4110 and some knowledge of Matrix Theory

MATH 8460: Mathematical Finance I
Credit Hours: 3
Prerequisites: MATH 4110 and some knowledge of elementary probability or instructor's consent
MATH 8461: Mathematical Finance II
Credit Hours: 3
Prerequisites: knowledge of advance probability/stochastic processes or instructor's consent
Recommended: MATH 8460

MATH 8465: Mathematical Methods of Risk Theory
Credit Hours: 3
Prerequisites: knowledge of elementary probability or instructor's consent

MATH 8470: Advanced Numerical Analysis
Analysis and implementation of numerical algorithms selected from approximation theory, splines, quadrature, nonlinear systems, ordinary differential equations, and optimization.
Credit Hours: 3
Prerequisites: MATH 4700, MATH 4300 or equivalent, and MATH 4140

MATH 8480: Advanced Probability
(same as STAT 9810). Measure theoretic probability theory. Characteristic functions; conditional probability and expectation; sums of independent random variables including strong law of large numbers and central limit problem.
Credit Hours: 3
Prerequisites: MATH 4320 or MATH 8220; or instructor's consent

MATH 8502: Topics of Geometry
Topics of Geometry.
Credit Hours: 3
Prerequisites: instructor’s consent

MATH 8587: Topology Seminar
Topology Seminar
Credit Hours: 3

MATH 8602: Topics in Financial Mathematics and Insurance
Topics in Financial Mathematics and Insurance
Credit Hours: 3

MATH 8615: Algebraic Geometry I
Affine and projective varieties and schemes; nullstellensatz; Zariski topology, morphisms and rational maps; divisors and linear systems; topics from curves, surfaces, Grassmann varieties; commutative algebra and homological algebra as needed.
Credit Hours: 3
Prerequisites: MATH 8410

MATH 8616: Algebraic Geometry II
Continuation of MATH 8615.
Credit Hours: 3
Prerequisites: MATH 8615

MATH 8618: Introduction to Algebraic Topology
Development of singular homology theory; reference to other homology and cohomology theories. Introduction to homological algebra.
Credit Hours: 3
Prerequisites: MATH 8250

MATH 8628: Functional Analysis I
Linear topological spaces, Banach spaces, Hilbert spaces. Operator theory, including the Hahn-Banach, uniform boundedness and closed graph theorems.
Credit Hours: 3
Prerequisites: MATH 4900 and instructor's consent or MATH 8420

MATH 8629: Functional Analysis II
Topological vector spaces, duality theory, Banach algebras.
Credit Hours: 3
Prerequisites: MATH 8628

MATH 8630: Harmonic Analysis I
An introduction to Fourier Analysis in one and higher Dimensions. Topics include Fourier Series, conjugate functions, Fourier transforms, distributions, interpolation, and maximal functions.
Credit Hours: 3
Prerequisites: MATH 8420

MATH 8631: Harmonic Analysis II
Singular integrals, Littlewood-Paley theory, Hardy spaces, bounded mean oscillation, weighted norm inequalities, boundary value problems, and analysis on groups.
Credit Hours: 3
Prerequisites: MATH 8630

MATH 8642: Nonlinear Differential Equations
Existence theorems; criteria for periodic solutions; boundedness of solutions; perturbation theory. Emphasizes second order equations.
Credit Hours: 3
Prerequisites: MATH 4100 and MATH 4110 or MATH 4700

MATH 8648: Advanced Mathematics for the Physical Sciences
MATH 8650: Differentiable Manifolds and Riemannian Geometry
Tensor product spaces and tensor fields on manifolds. Differentiation and integration of differential forms. Riemannian geometry and applications.
Credit Hours: 3
Prerequisites: MATH 4700, PHYSCS 8660

MATH 8655: General Topology I
Credit Hours: 3
Prerequisites: MATH 4900, MATH 4400 or instructor's consent

MATH 8680: Stochastic Processes
(same as STAT 9820). Markov processes, martingales, orthogonal sequences, processes with independent and orthogonal increments, stationary, linear prediction.
Credit Hours: 3
Prerequisites: MATH 8480

MATH 8702: Topics in Applied Mathematics
Selected topics in applied mathematics drawn from variety of areas: partial differential equations, tensor analysis, calculus of variations, asymptotic methods, integral equations, advanced theory of transforms and distributions, numerical analysis.
Credit Hours: 3

MATH 8787: Numerical Mathematics Seminar
Numerical Mathematics Seminar
Credit Hours: 3

MATH 9090: Doctoral Dissertation Research in Mathematics
Doctoral Dissertation Research in Mathematics. Graded on a S/U basis only.
Credit Hour: 1-9

MATH 9187: Algebra Seminar
Algebra Seminar
Credit Hours: 3

MATH 9287: Functional Analysis Seminar
Functional Analysis Seminar
Credit Hours: 3

MATH 9387: Harmonic Analysis Seminar
Harmonic Analysis Seminar
Credit Hours: 3

MATH 9487: Mathematical Physics Seminar
Mathematical Physics Seminar
Credit Hours: 3

MATH 9502: Topics in Topology
Advanced topics in topology or topological algebra.
Credit Hours: 3

MATH 9587: Geometry Seminar
Geometry Seminar
Credit Hours: 3

MATH 9687: Financial Mathematics Seminar
Financial Mathematics Seminar
Credit Hours: 3

MATH 9702: Topics in Numerical Mathematics
Topics in Numerical Mathematics.
Credit Hours: 3
Prerequisites: instructor's consent

MATH 9787: Applied Mathematics Seminar
Applied Mathematics Seminar
Credit Hours: 3

MATH 9887: Analysis Seminar
Analysis Seminar
Credit Hours: 3