MATH 5301 Elementary Analysis I (3 semester credit hours) Real numbers, differentiation, integration, metric spaces, basic point set topology, power series, analytic functions, Cauchy's theorem. Prerequisite: One year of calculus through multivariate calculus or instructor consent required. (3-0) Y (2016-02-05 23:35:16)

MATH 5302 Elementary Analysis II (3 semester credit hours) Continuation of MATH 5301. Prerequisite: MATH 5301. (3-0) Y (2016-02-05 23:35:16)

MATH 5304 Applied Mathematical Analysis for Non-Majors (3 semester credit hours) Techniques of mathematical analysis applicable to social, behavioral and management sciences. Differential and integral calculus of one and many variables. May not be used to fulfill degree requirements. Prerequisite: College algebra or instructor consent required. (3-1) S (2016-02-05 23:35:16)

MATH 5305 Higher Geometry for Teachers (3 semester credit hours) Topics in modern Euclidean geometry including distinguished points of a triangle, circles including the nine-point circle, cross ratio, transformations; introduction to projective geometry. May not be used to fulfill degree requirements for mathematical sciences majors except those in the Master of Arts in Teaching (MAT) program. Prerequisite: Junior-level mathematics course. (3-0) T (2016-02-05 23:35:16)

MATH 5306 Non-Euclidean Geometry for Teachers (3 semester credit hours) The relations among elliptic, Euclidean and hyperbolic geometries. Euclidean models of elliptic and hyperbolic geometries. May not be used to fulfill degree requirements for mathematical sciences majors except those in the Master of Arts in Teaching (MAT) program. Prerequisite: Junior-level mathematics course. (3-0) T (2016-02-05 23:35:16)

MATH 5313 Modern Algebra for Teachers (3 semester credit hours) Study of modern algebra involving groups, rings, fields and Galois Theory. May not be used to fulfill degree requirements for mathematical sciences majors except those in the Master of Arts in Teaching (MAT) program. Prerequisite: Junior-level mathematics course. (3-0) R (2016-02-05 23:35:16)

MATH 5390 Topics in Mathematics - Level 5 (3 semester credit hours) May be repeated for credit as topics vary. Instructor consent required. (3-0) R (2016-02-05 23:35:16)

MATH 6301 Real Analysis (3 semester credit hours) Lebesgue measure in finite-dimensional spaces, abstract measures, measurable functions, convergence a.e., Egorov's Theorem, convergence in measure, Lebesgue integral, Lebesgue's bounded convergence theorem, Levi's monotone convergence theorem, Fatou's Lemma, Fubini's theorem, Lp-spaces. Prerequisite: MATH 5302. (3-0) Y (2016-02-05 23:35:16)

MATH 6302 Functional Analysis I (3 semester credit hours) Banach and Hilbert spaces, classical theorems of functional analysis, compact operators, Fredholm operators, elements of spectral theory, introduction to unbounded operators. Prerequisite: MATH 6301. (3-0) Y (2016-02-05 23:35:16)

MATH 6303 Theory of Complex Functions I (3 semester credit hours) Complex integration, Cauchy's theorem, calculus of residues, power series, entire functions, Riemann mapping theorems, Riemann surfaces, conformal mapping with applications. Prerequisites: MATH 5301 and MATH 5302 or instructor consent required. (3-0) Y (2016-02-05 23:35:16)
MATH 6304 Theory of Complex Functions II (3 semester credit hours) Riemann surfaces, meromorphic and holomorphic functions and differentials, the normalization theorem, the Riemann-Roch theorem, Abel theorem, applications to nonlinear equations. Prerequisite: MATH 6303. (3-0) T (2016-02-05 23:35:16)

MATH 6305 Mathematics of Signal Processing (3 semester credit hours) The course is devoted to a mathematical foundation of some of the key topics in signal processing: discrete and continuous signal transforms, least squares methods and adaptive filtering, compressed sensing and related topics. Prerequisites: Linear algebra and calculus through multivariate calculus or instructor consent required. (3-0) T (2016-02-05 23:35:16)

MATH 6307 Wavelets and Their Applications (3 semester credit hours) An introduction to windowed Fourier and continuous wavelet transforms, generalized frames, discrete wavelet frames, multiresolution analysis, Daubechies' orthogonal wavelet bases, and their applications in partial differential equations and signal processing. Prerequisites: Two semesters of calculus and differential equations or instructor consent required. (3-0) T (2016-02-05 23:35:16)

MATH 6308 Inverse Problems and Applications (3 semester credit hours) Exact and approximate methods of nondestructive inference, such as tomography and inverse scattering theory in one and several dimensions, with applications in physical and biomedical sciences and engineering. Prerequisites: Two semesters of calculus and differential equations or instructor consent required. (3-0) T (2016-02-05 23:35:16)

MATH 6309 Differential Geometry (3 semester credit hours) Smooth manifolds, tangent bundles, smooth partitions of unity, submanifolds, Sard's theorem, transversality, embeddings, Whitney theorem, differential forms, Frobenius Theorem, de Rham cohomology, degree theory on manifolds, Riemannian metric, Gauss-Bonnet theorem. Prerequisite: MATH 5301 or instructor consent required. (3-0) T (2016-02-05 23:35:16)

MATH 6310 Topology (3 semester credit hours) Metric spaces, introduction to topology, elements of homotopy theory, covering spaces, fundamental group, homotopy groups, fibrations, simplicial complexes and CW-complexes, degree theory. Prerequisite: MATH 5301 or instructor consent required. (3-0) Y (2016-02-05 23:35:16)

MATH 6311 Abstract Algebra I (3 semester credit hours) Basic properties of groups, rings, fields, and modules. Prerequisite: Two semesters of undergraduate abstract algebra or instructor consent required. (3-0) Y (2016-02-05 23:35:16)

MATH 6312 Combinatorics and Graph Theory (3 semester credit hours) This course covers theory and applications of combinatorics and graphs, topics from basic counting principles, principle of inclusion and exclusion, permutation statistics, ordinary and exponential generating functions, composition of integers, integer partitions, Stirling numbers of the first kind, q-analogs of binomial and multinomial coefficients, Euler's formula, Hamilton paths, planar graphs, chromatic and Tutte polynomials and algorithms on networks. Prerequisites: Theoretical Concepts of Calculus and Abstract Algebra I is required or instructor consent required. (3-0) T (2016-02-05 23:35:16)

MATH 6313 Numerical Analysis (3 semester credit hours) A study of numerical methods including the numerical solution of non-linear equations, interpolation, approximation by polynomials, numerical integration. Numerical solution of ordinary differential equations including initial value problems and two-point boundary value problems. Prerequisites: Knowledge of a high-level programming language and
linear algebra and calculus through multivariable calculus and department consent required. (3-0) Y (2016-02-05 23:35:16)

**MATH 6314** Algebraic Topology (3 semester credit hours) This course covers basics in algebraic topology. Topics will include simplicial and singular homology groups, cellular homology groups, exact sequences and excision, chain maps, Mayer-Vietoris sequences, homology with coefficients, Eilenberg-Steenrod axioms; cohomology theory, the universal coefficient theorem, cup products, Kunneth formulas, and Poincare duality. Prerequisites: Abstract Algebra I and Topology or equivalent is required or instructor consent required. (3-0) T (2016-02-05 23:35:16)

**MATH 6315** Ordinary Differential Equations (3 semester credit hours) The study of ordinary differential equations with emphasis on existence, uniqueness, linear systems, boundary value problems, and stability. Prerequisites: Linear algebra and differential equations and **MATH 5302** or instructor consent required. (3-0) Y (2016-02-05 23:35:16)

**MATH 6316** Differential Equations (3 semester credit hours) Continuation of **MATH 6315** and an introduction to partial differential equations. Prerequisite: **MATH 6315**. (3-0) T (2016-02-05 23:35:16)

**MATH 6318** Numerical Analysis of Differential Equations (3 semester credit hours) Practical and theoretical aspects of numerical methods for partial differential equations are discussed. Topics selected from: finite difference, finite element and boundary element approximations for partial differential equations. Application of methods will be illustrated using MATLAB. Prerequisite: **MATH 6313** or equivalent. (3-0) T (2016-02-05 23:35:16)

**MATH 6319** Principles and Techniques in Applied Mathematics I (3 semester credit hours) Mathematical methods usually used in applied sciences and engineering. Topics chosen from advanced linear algebra; Hilbert spaces; positivity; quaternions; integral equations; Fourier analysis; distributions; convexity; asymptotic methods; special functions. Prerequisites: Linear algebra and differential equations or instructor consent required. (3-0) T (2016-02-05 23:35:16)

**MATH 6320** Principles and Techniques in Applied Mathematics II (3 semester credit hours) Continuation of Math 6319. Prerequisite: **MATH 6319**. (3-0) T (2016-02-05 23:35:16)

**MATH 6321** Optimization (3 semester credit hours) Introduction to theoretical and practical concepts of optimization in finite and infinite dimensional setting, least-squares estimation, optimization of functionals, local and global theory of constrained optimization, iterative methods. Prerequisites: Linear algebra or instructor consent required. (3-0) T (2016-02-05 23:35:16)

**MATH 6324** Applied Dynamical Systems I (3 semester credit hours) Topics from the theory of discrete time dynamical systems including symbolic dynamics, chaos, box counting dimension and fractals, bifurcations, period doubling route to chaos, Sharkovsky’s theorem, Lyapunov exponents, maps of the circle and synchronization, area preserving maps, invariant curves, and strange attractors. Topics selected from the singularity theory and the theory of continuous time dynamical systems. Examples of models from ecology, epidemiology, economics, and engineering are presented. Prerequisite: **MATH 6301**. (3-0) T (2016-02-05 23:35:16)

**MATH 6325** Nonlinear Analysis I (3 semester credit hours) Topological degree in finite dimensions and applications to intermediate value theorem in dimension $n > 1$, Fundamental Theorem of Algebra, Argument Principle in Complex Analysis, Brouwer fixed point theorem, Poincare-Bendixson Theorem on periodic solutions to ODEs, Lyapunov stability of equilibrium, guiding function method, Leray-Schauder
degree, solvability of boundary value problems, and bifurcation theory. Prerequisite: MATH 6301. (3-0) T
(2016-02-05 23:35:16)

MATH 6331 Linear Systems and Signals (3 semester credit hours) Basic principles of systems and control
time: state space representations, stability, observability, controllability, realization theory, transfer
functions, feedback. Prerequisites: Linear algebra and differential equations or instructor consent
required. (3-0) T (2016-02-05 23:35:16)

MATH 6332 Advanced Control (3 semester credit hours) Theoretical and practical aspects of modern
control methodologies in state space and frequency domain, in particular LQG and H-infinity control;
coprime factorizations, internal stability, Kalman filter, optimal regulator, robust control, sensitivity
minimization, loop shaping, model reduction. Prerequisite: MATH 6331. (3-0) T (2016-02-05 23:35:16)

MATH 6336 Nonlinear Control Systems (3 semester credit hours) Differential geometric tools, input-output
maps, feedback linearization, nonlinear observers, input-output linearization, output tracking, and
regulation, passivity based control, control systems on Lie groups. Prerequisites: (MATH 6315 and MATH 6
331) or instructor consent required. (3-0) T (2016-02-05 23:35:16)

MATH 6339 Control of Distributed Parameter Systems (3 semester credit hours) Theoretical and technical
issues for control of distributed parameter systems in the context of linear infinite dimensional dynamical
systems. Evolution equations and control on Euclidean space, elements of functional analysis, semigroups
of linear operators, abstract evolution equations, control of linear infinite dimensional dynamical systems,
approximation techniques. Prerequisites: partial differential equations and MATH 5301 or instructor
consent required. (3-0) T (2016-02-05 23:35:16)

MATH 6340 Numerical Linear Algebra (3 semester credit hours) Topics include direct and iterative methods
for solving linear systems; vector and matrix norms; condition numbers; least squares problems;
orthogonalization, singular value decomposition; computation of eigenvalues and eigenvectors; conjugate
gradients; preconditioners for linear systems; computational cost of algorithms. Topics will be
supplemented with programming assignments. Prerequisites: Knowledge of a high-level programming
language and linear algebra and numerical analysis or instructor consent required. (3-0) Y (2016-02-05
23:35:16)

MATH 6341 Bioinformatics (3 semester credit hours) Fundamental mathematical and algorithmic theory
behind current bioinformatics techniques are covered and implemented. They include hidden Markov
models, dynamic programming, genetic algorithms, simulated annealing, neural networks, cluster analysis,
and information theory. Prerequisites: Knowledge of Unix and a high level programming language. (3-0) T
(2016-02-05 23:35:16)

MATH 6342 Scientific Computing (3 semester credit hours) Introduction to scientific computing through
projects in computational science and engineering. Topics include mathematical modeling; theoretical
analysis of such models; numerical and symbolic computation; verification and validation; computational
simulation. Representative projects will include applications of dynamical systems, Monte Carlo
simulations, numerical optimization, and linear and nonlinear partial differential equations. The course
includes an introduction to symbolic computation and to programming in MATLAB, Python, and/or C.
Some prior programming experience is recommended. Prerequisites: Prior courses in numerical analysis
and partial differential equations and MATH 6315 or instructor consent required. (3-0) T (2016-02-05
23:35:16)
MATH 6343  Computational Biology (3 semester credit hours) Mathematical and computation methods and techniques to analyze and understand problems in molecular biology are covered. Topics include sequence homology and alignment, genetic mapping, protein folding, and DNA computing. Prerequisite: A course in linear algebra or instructor consent required. (3-0) T (2016-02-05 23:35:16)

MATH 6345  Mathematical Methods in Medicine and Biology (3 semester credit hours) Introduction to the use of mathematical techniques in solving biologically important problems. Some examples of topics that might be covered are biochemical reactions, ion channels, cellular signaling mechanisms, kidney function, and nerve impulse propagation. Prerequisite: One year of calculus is required with differential equations recommended or instructor consent required. (3-0) T (2016-02-05 23:35:16)

MATH 6350  Quantum Computation and Information (3 semester credit hours) Quantum states, channels, measurements; entropy, subadditivity; entanglement measures, discord; teleportation, dense coding, quantum key distribution; Shor's algorithm, Grover's search algorithm, hidden subgroup algorithms. Prerequisite: Linear algebra or instructor consent required. (3-0) T (2016-02-05 23:35:16)

MATH 6364  Stochastic Calculus in Finance (3 semester credit hours) Brownian Motion, Ito Calculus, Feynman-Kac formula and an outline of Stochastic Control, Black Scholes Analysis, Transaction Costs, Optimal Portfolio Investment. Prerequisite: STAT 5351 or instructor consent required. (3-0) T (2016-02-05 23:35:16)

MATH 6390  Topics in Mathematics - Level 6 (3 semester credit hours) May be repeated for credit as topics vary. Instructor consent required. (3-0) R (2016-02-05 23:35:16)

MATH 6V81  Special Topics in Mathematics - Level 6 (1-9 semester credit hours) May be repeated for credit as topics vary. Instructor consent required. ([1-9]-0) S (2016-02-05 23:35:16)

MATH 6V98  Masters Thesis (3-9 semester credit hours) Pass/Fail only. May be repeated for credit. Instructor consent required. ([3-9]-0) S (2016-02-05 23:35:16)

MATH 7309  Knot Theory (3 semester credit hours) This course covers basics in combinatorial knot theory. Topics will include: ambient isotopy, basic invariants of knots and links in S3, polynomial invariants of knots and links, fundamental group of link complement, fundamental group of cyclic branched covers, Fox calculus, Alexander matrix, and categorification of polynomial invariants and their properties. Prerequisites: MATH 6310 and MATH 6311 or instructor consent required. (3-0) T (2016-02-05 23:35:16)


MATH 7314  Partial Differential Equations II (3 semester credit hours) Continuation of MATH 7313. Prerequisite: MATH 7313. (3-0) T (2016-02-05 23:35:16)

MATH 7316  Wave Propagation with Applications (3 semester credit hours) Study of the wave equation in one, two and three dimensions, the Helmholtz equation, associated Green's functions, asymptotic techniques for solving the propagation problems with applications in physical and biomedical sciences and engineering. Prerequisites: MATH 6303 and MATH 6318 or equivalent. (3-0) T (2016-02-05 23:35:16)
MATH 7319 Functional Analysis II (3 semester credit hours) Topological vector spaces, locally convex spaces, Frechet spaces, test function spaces and tempered distributions, Fourier transforms and applications to differential equations. Recommended Prerequisite: MATH 6303. Prerequisites: MATH 6301 and MATH 6302. (3-0) T (2016-02-05 23:35:16)

MATH 7325 Nonlinear Analysis II (3 semester credit hours) This course covers elements of the equivariant topology, Burnside ring and the related algebraic structures, Euler ring, equivariant degrees. This subject has applications to differential equations, symmetric Hopf bifurcation theory and critical point theory. Prerequisite: MATH 6325. (3-0) T (2016-02-05 23:35:16)

MATH 7329 Topological and Algebraic Methods in Nonlinear Differential Equations (3 semester credit hours) This course covers Polynomial homogeneous systems of ODEs, Poincare index, elliptic, hyperbolic and parabolic sectors, Bendixon formula, classification of plane quadratic systems, Riccati equation in non-associative commutative algebras, nilpotents and equilibria, idempotents and ray solutions, complex structures in algebras and bounded/periodic regimes, applications to Kasner equation, Euler equation and second order chemical reactions. Prerequisite: MATH 6315. (3-0) T (2016-02-05 23:35:16)

MATH 7361 Algebraic Geometry and Non-linear Equations (3 semester credit hours) This course covers Theta-functions of one variable, Analytic construction of the Jacobian of a compact Riemann surface, Related theta-functions, Algebraic construction of the hyperelliptic Jacobians, C. Neumann dynamical system, Characterization of the hyperelliptic period matrices, Soliton equations, The Riemann-Schottky problem and the Novikov conjecture. This subject has applications to Mechanics, Geometry, and Cryptography. Prerequisite: MATH 5301 or MATH 6301. (3-0) T (2016-02-05 23:35:16)

MATH 7390 Topics in Mathematics - Level 7 (3 semester credit hours) May be repeated for credit as topics vary. Instructor consent required. (3-0) R (2016-02-05 23:35:16)

MATH 8V02 Individual Instruction in Mathematics (1-6 semester credit hours) Pass/Fail only. May be repeated for credit as topics vary. Instructor consent required. ((1-6]-0) S (2016-02-05 23:35:16)

MATH 8V04 Topics in Mathematics - Level 8 (1-6 semester credit hours) Pass/Fail only. May be repeated for credit as topics vary. Instructor consent required. ((1-6]-0) R (2016-02-05 23:35:16)

MATH 8V07 Research (1-9 semester credit hours) Open to students with advanced standing subject to approval of the Graduate Advisor. Pass/Fail only. May be repeated for credit. Instructor consent required. ((1-9]-0) S (2016-02-05 23:35:16)

MATH 8V99 Dissertation (1-9 semester credit hours) Pass/Fail only. May be repeated for credit. Instructor consent required. Prerequisite: Open to PhD students only. ((1-9]-0) S (2016-02-05 23:35:16)