MATH 501. Applied & Interdisciplinary Mathematics Student Seminar
At least two 300 or above level math courses, and Graduate standing; Qualified undergraduates with permission of instructor only. (1). May be repeated for a maximum of 6 credits. Offered mandatory credit/no credit.

MATH 501 is an introductory and overview seminar course in the methods and applications of modern mathematics. The seminar has two key components: (1) participation in the Applied and Interdisciplinary Math Research Seminar; and (2) preparatory and post-seminar discussions based on these presentations. Topics vary by term.

MATH 506 / IOE 506. Stochastic Analysis for Finance
Graduate students or permission of instructor. (3). (BS). May not be repeated for credit.

The aim of this course is to teach the probabilistic techniques and concepts from the theory of stochastic processes required to understand the widely used financial models. In particular concepts such as martingales, stochastic integration/calculus, which are essential in computing the prices of derivative contracts, will be discussed. Pricing in complete/incomplete markets (in discrete/continuous time) will be the focus of this course as well as some exposition of the mathematical tools that will be used such as Brownian motion, Levy processes and Markov processes.

MATH 521. Life Contingencies II
MATH 520 with a grade of C- or higher. (Prerequisites enforced at registration.) (3). (BS). May not be repeated for credit.

This course extends the single decrement and single life ideas of MATH 520 to multi-decrement and multiple-life applications directly related to life insurance. The sequence 520-521 covers the Part 4A examination of the Casualty Actuarial Society and covers the syllabus of the Course 150 examination of the Society of Actuaries. Concepts and Calculation are emphasized over proof.

MATH 524. Loss Models II
STATS 426 and MATH 523. (Prerequisites enforced at registration.) (3). (BS). May not be repeated for credit.

Risk management and modeling of financial losses. Frequentist and Bayesian estimation of probability distributions, model selection, credibility, and other topics in casualty insurance.

MATH 525 / STATS 525. Probability Theory
MATH 451 (strongly recommended). MATH 425/STATS 425 would be helpful. (3). (BS). May not be repeated for credit.
MATH 526 / STATS 526. Discrete State Stochastic Processes
MATH 525 or STATS 525 or EECS 501. (3). (BS). May not be repeated for credit.

MATH 555. Introduction to Functions of a Complex Variable with Applications
MATH 451 or equivalent experience with abstract mathematics. (3). (BS). May not be repeated for credit.

Intended primarily for students of engineering and of other cognate subjects. Doctoral students in mathematics elect Mathematics 596. Complex numbers, continuity, derivative, conformal representation, integration, Cauchy theorems, power series, singularities, and applications to engineering and mathematical physics.

MATH 557. Applied Asymptotic Analysis
MATH 217, 419, or 420; MATH 451; and MATH 555. (3). (BS). May not be repeated for credit.

Topics include: asymptotic sequences and (divergent) series; asymptotic expansions of integrals and Laplace's method; methods of steepest descents and stationary phase; asymptotic evaluation of inverse Fourier and Laplace transforms; asymptotic solutions for linear (non-constant coefficient) differential equations; WBK expansions; singular perturbation theory; and boundary, initial, and internal layers.

MATH 563 / BIOINF 563. Advanced Mathematical Methods for the Biological Sciences
Graduate standing. (3). (BS). May not be repeated for credit.

This course focuses on discovering the way in which spatial variation influences the motion, dispersion, and persistence of species. Specific topics may include i) Models of Cell Motion: Diffusion, Convection, and Chemotaxis; ii) Transport Processes in Biology; iii) Biological Pattern Formation; and iv) Delay-differential Equations and Age-structured Models of Infectious Diseases.

MATH 566. Combinatorial Theory
MATH 465. (3). (BS). May not be repeated for credit.

MATH 567. Introduction to Coding Theory
One of MATH 217, 419, 420. (3). (BS). May not be repeated for credit.

Introduction to coding theory focusing on the mathematical background for error-correcting codes. Topic include: Shannon's Theorem and channel capacity; review of tools from linear algebra and an introduction to abstract algebra and finite fields; basic examples of codes such and Hamming, BCH, cyclic, Melas, Reed-Muller, and Reed-Solomon; introduction to decoding starting with syndrome decoding and covering weight enumerator polynomials and the Mac-Williams Sloane identity.

MATH 571. Numerical Linear Algebra
MATH 214, 217, 417, 419, or 420; and one of MATH 450, 451, or 454. (3). (BS). May not be repeated for credit.

Direct and iterative methods for solving systems of linear equations (Gaussian elimination, Cholesky decomposition, Jacobi and Gauss-Seidel iteration, SOR, introduction to multi-grid methods, steepest descent, conjugate gradients), introduction to discretization methods for elliptic partial differential equations, methods for computing eigenvalues and eigenvectors.

MATH 572. Numerical Methods for Differential Equations
MATH 214, 217, 417, 419, or 420; and one of MATH 450, 451, or 454. (3). (BS). May not be repeated for credit.


MATH 574. Financial Mathematics II
MATH 526 and MATH 573. (Prerequisites enforced at registration.) Although MATH 506 is not a prerequisite for MATH 574, it is strongly recommended that either these courses are taken in parallel, or MATH 506 precedes MATH 574. (3). (BS). May not be repeated for credit.

This is a core course for the quantitative finance and risk management masters program and is a sequel to Math 573. This course emphasizes the application of mathematical methods to the relevant problems of financial industry and focuses mainly on developing skills of model building.

MATH 575. Introduction to Theory of Numbers I
MATH 451 and 420 or permission of instructor. (1 - 3). (BS). May not be repeated for credit.

Topics covered include divisibility and prime numbers, congruences, quadratic reciprocity, quadratic forms, arithmetic functions, and Diophantine equations. Other topics may be covered as time permits or by request.
MATH 582. Introduction to Set Theory
MATH 412 or 451 or equivalent experience with abstract mathematics. (3). (BS). May not be repeated for credit.

The main topics covered are set algebra (union, intersection), relations and functions, orderings (partial, linear, well), the natural numbers, finite and denumerable sets, the Axiom of Choice, and ordinal and cardinal numbers.

MATH 583. Probabilistic and Interactive Proofs
MATH 412, 451 or permission of instructor. May not be repeated for credit.

Probabilistically-checkable proofs, zero-knowledge proofs, and other interactive proofs are studied and their computational and other advantages discussed. Appropriate background in mathematics and computer science is presented.

MATH 590. Introduction to Topology
MATH 451. (3). (BS). May not be repeated for credit. Rackham credit requires additional work.

Topics include metric spaces, topological spaces, continuous functions and homeomorphisms, separation axioms, quotient and product topology, compactness, and connectedness. We will also cover a bit of algebraic topology (e.g., fundamental groups) as time permits.

MATH 592. Introduction to Algebraic Topology
MATH 591. (3). (BS). May not be repeated for credit.

Fundamental group, covering spaces, simplicial complexes, graphs and trees, applications to group theory, singular and simplicial homology, Eilenberg-Steenrod axioms, Brouwer's and Lefschetz' fixedpoint theorems, and other topics.

MATH 594. Algebra II
MATH 593. (3). (BS). May not be repeated for credit.

Topics include group theory, permutation representations, simplicity of alternating groups for n>4, Sylow theorems, series in groups, solvable and nilpotent groups, Jordan-Holder Theorem for groups with operators, free groups and presentations, fields and field extensions, norm and trace, algebraic closure, Galois theory, and transcendence degree.

MATH 597. Analysis II
MATH 451 and 420; or MATH 395. (3). (BS). May not be repeated for credit.

Topics include: Lebesgue measure on the real line; measurable functions and integration on R; differentiation theory, fundamental theorem of calculus; function spaces, Lp (R), C(K), Holder and Minkowski inequalities, duality; general measure spaces, product measures, Fubini's Theorem; Radon-Nikodym Theorem, conditional expectation, signed measures, introduction to Fourier transforms.
MATH 605. Several Complex Variables  
MATH 596 and 597. Graduate standing. (3). (BS). May not be repeated for credit.

MATH 615. Commutative Algebra II  
MATH 614 or permission of instructor. Graduate standing. (3). (BS). May not be repeated for credit.

MATH 632. Algebraic Geometry II  
MATH 631 and Graduate standing. (3). (BS). May not be repeated for credit.

MATH 635. Differential Geometry  
Consent of instructor required. (3). (BS). May not be repeated for credit.

Second fundamental form, Hadamard manifolds, spaces of constant curvature, first and second variational formulas, Rauch comparison theorem, and other topics chosen by the instructor.

MATH 636. Topics in Differential Geometry  
MATH 635 and Graduate standing. (3). (BS). May not be repeated for credit.

MATH 650. Fourier Analysis  
MATH 596, 602, and Graduate standing. (3). (BS). May not be repeated for credit.

MATH 651. Topics in Applied Mathematics I  
MATH 451, 555 and one other 500-level course in analysis or differential equations. Graduate standing. (3). (BS). May be elected twice for credit.

Topics such as celestial mechanics, continuum mechanics, control theory, general relativity, nonlinear waves, optimization, statistical mechanics.

MATH 657. Nonlinear Partial Differential Equations  
MATH 656. (3). (BS). May not be repeated for credit.

MATH 669. Topics in Combinatorial Theory  
MATH 565, 566, or 664; and Graduate standing. (3). (BS). May not be repeated for credit.
MATH 679. Arithmetic of Elliptic Curves
MATH 594 and Graduate standing. (3). (BS). May be repeated for credit.

MATH 681. Mathematical Logic
Mathematical maturity appropriate for a 600-level MATH course. Graduate standing. (3). (BS). May not be repeated for credit.

MATH 697. Topics in Topology
Graduate standing. (2 - 3). (BS). May not be repeated for credit.

MATH 710. Topics in Modern Analysis II
MATH 597 and Graduate standing. (3). (BS). May not be repeated for credit.

MATH 732. Topics in Algebraic Geometry II
MATH 631 or 731. (3). (BS). May not be repeated for credit.

Course Description: The 19th century origins of this subject were concerned with varieties of m by n matrices of rank at most r. Since these varieties are usually defined by many more equations than their codimensions, computing even their degrees was a challenge. In the 20th century this was generalized to the loci where maps of vector bundles have restricted ranks; the classical formulas involve Chern classes of the bundles. Symmetric and skewsymmetric matrices and bundle maps were also studied. Finding formulas for these loci was one of the motivations for developing intersection theory in algebraic geometry. These loci are now understood as special cases of those one has for each element of a Weyl group in each type A, B, C, and D. Formulas for these loci are given by what are called Schubert polynomials, which have a rich combinatorial structure.

MATH 776. Topics in Algebraic Number Theory
MATH 676 and Graduate standing. (3). (BS). May be repeated for credit.
MATH 797. Advanced Topics in Topology
Graduate standing and permission of instructor. (3). (BS). May not be repeated for credit.

Course Description: In this course we focus on the geometric viewpoint on the study of groups. The basic idea here is that it is often easier to study a group by studying its geometric action on some space. Hyperbolic groups are those groups which act properly discontinuously and cocompactly (i.e. with compact quotient) on a space which "coarsely" has negative curvature. It is one of Gromov's fundamental discoveries that it suffices to work with a very naive notion of coarse negative curvature, e.g. that all geodesic triangles are "thin", and that one can still obtain powerful consequences, e.g. the solvability of the word problem for hyperbolic groups. Therefore, proofs of seemingly complicated result can be reduced to their simple essence and become quite accessible. Examples of hyperbolic groups include free groups, fundamental groups of surfaces of genus at least 2, and fundamental groups of negatively curved manifolds. Gromov's concise and elegant notion of coarse negative curvature has been tremendously influential in a wide swath of mathematics where geometric techniques or ideas are used. As time permits we will focus on various aspects of representations of hyperbolic groups into Lie groups in the later part of the semester. Possible topics include representations into PSL (2,C), i.e. the theory of hyperbolic 3-manifolds, and Anosov representations into higher rank Lie groups. The actual topics discussed will be chosen in consultation with the class.