Seminars and Advanced Graduate Courses offered by the Mathematics Department Spring, 1999

MA 598A	MA 598B	MA 598G	MA 598T
MA 611	MA 639	MA 648	MA 661	MA 673
MA 690A	MA 690B	MA 690C	MA 690D	MA 692A	MA 692B
MA 693A	MA 693B	MA 693C	MA 693D	MA 694A

Seminars

MA 598A: Using Algebraic Geometry

Instructor: Prof. A. Gabrielov , office: MATH 648, phone: 494-7911, agabriel@math.purdue.edu
Time: TTh 10:30-11:45
Prerequisite: Linear Algebra; **no previous knowledge of algebraic geometry is expected**.
Description: This graduate course, suitable also for advanced undergraduates, will introduce some basic ideas from Algebraic Geometry, emphasizing computational aspects and interactions with linear algebra and combinatorics.

We will cover roughly chapters 1-3 and 7 of the text: *Using Algebraic Geometry* by Cox, Little and O'Shea, with some preliminaries from *Ideals, Varieties, and Algorithms* by Cox, Little and O'Shea, and *Introduction to Groebner Bases* by Adams and Loustaunau.

Our principal subject will be solving systems of polynomial equations, both algebraically and geometrically. Two principal computational approaches are based on Groebner bases and resultants. For sparse systems solving, connection with polytopes and toric varieties will be discussed.

Some homework will use Maple, but no previous experience with Maple is required.

top

MA 598B: Mathematical Models of Earthquakes and Faulting

Instructor: Prof. A. Gabrielov , office: MATH 648, phone: 494-7911, agabriel@math.purdue.edu

Time: TTh 1:30-2:45
Description:

This course is an introduction to theory and models of rock fracture and earthquake sequences, with a view towards earthquake prediction.

No previous knowledge of seismology is required.

The program includes:

- Fracture mechanics: brittle fracture, stress corrosion
- Rock friction: experimental results and theoretical models
- Mechanics of Faulting; incompatibility in fault systems
- Mechanics of earthquakes; self-similarity in earthquake sequences
- Seismotectonic process as a nonlinear dynamical system
- Lattice models of seismicity and self-organized criticality
- Hierarchical models of seismicity and renormalization
- Earthquake prediction: theory and practice

We are going to follow loosely the text: *The Mechanics of Earthquakes and Faulting* by C.H. Scholz, with addition of earthquake-related chapters from: *Fractals and Chaos in Geology and Geophysics* by D.L. Turcotte

top

MA 598G: Advanced Probability and Financial Options
Instructor: Prof. P. Protter , office: MATH 602, protter@math.purdue.edu
Time: TTh 10:30-11:45
Prerequisite: Undergraduate probability theory (MA/STAT 519 or STAT 516), Ordinary Differential Equations (any of MA 360, 364, or 366), and Elementary Analysis (e.g. MA 440 or MA 504).
Description: We will develop financial models and study risky asset prices, admissible strategies, arbitrage, viable markets, contingent claims, and the pricing of European options. The mathematical tools used (and presented) will include stochastic processes, conditional expectation, martingales, stopping times, and equivalent martingale measures.

We will give an introduction to continuous models, and discuss Brownian motion, Ito integrals, and the Black Scholes model. An introduction to the term structure of interest rates completes the course.

Text: Martin Bexter and Andrew Rennie *Financial Calculus: an Introduction to Derivative Pricing,*

top

MA 598T: Toplogy for Undergraduates and Scientists
Instructor: Prof. D. Gottlieb , office: MATH 730, phone: 494-1951, gottlieb@math.purdue.edu
Time: TTh 10:30-11:45
Prerequisite: The ability to read carefully, and some Calculus (but only for some mathematical maturity). In a very real sense, Elementary Topology should be taught at the Freshman level. For those who can think carefully, or who can learn to think carefully, the topological viewpoint should make the following math courses much easier to learn.

Description: Topology is the study of continuity and connectivity. These two intuitive concepts were clarified and explored during the last one hundred years. The resulting subject of Topology is a system of concepts and relationships which underlies geometry and allows us to discuss with precision things like knots (as in Knot Theory), or twistings (as in Bundle Theory), or changes in form (as in singularity theory).

The scientists and engineers have been employing topological language more and more as a way to describe phenomina in their fields of study. And more and more of modern mathematics itself follows the topological paradigm. In many universities Topology is already being taught on the undergraduate level, resulting in students who learn to reason with words independently of much algebraic notation and who acquire sophisticated mathematical points of view which are aids in Analysis and Algebra.

For the economist, market equilibrium is discribed via fixed point theory; for the biologist, knot theory is used to study DNA; for the physicist, it is topology which is essential to the inevitabilities of Black Holes and to discriptions of phase changes and gauge theories; for the robotics engineer, topology can explain why robot arms must have anomolous motions; and the computer scientist might need to know topology to help in geometric modelling (the use of the word topology in describing computer networks however does not correspond to the subject matter of this course)

The Mathematics Department currently teaches Topology only as a graduate course for Mathematicians. Several engineering students and professors have attended these courses, but our obligation to rigorously instruct our mathematics students quickly drove these students away. It is our hope that this course can provide a less rigorous exposure to Topology for those scientists who come across topology in their fields.

top

MA 611: Methods of Applied Mathematics I
Instructor: Prof. A. SaBarreto , office: MATH OFFICE, phone: 494-1965, sabarre@math.purdue.edu
Time: TTh 3:00-4:15
Prerequisite: MA 511 or 554, 544, 525 or 530, and 520 or equivalent
Description: Banach and Hilbert spaces; linear operators; spectral theory of compact linear operators; applications to linear integral equations and to regular Sturm-Liouville problems for ordinary differential equations.

top

MA 639: Stochastic Processes II
Instructor: Prof. S. Lalley , office: MATH 504, phone: 494-6035, lalley@stat.purdue.edu
Time: TTh 12:00-1:15
Description: A continuation of MA 638.

top

MA 648: Linear Partial Differential Equations II
Instructor: Prof. N. Garofalo , office: MATH 616, phone: 494-1971, garofalo@math.purdue.edu
Time: TTh 1:30-2:45
Prerequisite: MA 678
Description: A continuation of MA 647.

top

MA 661: Modern Differential Geometry
Instructor: Prof. H. Donnelly , office: MATH 716, phone: 494-1944, hgd@math.purdue.edu
Time: MWF 3:30
Prerequisite: MA 544 and 554
Description: Differential manifolds, tangent vectors, vector fields and differential forms, tensor fields, DeRham's theorems, imbedding theorems, Riemannian geometry, curvatures, harmonic integrals.

top

MA 673: Algebraic Topology II
Instructor: Prof. J. Smith , office: MATH 720, phone: 494-7910, jhs@math.purdue.edu
Time: MWF 11:30
Description: This year, MA 673 will be a continuation of MA 572 which is the only prerequisite. We will study the cohomology of spaces and some of the many applications of cohomology to homotopy theory. We will develop the basics of homotopy theory as we go along. We will begin by defining the cup product in cohomology and the singular cohomology ring of a topological space. The first application will be Poincare duality of manifolds. Next we will define cohomology operations and the Steenrod algebra. One typical application is the proof that there are no nonsingular bilinear pairings R^nxR^n--> R^n unless *n* is a power of two. (In fact, *n* must be 1, 2, 4 or 8.) Next we will develop the algebric machinery of spectral sequences and work through the definition and the properties of fibrations so that we can construct the Serre spectral sequence of a fibration. Last we will look at some of the ways the Serre spectral sequence is used.

top

MA 690A: Topics in Algebraic Geometry
Instructor: Prof. S. Abhyankar , office: MATH 950, phone: 494-1933, ram@math.purdue.edu
Time: TTh 3:00-4:15
Description: This is a continuation of MA 665, Fall, 1998. We shall discuss various current areas of algebraic geometry

top

MA 690B: Algebraic Curves over Finite Fields
Instructor: Prof. D. Arapura , office: MATH 642, phone: 494-1983, dvb@math.purdue.edu
Time: TTh 12:00-1:15
Prerequisite: This course is intended to be an approximate sequel to Prof. Lipman's MA 663 class this Fall semester (Fall, 1998).
Description: The title pretty much says it all. The subject is, at least to my mind, a very pretty blend of algebraic geometry and number theory. One of the high points of this class will be the proof (by Bombieri-Stepanov) of Weil's estimate on the number of points of a smooth curve over a finite field, and its reinterpretion as an analogue of the Riemann hypothesis.
Text: C. Moreno, *Algebraic Curves over Finite Fields*

top

MA 690C: Class Field Theory

Instructor: Prof. J. Lipman , office: MATH 750, phone: 494-1994, lipman@math.purdue.edu
Time: MWF 10:30
Prerequisite: Some knowledge of Dedekind domains, such as Chapter 5 of Zariski-Samuel *Commutative Algebra*, vol. 1 (on reserve in the Math Library)
Description: Class field theory deals with the classification of abelian extensions of number fields, the behavior of prime ideals in passing through such extensions, and the codification of these and other arithmetic facts in various analytic (zeta- and L-) functions. The central result is Artin reciprocity, a vast generalization of the classical quadratic, cubic, etc. reciprocity theorems).

We will approach the theory via cohomology of groups, adeles, ... (all to be defined), roughly following books by Neukirch. It is hoped there will be time for applications such as those in Cox's book on "primes of the form x^2+ny^2"

top

MA 690D: Classification of Semisimple Algebraic Groups
Instructor: Prof. F. Shahidi , office: MATH 802, phone: 494-1917, shahidi@math.purdue.edu
Time: MWF 9:30
Prerequisite: Some elementary algebraic geometry
Description: We will use T. Satake's *Classification Theory of Semisimple Algebraic Groups*, Marcel Dekker, 1971, which is a beautiful book. The course will finish with some application to automorphic forms and number theory. When complemented with the course taught by Prof. Roche last spring on Linear Algebraic Groups (MA 690C, Spring, 1998), the student will have a solid background in the basics of these groups which are fundamental in the theory of automorphic forms and modern number theory.

top

MA 692A: Special Topics in Numerical Analysis
Instructor: Prof. J. Douglas , office: MATH 822, phone: 494-1927, douglas@math.purdue.edu
Time: TTh 3:00-4:15
Description: Numerical solution of differential equations, modelling of flows and waves in porous media and their numerical approximation, inverse and not-well-posed problems.

top

MA 692B: Developing Models for Chemical Transport in Porous Media
Instructor: Prof. J. Cushman , office: MATH 816, phone: 494-8040, jcushman@math.purdue.edu
Time: TTh 1:30-2:45
Prerequisite: The prerequisites consist of a basic understanding of classical fluid mechanics, a first course in stochastic processes, elementary PDE's, and basic thermodynamics.
Description: Chemical transport in porous media is of relevance to most branches of science, engineering and agriculture. This course will focus on developing a multiscale framework for constructing quantitative transport models. The sweet of models will have applicability from the molecular scale to the kilometer scale. A significant emphasis will be placed on data uncertainty and its manifestation in stochasticity of the models. Both discrete and continuous hierarchical porous media will be considered.

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MA 693A: Commutative and Noncummutative Harmonic Analysis: The Science of Symmetry
Instructor: Prof. L. Lempert , office: MATH 734, phone: 494-1952 lempert@math.purdue.edu
Time: MWF 10:30
Prerequisite: Mathematics as required on the Qualifier Examinations; basic general topology (MA 571 is more than enough); notions of a differentiable manifold, Hilbert space.
Description: The Leitmotive of this course is the view that a large part of mathematics can be understood in terms of symmetries (or: in terms of group representations). This will be illustrated historically starting with XVII-th century number theory and probability and concluding with XX-th century quantum mechanics; symmetries lurk behind all.

Topics touched upon: Early probabilities; representing integers by quadratic forms; Dirichlet's work on: Fourier series, Gauss sums, primes in arithmetic progressions; the birth of noncommutative representation theory; partial differential equations; Weyl's work on: representation theory of compact Lie groups, quantum mechanics; symmetries in quantum mechanics according to Neumann and Wigner.

Recommended Text: G. M. Mackey *The Scope and History of Commutative and Nonommutative Harmonic Analysis,* American Mathematical Society, 1992

top

MA 693B: Number Theory
Instructor: Prof. L. de Branges , office: MATH 800, phone: 494-6057, branges@math.purdue.edu
Time: MWF 2:30
Description: This course replaces Polynomial Approximation, which was offered under the same title for the spring semester. New insights in the theory of Hecke zeta functions result from the proof of the Riemann hypothesis for Dirichlet zeta functions. A construction of zeta functions results from the relationship between Fourier analysis on a plane and Fourier analysis on a line expressed by the Radon transformation. The Euclidian plane and line are combined with the p-adic plane and line for every prime p to form an adelic plane and line. Special functions on these planes are found through the representation theory of compact groups obtained by quatifying the commutative groups of units. Zeta functions are obtained as Mellin transforms. The functional identity for the zeta function is an application of the Poisson summation formula as is also the Riemann hypothesis. The construction is conjectured to produced all Hecke zeta functions.

top

MA 693C: Introduction to Holomorphic Dynamical Systems
Instructor: Prof. A. Eremenko , office: MATH 612, phone: 494-1975, eremenko@math.purdue.edu
Time: TTh 12:00-1:15
Prerequisite: MA 530 and MA 544
Description: The course contents are:

- Fatou-Julia theory of iteration of rational functions
- Elementary theory of Kleinian groups
- Dynamics of a holomorphic germ near a fixed point
- Siegel's linearization theorem
- Quasiconformal mappings
- Sullivan's non-wandering theorem
- Ahlfors' finiteness theorem for finitely generated Kleinian groups
- Structural stability and hyperbolicity
- Quadratic family

Sources:

- Milnor's lectures on holomorphic dynamics
- McMullen's notes on conformal geometry and dynamics (both available free on the web), original papers
- Ahlfors, *Conformal Invariants* (out of print)
- Ahlfors, *Lectures on Quasiconformal Mappings* (out of print)
- original papers of Sullivan, Dauady, Shishikurta and McMullen

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MA 693D: Topics in Complex Manifolds
Instructor: Prof. S. K. Yeung , office: MATH 712, phone: 494-1942, yeung@math.purdue.edu
Time: TTh 1:30-2:45
Prerequisite: MA 530 and MA 562. Some basic understandings in algebraic geometry and several complex variables will be helpful as well.
Description:
In this course, some basic techniques in Kahler geometry will be studied. Tentatively, the following topics will be covered: introduction to Kahler geometry, Hermitian symmetric spaces, L^2-existence theorem, vanishing theorems, harmonic maps, rigidity problems, and other topics depending on the progress of the course.
References: 1. Griffiths, P.A. and Harris, J., *Principle of Algebraic Geometry*, Wiley-Interscience
2. Mok, N., *Metric Rigidity Theorems on Hermitian locally symmetric manifolds*, World Scientific.

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MA 694A: Methods of Linear and Nonlinear Partial Differential Equations II
Instructor: Prof. P. Bauman , office: MATH 718, phone: 494-1945, bauman@math.purdue.edu
Time: MWF 11:30
Description: This is a continuation of MA 642. Topics to covered include L_p theory for elliptic equations. Moser's estimates, Calderon-Zygmund theory, Aleksandrov maximum principle. Introduction to evolution problems. Parabolic and hyperbolic equations. Galerkin approximation, semigroup techniques. Applications to nonlinear problems. In subsequent semesters, this course will be call MA 643.

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Seminars, Spring 1999

The seminar list will be forthcoming.