

**Seminars and Advanced Graduate Courses  
offered by the  
Mathematics Department  
Fall, 1998**

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**MA 598A: Abstract Algebra**

**Instructor:** Prof. J. Lipman, office: Math 750, phone: 41994, [lipman@math.purdue.edu](mailto:lipman@math.purdue.edu)

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

**Description:** This course will cover fundamentals on groups, rings, and fields (excluding galois theory). It is intended to prepare students who don't have enough background in algebra for the faster-paced Ph.D. qualifier courses MA 553 and 554, as well as to introduce those whose goals may not include the algebra qualifiers to some of the basic concepts.

**Text:** A. Clark *Elements of Abstract Algebra*, Dover

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**MA 598D: How to Design a Course**

**Instructor:** Dr. R. Saerens, Office: MATH 826, phone: 49-41906, [saerens@math.purdue.edu](mailto:saerens@math.purdue.edu)

**Time:** M 3:30-4:20

**Prerequisite:** Though open to all graduate students, more senior TAs who have taught their own class and have experience writing exams, will benefit most. A minimum of 7 students is needed for the course to run.

**Goal:** Using a concrete example, participants will be guided through the various aspects of designing an undergraduate mathematics course (junior level), from choosing a textbook, to deciding on a lesson plan, writing ground rules, etc. The emphasis will be on the participants designing the course themselves and on participants critiquing each others' efforts in a constructive manner. "Lecturing" will be kept to an absolute minimum. Participants are expected to complete assignments by given deadlines. A commitment on the part of the participants to attend all the meetings and to do the assignments is expected.

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**MA 598F: Mathematics of Finance**

**Instructor:** Prof. V. Weston, office: Math 746, [weston@math.purdue.edu](mailto:weston@math.purdue.edu)

**Time:** MWF 12:30

**Prerequisite:** MA 366 or equivalent (in particular, solutions of O.D.E.'s), MA 510 or equivalent (knowledge of multivariate calculus, in particular, curves, line integrals, double integrals, and the chain rule for partial derivatives). Also some knowledge of basic probability theory is required. Some basic analysis (Riemann integral and implicit function theorem).

**Description:** This is the core course for the new interdisciplinary Masters program in computational finance. The course outline is:

1. Mathematical model. Basic definition of options, risk, etc.; mathematical model of the market, asset, prices; put and call options; Ito's Lemma. Black-Scholes equation and boundary conditions.

2. Introduction to the diffusion equation. Well-posedness of mathematical problem; diffusion equation and its properties; initial- and terminal-boundary value problems.
3. Some explicit solutions of the diffusion equation. Self-similar solutions; explicit solutions of the Black-Scholes equation, etc.
4. Green's function. Introduction to distribution theory, delta function and Heaviside step function; fundamental solution of the diffusion equation; Green's function representation of the solution of the initial-boundary value and terminal-boundary value problems.
5. Free boundary problems. Free boundary problems as applied to American options; formulation of the free boundary using the Green's function; local analysis of the free boundary; iterative methods for solving the free boundary equation.
6. Time dependent parameters. Discrete dividends and jump conditions.
7. Exotic and path dependent options.
8. Interest Rate Derivative Products.
9. Variational Techniques. Application to the free boundary problem.
10. Inverse Problem.  
Existing techniques for solving the inverse problem for the diffusion equation; applications to the determination of volatility, etc.

**Text:** *The Mathematics of Financial Derivatives, A Student Introduction*, by P. Wilmott, Howison, and Dewynne. Cambridge University Press, 1996.

**References:**

1. *Option Pricings, Mathematical Models and Computation*, by P. Wilmott, J. Dewynne, S. Howison (Oxford Financial Press, 1997)
2. *Options, Futures and Other Derivatives of Securities*, by J. C. Hull (Prentice-Hall, 2nd edition)
3. *Variational Principles and Free-Boundary Problems*, by A. Friedman (Wiley, 1982)
4. *Mathematics of Financial Derivatives*, by S. N. Neftci (Academic Press, 1996)

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**MA 620: Mathematical Theory of Optimal Control**

**Instructor:** Prof. L. Berkovitz, office: Math 700, phone: 41936, [brkld@math.purdue.edu](mailto:brkld@math.purdue.edu)

**Time:** MWF 10:30

**Prerequisite:** MA 544

**Description:** The course will be concerned with the mathematical theory of optimal control problems for systems governed by ordinary differential equations. The topic outline for the course is as follows: Examples of control problems from applied areas. Existence theorems. The Pontryagin Maximum Principle. Linear systems, Linear quadratic problems, Time optimal problems. Relationship to the calculus of variations. Hamilton-Jacobi theory and optimal feedback. The "text" will be notes for a projected revised edition of my 1974 book *Optimal Control Theory*, Applied Mathematical Sciences, Vol. 12, Springer Verlag. An overview of the course content can also be gotten from L. Cesari, *Optimization - Theory and Applications. Problems with Ordinary Differential Equations*, Springer Verlag, 1983. I have put these books on reserve for perusal by interested parties.

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**MA/STAT 638: Stochastic Processes I**

**Instructor:** Prof. S. Lalley, office: Math 504, [lalley@stat.purdue.edu](mailto:lalley@stat.purdue.edu)

**Time:** MWF 10:30 <<< NOTE NEW TIME >>>

**Prerequisite:** MA/STAT 539

**Description:** Advanced topics in probability theory which may include stationary processes, independent increment processes, Gaussian processes; martingales, Markov processes, ergodic theory.

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**MA 642: Methods of Linear and Nonlinear Partial Differential Equations I**

**Instructor:** Prof. D. Phillips, office: Math 706, phone: 41939, [phillips@math.purdue.edu](mailto:phillips@math.purdue.edu)

**Time:** MWF 11:30 <<< NOTE NEW TIME >>>

**Prerequisite:** MA 523 and 611.

**Description:** Second order elliptic equations including maximum principles, Harnack inequality, Schauder estimates, and Sobolev estimates. Applications of linear theory to nonlinear equations.

**Text:** Gilbarg and Trudinger *Elliptic Partial Differential Equations of Second Order*, 2nd Ed., Springer Verlag.

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### MA 663: Algebraic Curves and Functions I

**Instructor:** Prof. J. Lipman, office: Math 750, phone: 41994, [lipman@math.purdue.edu](mailto:lipman@math.purdue.edu)

**Time:** TTh 10:30-11:45

**Prerequisite:** MA 553, 554, or permission of the instructor.

**Description:** The course will provide an algebraic foundation for further study in number theory or algebraic geometry. Some commutative algebra (integral dependence, Dedekind domains, discrete valuation rings, Krull dimension...) will be covered, and applied to set up basic theory of algebraic numbers and algebraic curves, including factorization, units, divisor class groups, and the Riemann-Roch theorem.

**Text:** D. Lorenzini *An invitation to Arithmetic Geometry*, chapters I-VII and IX, (on reserve in the library)

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### MA 665: Algebraic Geometry

**Instructor:** Prof. S. Abhyankar, office: Math 950, phone: 41933, [ram@math.purdue.edu](mailto:ram@math.purdue.edu)

**Time:** TTh 3:00-4:15

**Description:** Topics discussed will include Resolution of Singularities, Calculation of Algebraic Fundamental Groups, Geometry of Lie Type Groups, and the Jacobian Problem. The presentation will be self-contained. There are no formal prerequisites. All interested persons are welcome.

**Recommended Texts:**

1. Abhyankar *Algebraic Geometry for Scientists and Engineers*, AMS.
2. Abhyankar *Resolution of Singularities of Embedded Algebraic Surfaces*, Second Edition (1998), Springer-Verlag, ISBN 3-540-63719-2

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### MA 672: Algebraic Topology I

**Instructor:** Prof. J. Becker, office: Math 732, phone: 41953, e-mail: [becker@math.purdue.edu](mailto:becker@math.purdue.edu)

**Time:** MWF 10:30

**Description:** The course will be a continuation of MA 572. Topics will include: cohomology theory with primary emphasis on K-theory, Poincare, Alexander, Spanier--Whitehead duality, characteristic classes, and equivariant K--theory as time permits.

**References:**

1. M. F. Atiyah *K-Theory*
2. A. Dold *Lectures on Algebraic Topology*

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### MA 690A: Introduction to Geometric Invariant Theory

**Instructor:** Prof. K. Matsuki, office: Math 614, phone: 41970, [kmatsuki@math.purdue.edu](mailto:kmatsuki@math.purdue.edu)

**Time:** MWF 1:30

**Prerequisite:** Some familiarity with commutative algebra is desired but not absolutely necessary. If you have taken Prof. Huneke's course in 1997-98, then you know probably more than I do. Some familiarity with algebraic geometry is desired but again not necessary. If you browse through the first chapters of Harris' textbook *Algebraic Geometry*, then you know probably more words than I would use in the class. Absolute requirement, though, is mathematical enthusiasm to participate and work out the homework assignments that I give for the course.

**Description:** In many subjects of mathematics we observe the importance of studying the action of a group  $G$  on an object  $X$  and its quotient  $X/G$ . Algebraic Geometry is no exception! The purpose of this course is to understand the action of a group  $G$  (finite groups, reductive groups, etc.) on an algebraic variety  $X$  and the subtleties about the

"quotient"  $X/G$  leading up to Geometric Invariant Theory of Mumford.

I would like to start with such a classical subject, Hilbert's Fourteenth Problem, concerning the finiteness of the generators for the invariant ring  $R^G$  where  $R$  is the ring of regular functions  $R=k[x_1, \dots, x_n]/I$  for an AFFINE variety defined by the ideal  $I$ . Then we move on to the discussion of taking the quotient of a PROJECTIVE variety, the main subject of Geometric Invariant Theory. Despite its importance, the theory has not been readily available to beginners or people outside the field, partially because Mumford's original book requires a substantial amount of technical mastery on the reader's side. Fortunately Mukai has written a textbook which tries to convey the main ideas of GIT, with many interesting examples but without assuming a huge technical background (No use of language of SCHEME). The only catch is \dots it is in Japanese! In the course, I'll try to be both translator in language and a guide in this beautiful garden to wander around.

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### MA 690B: Representation Theory and Automorphic Forms

**Instructor:** Prof. F. Shahidi, office: Math 802, phone: 41917, [shahidi@math.purdue.edu](mailto:shahidi@math.purdue.edu)

**Time:** MWF 9:30

**Prerequisite:** The course taught by Prof. Lipman in the Fall of 1997 should cover some of the things needed for chapter 2 (modular forms). The course being taught by Prof. Roche in the Spring of 1998 should be covering a lot more than what I may need from structure theory.

**Description:** I am planning to teach a course on representation theory of reductive groups (over  $R$ ,  $\mathbb{Q}_p$  or  $\mathbb{Q}$ ) through the theory of automorphic forms. I will probably use Bump's book. But try to do the theory for  $GL(n)$  and some other groups. My aim will be to develop enough representation theory that some theory of  $L$ -functions and automorphic forms can be developed from.

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### MA 692A: Special Topics in Numerical Analysis

**Instructor:** Prof. J. Douglas, office: Math 822, phone: 41927, [douglas@math.purdue.edu](mailto: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.

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### MA 692B: Wavelets and Image Processing

**Instructor:** Prof. B. Lucier, office: Math 634, phone: 41979, [lucier@math.purdue.edu](mailto:lucier@math.purdue.edu)

**Time:** MWF 9:30

**Prerequisite:** MA 544 (real analysis through measure theory) and some functional analysis (the first three chapters on Metric Spaces, Banach Spaces, and Hilbert Spaces of  $\{\text{it Elements of Applicable Functional Analysis}\}$  by Charles W. Groetsch would suffice).

**Description:** The goal of the course is to describe and analyze nonlinear wavelet algorithms for three fundamental problems in low-level image processing: image compression, Gaussian noise removal, and inverting the Radon transform and other homogeneous linear operators with noisy data (which has application to medical imaging-Magnetic Resonance Imaging, Computed Tomography, and especially Positron Emission Tomography). The main mathematical tool will be Nonlinear Approximation Theory and its relation to the theory of smoothness spaces (i.e., characterizing the smoothness of images in useful ways); we will also use some simple probability theory, variational principles, etc. The main focus of the course will be the rigorous analysis of the algorithms, not the development or theory of wavelet filters per se.

**Text:** *Ten Lectures on Wavelets* by I. Daubechies

Although (or perhaps because) the material presented in class will complement the material in this book, every student should have a copy of this book.

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### MA 692C: Topics in Mathematical Biology

**Instructor:** \rm Prof. Z. Feng, [zfeng@math.purdue.edu](mailto:zfeng@math.purdue.edu)

**Time:** MWF 9:30

**Prerequisite:** Calculus and an introductory course in probability and/or statistics. Some knowledge of linear algebra would be helpful.

**Description:** This course is an introduction to the application of mathematical methods and concepts to the description and analysis of biological processes. The mathematical contents consist of difference and differential equations, basic probability theory and elements of stochastic processes. The topics to be covered include dynamical systems theory motivated in terms of its relationship to biological theory, deterministic models of population processes, life history evolution, epidemiology, coevolutionary systems, structured population models, nonlinear dynamics and chaos, stochastic processes, and introduction to *Mathematica* (computer package). Bio-mathematical research projects (in small group) may be carried out. Course grading will be based on weekly assignments, in-class mid-term, a take home final, and a project.

**Text and class materials:**

1. Alan Hastings *Population Biology, Concepts and Models*, Springer Verlag, 1996.
2. Class notes and Handouts and Articles on reserve.
3. *Mathematica Reference Guide* (optional).

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### MA 693B: Invariant Spaces

**Instructor:** Prof. L. de Branges, office: Math 800, phone: 46057, [branges@math.purdue.edu](mailto:branges@math.purdue.edu)

**Time:** MWF 2:30

**Description:** The course continues the theme of a return to fundamentals for advanced applications. The fundamental concepts involved are the Hahn-Banach theorem and its applications to integration theory. A generalization of the Riesz-Stieltjes representation of nonnegative linear functionals on spaces of continuous functions has been outlined in a previous application of the Hahn-Banach theorem. A related structure theory is now obtained for continuous linear functionals on spaces of vector valued functions defined on a vector space. The Burnside construction of invariant subspaces is an application when the vector space has finite dimension. A generalization due to Victor Lomonosov is obtained when the vector space is a Banach space. A compactness hypothesis which he assumes is removed. A structure theory results for algebras of continuous linear transformations on a Banach space which are closed on the weak topology induced by the trace class.

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### MA 696A: Topics in Complex Manifolds

**Instructor:** Prof. S. Yeung, office: Math 712, phone: 41942, [yeung@math.purdue.edu](mailto:yeung@math.purdue.edu)

**Time:** MWF 11:30

**Prerequisite:** 530, 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, vanishing theorems, harmonic maps, rigidity problems, and other topics depending on the progress of the course.

**References:**

1. Griffiths, P. A. and Harris, J. *Principles of Algebraic Geometry*, Wiley-Interscience
2. Mok, N. *Metric Rigidity Theorems on Hermitian locally symmetric manifolds*, World Scientific

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## Seminars, Fall 1998

- **Topology Seminar**, Prof. Gottlieb  
**Time:** Thursdays, 3:00-4:00
- **PDE Seminar**, Prof. Phillips  
**Time:** Tuesdays, 9:30-10:20

- **Algebraic Geometry Seminar**, Prof. Abhyankar  
**Time:** Thursdays 4:30-6:00
- **Geometric Analysis Seminar**, Prof. Lempert  
**Time:** Monday 4:30
- **Probability Seminar**, Prof. Protter  
**Time:** Wednesdays 3:30
- **Linear Algebra and Complex Analysis**, Prof. de Branges  
**Time:** Thursdays 2:30
- **Function Theory**, Prof. Drasin  
**Time:** Wednesdays 1:30
- **Commutative Algebra/Algebraic Geometry**  
**Time:** Wednesdays 4:30
- **Automorphic Forms and Representation Theory**, Prof. F. Shahidi  
**Time:** Thursdays 1:30

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