Spring 2010

# 2010 (Spring)

University of Dayton. Department of Mathematics

**Abstracts of the Colloquium Talks: Spring 2010**
**Department of Mathematics**

| Date | Speaker and Title | Time/Location |
|---|---|---|
| Thursday, Jan 21 | Art Busch, University of Dayton<br>Finding Odd Cycles in Graphs Defined on a Torus | 3:00 PM, SC 323 |
| Thursday, Jan 28 | Virginia Keen, University of Dayton<br>Using Digital Video to Strengthen Student Learning of Mathematics | 3:00 PM, SC 323 |
| Thursday, Feb 4 | Paul Eloe, University of Dayton<br>The Fundamental Matrix of a System of Linear Fractional Backward Difference Equations | 3:00 PM, SC 323 |
| Thursday, Feb 11 | Chandra Dinavahi, University of Findlay<br>Diagonally Switchable 4-Cycle systems | 3:00 PM, SC 323 |
| Thursday, Feb 18 | Muhammad Islam, University of Dayton<br>Three Fixed Point Theorems; Periodic Solutions of Integral Equations Evolved From Retarded Differential Equations | 3:00 PM, SC 323 |
| Thursday, Feb 25 | Marie Snipes, Kenyon College<br>Harmonic measure distribution functions and Brownian motion in planar domains | 3:00 PM, SC 323 |
| Thursday, Mar 11 | Harry Khamis, Wright State University<br>Multigraph Representations of Hierarchical Loglinear Models | 3:00 PM, SC 323 |
| Thursday, Mar 18 | Imran Akhtar, Virginia Tech<br>Applications of the Proper Orthogonal Decomposition in Dynamical Systems | 3:00 PM, SC 323 |
| Thursday, Mar 25 | Jennifer Hutchison, Cedarville University<br>Thin-Type Dense Sets and Related Properties | 3:00 PM, SC 323 |
| Thursday, Apr 8 | Maher Qumsiyeh, University of Dayton<br>Comparison Between the Bootstrap and the Empirical Edgeworth Expansion | 3:00 PM, SC 323 |
| Thursday, Apr 15 | Elham Negahdary, University of Dayton<br>Pricing Options in Mean-Reversion Jump-Diffusion Model by Radial Basis Functions | 3:00 PM, SC 323 |
| Thursday, Apr 22 | Richard Wuebker, University of Dayton<br>Analysis of the Pricing and Hedging of Spread Options | 3:00 PM, SC 323 |

**FINDING ODD CYCLES IN GRAPHS DEFINED ON A TORUS**

ARTHUR H. BUSCH

**Abstract.** In this talk, we consider how to prove that all graphs in three related families of graphs contain at least one odd cycle. The families are initially defined using a graph $H_{mn}$ with $mn$ vertices arranged in an $m \times n$ grid embedded on a torus, where both $m$ and $n$ are odd. Each vertex is adjacent to the four diagonally adjacent vertices in the grid.

**Using Digital Video to Strengthen Student Learning of Mathematics**

Virginia (Ginny) Keen

**Abstract** This presentation includes a description and initial analysis of the results of using student-created video products to enhance the mathematical content knowledge of prospective early childhood and intervention teachers. While it is felt that using student-designed video can support learning, there is little research confirming this. This action research assesses the value of having students create "video snippets" that model and explain various mathematical concepts through the use of visual representations, explanations, correct notation and vocabulary, and examples and non-examples. Sample student videos and analyses will demonstrate how the initial project was assessed and revised for the next iteration. The presentation will conclude with a look at how we can extend our understanding of the potential for the use of digital video in instruction, assessment, and research.

**The Fundamental Matrix of a System of Linear $\nu th$ Order Fractional Backward Difference Equations**

Paul Eloe

**Abstract** We consider the system of linear $\nu$ th order fractional backward difference equations,

$$\nabla\nu\, y(t) = Ay(t) + f(t), t = 1, 2 \ldots.$$

$A$ is an $n \times n$ matrix with real entries and $0 < \nu < 1$. Define $\nabla^{\nu} = \nabla\nabla^{\nu-1}$ where $\nabla y(t) = y(t) - y(t-1)$ and the fractional sum, $\nabla^{\nu-1}$, is defined by

$$\nabla_a^{-(\nu-1)} y(t) = \sum_{s=a}^{t} \frac{(t-\rho(s))^{\overline{(\nu-1)-1}}}{\Gamma(\nu-1)} f(s)$$

where $\rho(s) = s - 1$ and $t^{\overline{\alpha}} = \frac{\Gamma(t+\alpha)}{t}$. In particular, $\nabla^{\nu}$ denotes the Riemann-Liouville fractional difference operator.

We shall construct the fundamental matrix and causal Green's function associated with this system of equations. We are particularly interested to develop the theory analogous to the theory associated with the system of differential equations, $y^0 = Ay + f(t)$. In that setting, the fundamental matrix is $e^{At}$and the causal Green's function is $e^{A(t-s)}$. Knowledge of the scalar equation $y^0 = ay + f(t)$ is the only prerequisite for the talk.

This work is in collaboration with Ferhan Atici of Western Kentucky University.

**Diagonally Switchable 4-Cycle systems**

Chandra Dinavahi

**Abstract:**

A 4-cycle system is said to be diagonally switchable if each 4-cycle can be replaced by another 4-cycle obtained by replacing one pair of non-adjacent edges of the original 4-cycle by its diagonals so that the transformed set of 4-cycles forms another 4-cycle system. The existence of diagonally switchable 4-cycle system of $K_v$ has already been solved. In this presentation we will discuss an alternative proof of this result and use the method to prove a new result for $K_v - I$, where I is any one factor of $K_v$

**About the speaker:**
Dr.Chandra Dinavahi obtained a masters degree in Mathematics & Computing from University of Hyderabad, India. Later he came to U.S and attended Texas A&M University. After graduating from TAMU with a masters degree, he joined Auburn University to pursue his PhD in discrete mathematics. He received his PhD in Discrete Mathematics under the guidance of Dr. Chris Rodger. He has been an assistant professor of mathematics in the University of Findlay since 2007.

**Three Fixed Point Theorems; Periodic Solutions of Integral Equations Evolved From Retarded Differential Equations**

MUHAMMAD N. ISLAM

**Abstract:** The existence of periodic solutions of integral equations, which evolve from retarded functional differential equations, is studied in this paper. Banach fixed point theorem, Krasnoselskii's fixed point theorem, and a fixed point theorem which is a combination of Krasnoselskii's theorm and Schaefer's fixed point theorem, are employed in the analysis. This comined theorm of Krasnoselskii and Schaefer is named as Theorem Krasnoselskii-Schaefer in this article. Theorem Krasnoselskii-Schaefer requires an a priori bound on all solutions. Liapunov's direct method is employed to obtain such an a priori bound. Comparisons of these theorems in terms of the assumptions and the outcomes are made in the process.

**Harmonic measure distribution functions and Brownian motion in planar domains**

Marie Snipes

**Abstract:** Given a domain $D$ in the plane containing the origin, the harmonic measure distribution function $h(r)$ gives information about the behavior of a Brownian particle in the domain. Specifically, for $r > 0, h(r)$ denotes the probability that a Brownian particle starting at zero will first hit the boundary of $D$ within distance $r$ of its starting point. The harmonic measure distribution function of a domain is a right-continuous function that increases from 0 toward 1. A long-term goal is to determine whether such an increasing function $f$ can be realized as the harmonic measure distributions of a domain, and if possible, to explicitly construct the domain. We will discuss the special case where $f$ is a step function which increases from 0 to 1 in finitely many steps. This is joint work with L. Ward.

**About the speaker:** Marie Snipes holds a BS in mathematics from Harvey Mudd College and an MS and a PhD in mathematics from the University of Michigan. She joined the Kenyon Mathematics Department in 2009. Her research interests lie in the field of geometric measure theory, an area of mathematics that uses measure theory to analyze geometric properties of sets and has its origins in the study of soap films. Prior to her doctoral studies at the University of Michigan, Marie spent four years in the Air Force conducting statistical analyses and developing mathematical models of personnel data. Outside the classroom, Marie's primary hobby is applied topology through a handson study of continuous deformations of phyllosilicate minerals (in other words, throwing pottery). She also enjoys playing racquetball, Scrabble, and chess.

**Multigraph Representations of Hierarchical Loglinear Models**

Harry Khamis

**ABSTRACT** The topic of this talk represents a wonderful marriage between graph theory and statistics. The work was done jointly with Wright State University Professor (Emeritus) Terry McKee, an expert in chordal graphs. A brief development of the loglinear model for multidimensional contingency tables will be presented from first principles for two and three categorical variables, and then generalized to $k$ categorical variables. A brief discussion of graphical models will be followed by the development of the multigraph representation of hierarchical loglinear models; applications will be illustrated with numerous examples. This talk will be a "how to" presentation rather than a theoretical development.

**BIO** Harry Khamis received his Ph.D. in statistics at Virginia Tech in 1980. Since then he has been at Wright State University in the Department of Mathematics & Statistics, except for a two-year visiting professorship at Uppsala University and two one-quarter visiting positions at Umeå University in Sweden. He became Director of the Statistical Consulting Center in 1993. He has a joint appointment in the Boonshoft School of Medicine, where he has worked on the famous Fels Longitudinal Study, the largest and longest running (since 1929) study of human growth and body composition in the world.

**Applications of the Proper Orthogonal Decomposition in Dynamical Systems**

Imran Akhtar

**Abstract:** The Proper Orthogonal Decomposition (POD) is widely used to derive low-dimensional models of large and complex dynamical systems and has emerged as a powerful tool in fluid dynamics. Given a set of flow field data, it extracts the most energetic global functions (modes) that can be used to characterize and analyze flows. The optimality of the POD modes, in terms of energy representation, makes them a good candidate to build low-dimensional models of the system dynamics using Galerkin projections. These models can be further modified to design flow controls. However, the standard models are often limited in their application. A few of the shortcomings include accuracy of the models away from the reference simulation, stability issues, inability to predict bifurcation points, and restriction to low Reynolds number flow. This talk will provide an overview of the development of POD based low-dimensional models for the flow past a cylinder and a control design to suppress vortex shedding. The limitations of these models will be discussed in detail along with potential remedies to these issues. These include (a) sensitivity analysis to enhance the accuracy of the models beyond the parameter values from which they are derived; (b) a shooting technique to investigate stability issues; (c) extension of the model to predict hydrodynamic forces; and (d) closure modeling for high Reynolds number flows.

**Thin-Type Dense Sets and Related Properties**

Jennifer Hutchison

**Abstract:** The concept of a dense set in a topological space is an elementary one: a set which meets every open set. Dense sets may be thought of as those that are ubiquitous in a space. In this presentation, we will look at the situations in which dense sets in product spaces may be well spread out. Thin, very thin, and so on are terms describing how sparsely a subset of a product space is distributed through the space. We shall be discussing the situations under which such special kinds of dense sets exist in product spaces, along with the characteristics of these sets. We will also consider some criteria which imply the existence of slim dense sets.

About the Speaker: Jennifer Hutchison received her M.A. in mathematics from Miami University (Oxford, OH) in 2003 and will graduate in May with a Ph.D. in mathematics from Auburn University. She has taught mathematics at Cedarville University for the last five years, mostly teaching topology and various types of calculus.

**Comparison Between the Bootstrap and the Empirical Edgeworth Expansion**

Maher B. Qumsiyeh

**Abstract** The Bootstrap estimate for studentized statistics is more accurate than both the normal approximation and the two-term empirical Edgeworth expansion. In this talk it will be shown that the three-term empirical Edgeworth expansion for studentized statistics compares well with the bootstrap. It is also shown that the 3-term Edgeworth expansion is superior to the bootstrap in some cases, using more efficient estimators than sample moments in the Edgeworth expansion, such as using maximum likelihood estimators in the one parameter exponential family.

**Pricing Options in Mean-Reversion Jump-Diffusion Model by Radial Basis Functions**

Elham Negahdary

**Abstract:** In this work we use Radial Basis Functions (RBF) to compute the option price in mean reversion jump-diffusion model. The mesh free method based on RBF interpolation, instead of traditional mesh-based methods like Finite Differences (FDM) or Finite Elements (FEM), is used for solving Partial Integro-Differential Equation (PIDE) for non-dividend paying stocks in the mean-reversion jump-diffusion model. We implement Gaussian (GA), Multiquadric (MQ) and Inverse Multiquadric (IMQ) and compare them via numerical experiments. In addition, we compare those methods with Monte Carlo simulations. For the jump-diffusion model considered in this work, we numerically solve the PIDE that includes a non-local integral term. We treat both differential and integral terms in the PIDE by using RBF. After transforming the PIDE to a system of ODEs by using RBF, we solve the ODEs with an ODE solver, the Runge-Kutta fourth (RK4). Comparing with the standard Black-Scholes-Merton PDE, the model we study in this project leads to a Partial Integro-Differential Operator or PIDE, involving a non-local term in the form of an integral operator. Our main contribution is to examine how to numerically solve these equations in an efficient way using RBFs. The method in principle can be extended to Levy-models, since the model considered in this project is a special case of the Levy model that has been used for describing the price dynamics of the underlying risky asset with various jumps. The jump diffusion models can describe rare events such as crashes and draw downs at random intervals in a financial market such as the energy market.

**Analysis of the Pricing and Hedging Of Spread Options**

Rick Wuebker

**Abstract:** In this project we take a look at the process of pricing and hedging spread options. Spread options are becoming a widely used tool to manage risk and for speculation in markets such as energy, fixed income, and foreign exchange. We examine the partial differential equation used to price spread options with Black Scholes methodology and use techniques from volatility trading to examine the effects of the parameters of the standard deviations and correlation of the two underlying assets, using the analytical solution when the strike spread is zero. We also take a look at the latest numerical methods used to approximate the prices of spread options when the strike price is not zero, or the

option is non-European, including Monte Carlo method, explicit finite difference method, and the Alternating Direction Implicit finite difference method.