Conference on Undergraduate Research in Mathematics

Penn State University
November 4-5, 2011

Talk Abstracts

Plenary Speakers

Annalisa Crannell, Franklin & Marshall College

Math and Art: The Good, the Bad, and the Pretty

How do we fit a three-dimensional world onto a two-dimensional canvas? Answering this question will change the way you look at the world, literally: we'll learn where to stand as we view a painting so it pops off that two-dimensional canvas seemingly out into our three-dimensional space. In this talk, we'll explore the mathematics behind perspective paintings, which starts with simple rules and will lead us into really lovely, really tricky puzzles. Why do artists use vanishing points? What's the difference between 1-point and 3-point perspective? Why don't your vacation pictures don't look as good as the mountains you photographed? Dust off those old similar triangles, and get ready to put them to new use in looking at art!

Francis Su, Harvey Mudd College

Voting in Agreeable Societies

When do majorities exist? How does the geometry of the political spectrum influence the outcome? What does mathematics have to say about how people behave? When mathematical objects have a social interpretation, the associated theorems have social applications. We give examples of situations where sets model preferences, and prove extensions of classical theorems on convex sets such as Helly's theorem and Turan's theorem that can be used in the analysis of voting in "agreeable" societies. This talk also features research with undergraduates.

Student Speakers

Justin Antolin, California University of Pennsylvania

Triangles in Spherical Geometry

The differences in planer geometry and spherical geometry with concern to triangles. The focus will concentrate on the fact that in planer geometry because of parallel line triangles have interior angles that add up to 180. However, in spherical geometry the angles of the interior triangle can add up to as much as 540 for a hemisphere and 900 for a sphere using beach balls as visual aids. This now means that such things as the Law of Sines and Cosines have to be changed for use on a sphere and certain triangle congruences and similarities no longer apply.

Paul Apisa, Ohio State University

Groups with a Base Property Analogous to That of Vector Spaces

A generating set for a finite group, G, is said to be irredundant if no proper subset of the generating set generates G. Diaconis and Saloff-Coste (1996) demonstrated that the efficacy of certain algorithms for the random generation of group elements depend upon the minimum and maximum size of irredundant generating sets. Intriguingly, these values also constrain the group structure. If all irredundant generating sets of a finite group G have the same length, then G is said to be a B group. B stands for "base", since this property is analogous to the property that all bases of a given vector space have same cardinality.

In this talk, B groups are classified and it is shown that Frattini free B groups are either elementary abelian or specific subgroups of the holomorph of elementary abelian groups. This classification theorem resolves an outstanding problem in the study of generating sets of groups that is posed in a paper of McDougall-Bagnall and Quick. Moreover, the questions raised by McDougall-Bagnall and Quick as to whether B groups are solvable and whether the quotient of B groups are also B groups are resolved in the affirmative. Finally, the Scapellato and Verardi 1991 classification of matroid groups is derived as a corollary of B group classification. The techniques used to prove the classification theorem of B groups are a combination of original methods and forthcoming results of R. Keith Dennis.

Mark Beckwith, Slippery Rock University

A Twelve Coin Problem: Two Counterfeit Coins

We solve the following problem posed The College Mathematics Journal 42(May 2011).

954. Proposed by Erwin Just (Emeritus), Bronx Community College of the City University of New York, Bronx NY. Among twelve identical looking coins there are two counterfeits. The two counterfeits are equally heavier than the true coins and a maximum of four comparisons of sets of coins using a balance scale are permitted. Show how one can determine which coins are counterfeit under these conditions.

In our solution, the first two weighings are fixed and the last two are contingent.

Emily Bonomo, Nazareth College

Coloring Outside the Lines: Finding 4-Chromatic Unit Distance Graphs I

We explore the Hadwiger-Nelson Problem, which is to find the chromatic number of the plane, by describing a family of 4-chromatic unit distance graphs. We then demonstrate a method for finding graphs with certain chromatic properties.

In part I of the talk, we will give the necessary definitions and examples, and discuss the Hadwiger-Nelson Problem.

Eileen Bruns, Nazareth College

Coloring Outside the Lines: Finding 4-Chromatic Unit Distance Graphs III

We explore the Hadwiger-Nelson Problem, which is to find the chromatic number of the plane, by describing a family of 4-chromatic unit distance graphs. We then demonstrate a method for finding graphs with certain chromatic properties.

In part III of the talk, we will present our findings of a family of 4-chromatic unit-distance graphs.

Christian Bueno, Florida International University

Algebraic Pebble Motion Problems

Permutation pebble motion problems (PPM) are puzzles in which pebbles are placed on the vertices of a graph and the question of whether one arrangement can be turned into another through legal moves is considered. In this project we generalized R.M. Wilson's definition of groups of PPM problems to all graphs with arbitrary number of empty spaces and study properties of these groups. Furthermore, where Wilson's paper classified only the groups for 2-connected PPM puzzles with one empty space, we extend his results and classify all possible groups for PPM puzzles with one empty space and classify the groups for all 2-connected graphs with arbitrary number of spaces. Lastly, we tackle a few other special cases and classify their groups as well.

David Corey Chelf, Shepherd University

Approximating the Optimal Path of an Idealized Vehicle about a Parameterized Curve: Part II - Numerical Approximation and the Elliptic Integral

To locate the optimal path of a vehicle about any track, it is required that the motion of the vehicle be modeled using differential equations. In order to manage the complexity of the task, the vehicle is idealized and the curve is defined by a set of basic parameters. In this talk, we introduce the elliptic integral describing curvilinear motion under constant acceleration, and proceed with its analysis using the numerical tools found in the MATLAB software package.

Neil DeBoer, Michigan State University

3-Periodic Orbits of Polygonal Outer Billiards, Part 1

We explore the dynamics of 3-periodic orbits of the outer billiard system around triangular tables in the hyperbolic plane. We find an explicit formula for the location of 3-periodic orbit points, either inside the hyperbolic plane or at infinity. In the case of small triangular tables, we also prove a geometric construction of the 3-periodic orbit.

Theodore Dokos, Ohio State University

Patterns in Permutations: st-Wilf Equivalence and st-Polynomials as q-analogues

Consider a permutation on n letters as a sequence reordering the numbers 1 through n. This permutation is said to contain a pattern, which is just another permutation, if the former contains a subsequence whose elements are arranged in the same relative order as the latter. For example, the permutation 42513 contains the pattern 132, since it has 253 as a subsequence. Permutation pattern theory is more concerned with when a permutation avoids a pattern instead of containing it. The sets of permutations avoiding a specific pattern give rise to the notion of Wilf equivalence.

By considering statistic functions on permutations, we create a generalization of this relation, which we call st-Wilf equivalence. The talk discusses equivalences for the major and inversion statistics, and interprets naturally arising generating functions as q-analogues of various combinatorial sequences, including a q-Catalan recurrence which appears to be heretofore unmentioned in the literature. Additionally, a formerly open question on the existence of particular Mahonian Pairs is resolved in the affirmative.

Rex W. Edmonds, Slippery Rock University

Pythagorean triples of the form (Tn, Sn, Pn) where Tn, Sn, and Pn are triangular, square, and pentagonal numbers

In this talk we will consider Pythagorean triples along with triangular, square, and pentagonal numbers. Furthermore, we will answer the question of which natural numbers n provide Pythagorean triples of the form (Tn, Sn, Pn) when Tn, Sn, and Pn are triangular, square, and pentagonal numbers, respectively.

Kelsey Fry, Shepherd University

Approximating the Optimal Path of an Idealized Vehicle about Parameterized Curves: Part IV - Combining Linear and Circular Motion

The optimal path of an idealized vehicle can be approximated using parameterized curves. Kinematics equations and Newton's second law are used to describe the motion of the vehicle about the track which can then be optimized by using integration. In this talk, we will analyze a track consisting of two linear portions with a half-circle portion between; a combination of rectilinear motion and circular motion can be used to describe the optimal time of the vehicle, given the distances of the linear portions and the radius of the half-circle.

Jessica Fuller, Seton Hall University

Teleportation on Graphs

We study the movement of particles when they are dropped on a graph. We consider two different visual constructions of a multiple particle walk on a graph and find a connection between them. Our main concern is perfect state transfer of a particle while "walking" on a graph, or teleportation from one vertex to another. We look at perfect state transfer on graphs as well as their quotient graph, taken using equitable partitions, and the Cartesian product of graphs.

We find that we can equate perfect state transfer on a graph to perfect state transfer on its equitable partition. We also find that for a collection of graphs and their equitable partitions, there is an equitable partition so that the Cartesian product of the quotient graphs is the quotient of the Cartesian product of the graphs. This generalizes a construction of Feder, which was obtained from a k-boson quantum walk on a single graph.

Amanda Goodrick, Slippery Rock University

Domino Tilings of a Rectangle with the Central Rectangle Removed

This talk is motivated by the following problem posed by Donald E. Knuth in the April 2011 edition of Mathematics Magazine:

Let n>=2 be an integer. Remove the central (n-2)x(n-2) squares from an (n+2)x(n+2) array of squares. In how many ways can the remaining squares be covered with 4n dominoes?

Here we solve a generalization of Knuth's problem, namely the problem of finding the number of domino tilings of the region obtained by removing the central (m-2)x(n-2) rectangle from an (m+2)x(n+2) rectangle.

Anthony Joseph Grisafi, The University at Buffalo

Modeling Multiphase Flows: A Look at the Stability of Magma Flow Patterns in Extrusive Volcanic Eruptions

About the presentation: after a brief introduction to physical volcanology, a mathematical model for extrusive eruptions will be presented, along with a numerical solution scheme and interesting implementation details. Viewing and interpreting steady flow patterns for differing volcanic conduit geometries, and also discussing the potential instability of those patterns, will be a large part of the presentation.

About the multiphase flow problem and its solution: the mixture is composed of solids, liquids, and gasses typical of andesitic magmas, and it is described by a single pressure, two velocities, and three densities. The flow is incompressible, slow, and laminar, and is driven by the pressure gradient along the height of the volcanic conduit, which may vary in shape. We have adapted an existing 1.5D model and numerical scheme in order to identify steady flow patterns for many different conduit geometries. In particular, creative root finding and ordinary differential equation solving routines were implemented, allowing for robustness and rapid convergence. Continuous-in-time and discrete-in-space operator splitting methods were derived and implemented in order to investigate the stability of steady flow patterns under linear perturbations. The solutions of this generalized eigenvalue and vector problem show evidence of unstable wavelike behavior.

Laura Gruca, Seton Hall University

Exploring Properties of Certain Multithreshold Graphs

In graph theory, a graph G is threshold if, for all pairs of nodes u and v in G, where $deg(u) \leq deg(v)$, N(u)-{v} is a subset of N(v)-{u}. We explore the conditions of threshold graphs to see if it is possible to include certain types of multigraphs within the class of threshold graphs. We consider threshold properties including integer eigenvalues, unique degree sequence realization, and neighborhood nesting. In addition, we consider extending the Hammer and Simeone conditions to include a certain type of multigraph, with up to two different multiplicities. We present a proof of this extension allowing certain degree sequences of multigraphs to be shown to be realizable as split graphs.

Bryan Hansel, Shepherd University

Approximating the Optimal Path of an Idealized Vehicle about Parameterized Curves: Part III - Series Approximation and Error Analysis

The optimal path of an idealized vehicle can be approximated using parameterized curves. Kinematic equations and Newton's second law are used to model the motion of the vehicle on the track, which can then be analyzed using integration. The integral used to represent the motion around the track is an elliptical integral of the first kind, and can be approximated by several series solutions. This talk will focus on the Power and Taylor Series as well as the involved error analysis. These approximations will be used to verify numerical methods presented in Part II.

Brian Hardock, Penn State University

Freak Waves in Shallow Water

I am looking at the Korteweg de Vries equation and its linear counterpart, which model surface waves on shallow water. I used these models to investigate 'Freak Waves' in shallow water. Following a similar procedure described in a paper by 'Pelinovsky, Tatiana, and Holloway' (2005), I inverted a freak wave solution to the linearized KdV equation to obtain its corresponding initial condition. I conducted laboratory experiments to test this model. In experiments and in the field damping is important, and so I also investigated the effects of damping on the model.

Daniel Hast, University of Michigan

3-Periodic Orbits of Polygonal Outer Billiards, Part 2

We examine the question of which small polygonal outer billiard tables have 3-periodic orbits in the hyperbolic plane. We formulate a conjecture that all polygonal outer billiard tables satisfying a stronger smallness condition -- which we call triangle-small -- have such a 3-periodic orbit. We prove several special cases of the conjecture: polygons with at least three acute or right angles, regular polygons, and quadrilaterals.

Katie Heaps, Duquesne University

Variational Image Denoising and Decomposition Using Duality

Minimizing the total variation of an image coupled with an appropriate fidelity term has been used in the image processing community for decades as a way to denoise images while preserving important information such as edges and smooth regions. Unfortunately, it also results in staircasing, replacing smooth transitions in color with disconnected flat regions. In this talk, we examine several methods based on the total variation functional for reducing staircasing, including one that uses edge detection to control smoothing and a scheme that minimizes second differences (instead of first) to better preserve ramps. These functionals can be minimized using the dual problem, which allows for a more accurate solution. We will also look at how these methods can be extended to decompose images into their cartoon and texture components. We will observe the effects of these algorithms on a variety of images.

Katherine Hoeck, Shepherd University

Approximating the Optimal Path of an Idealized Vehicle about Parameterized Curves: Part I - Rectilinear and Curvilinear Motion

The optimal path of an idealized vehicle can be approximated using parameterized curves. The kinematic equations and Newton's second law set the foundation for the differential equations that model the motion of the vehicle about the track. This talk specifically addresses rectilinear and curvilinear motion and the assumptions made throughout the remaining parts of this presentation.

Calvin Holic, University at Buffalo

Numerical simulation of quantum dot formation: coarsening and model limitations

We implement an unconditionally-stable numerical method to study the formation of quantum dots in a thin-film evolution equation for quantum dot growth. We use our method to determine rates of quantum dot coarsening and the effect of the wetting layer on quantum dot growth. Our results suggest that while early stages of quantum dot formation are adequately described by the thin-film approximation, longer term coarsening behavior requires a higher-order approximation to the elasticity problem.

Lihua Huang, University of California, San Diego

Uniqueness Results for Extremal Holomorphic Functions in the Bidisk

A function f(z) is holomorphic in a region of the complex plane if it has a complex derivative at every point in the region. A function f(z,w) is holomorphic in a region of two dimensional space if for any fixed z or w, we have f(z,w) is holomorphic in the other variable. We consider the situation where f(z,w) is holomorphic in an open unit bidisk $D^2=\{(z,w):|z|<1 \text{ and } |w|<1\}$ and prove a version of the Schwarz Lemma in the bidisk. Then we show that the uniqueness part of the Schwarz Lemma fails in the family of complex ellipsoids (still in two variables). Furthermore, we consider the case where f(z) as well as f(z,w) has other zeros and establish more general versions of the Schwarz Lemma. These generalizations of the Schwarz Lemma to the bidisk follow from a more general uniqueness result for extremal holomorphic functions in the bidisk.

In-Jee Jeong, Brown University

Bipartite Graphs, Quivers, and Cluster Variables

In 1991, D. Gale and R. Robinson found a large family of rational sequences which, with appropriate initial conditions, produced integer sequences. The full proof of integrality was unknown until S. Fomin and A. Zelevinsky came up with new mathematical object called "cluster algebra" in 2002. We will look at a particular connection between cluster algebras and combinatorics, which was first observed by J. Propp and G. Musiker in 2007. They looked at the weighted perfect matchings of a certain family of graphs and proved that they correspond to a certain cluster algebra. It turns out that this connection can be generalized by introducing the notion of “dual quiver.”

Christopher Mitchell, University of Texas at Arlington

Death of the Bees: A Mathematical Model of Colony Collapse Disorder

A mysterious problem has developed within honey bee populations; in a worst case scenario, bee hives will spontaneously collapse as the entire population disappears from the hive. This phenomenon has been named Colony Collapse Disorder (CCD). The problem is recent and has no known cause, though it is surmised to stem from one or multiple infections. In order to gain insight into its dynamics and possible causes, we have attempted to create a mathematical model. First, we establish a baseline model for the population dynamics of a single healthy hive, using a system of ordinary differential equations. To this model we then add equations which account for the disease affecting the population. Here we must take some liberties regarding assumptions of the disease source given how little is known about CCD, but our model accommodates both direct (bee-to-bee) and indirect (via contaminated plants as vectors) transmission. An analysis of the model's six equilibria including disease-free, endemic, and extinction states develops criteria for distinguishing among several scenarios, including both survival and extinction due to CCD. These criteria identify several key parameters which could offer insight into the nature of the cause of this colony collapse. All theoretical results are supported by a set of numerical simulations and are consistent with raw data regarding the dynamics of the disorder.

Kerri Nunnamaker, Washington & Jefferson College

Representation of an Integer as Harmonic Means

Some formulas in finance, geometry, and electrical circuits can be represented by harmonic means. We showed that any positive integer can be written as the harmonic mean of two positive integers, and the number of different ways it can be represented can be counted. The Egyptian fractions are the generalization of this idea. We also showed that any positive proper fraction can be written as a sum of the reciprocals of distinct positive integers. The Ahmes Papyrus dealt mainly with this problem. From this the 1948 Erdos-Straus Conjecture which says that for every positive integer n, 4/n can be written as a sum of reciprocals of at most three distinct integers, was formed.

Trenton Osborn, Baylor University

Strongly Non Embeddable Metric Spaces

The notion of the generalized roundness of a metric space was introduced by Enflo as a means to show that not every separable metric space may be uniformly embedded into a Hilbert space. He did this by constructing a countable metric space of generalized roundness 0 which could not be uniformly embedded into any metric space of nonzero generalized roundness. The conclusion then followed from the observation that Hilbert space has generalized roundness 2.

Dranishnikov, Gong, Lafforgue and Yu later modified Enflo's example to construct a locally finite metric space which may not be coarsely embedded into any Hilbert space. In this presentation the concept of generalized roundness is introduced, and the examples of Enflo and Dranishnikov et al. are simplified and melded into one locally finite metric space which permits neither uniform nor coarse embedding into any metric space of nonzero generalized roundness. This work was done in collaboration with Casey Kelleher and Daniel Miller, under the direction of Anthony Weston. Research was performed at the Cornell Summer Math Institute, with funding provided by the National Science Foundation.

Krzysztof Pawelec, Penn State University

Euler's Identity and Division of the Circle

In this talk we will explore a possible method that the ancient Greeks would have used to derive Euler's formula if they accepted existence of complex numbers. We will derive Taylor series for sine and cosine using elementary ideas from geometry and compare them to Taylor series for the exponential function.

Jenny Peterson, St. Olaf College

Generalized Roundness of Finite Graphs

The notion of the roundness of a metric space was introduced by Per Enflo as a tool to study geometric properties of Banach spaces. Recently, roundness and generalized roundness have been used in the context of group theory to investigate relationships between the geometry of a Cayley graph of a group and the algebraic properties of the group. In this talk we examine the generalized roundness properties of certain finite graphs. Specifically we look at cycle graphs, and also give a formula to compute the exact generalized roundness of windmill graphs. We also look at the generalized roundness of the five L_1 embeddable fullerene graphs and prove that they, in fact, all have generalized roundness equal to one. This research was done at the 2011 Cornell University "Summer Mathematics Institute" in collaboration with Toyin Alli and Kevin Vissuet.

Mary E Russell, Canisius College

Everyday We Shufflin': Analyzing Circular Decks and Probability Transition Matrices

We consider shuffling strategies for a circular deck of cards. This is a deck that does not have either a top or bottom, but rather treats each card as having a card above and below it. It is interesting to examine decks with this different structure as well as varying size of decks. We will analyze two methods of shuffling on a circular deck and prove the surprising fact that they are equivalent. Additionally, we will analyze the probabilities of transitioning between decks of cards that differ in size by a single card.

Glenn Sidle, Duquesne University

Image Fusion Using Gaussian Mixture Models

In recent years, many image processing tasks such as denoising, inpainting, and deblurring have been solved by finding optimal sparse image representations in a (possibly redundant) dictionary. Yu, Sapiro, and Mallat have shown that related representations can be found using Gaussian Mixture Models (GMMs). In this talk we demonstrate how the GMM approach can easily be applied to solve the image fusion problem, and compare some of its results to those using sparse and redundant image representations.

Luis Sordo Vieira, Wayne State University

Isoperimetric Problem in Surfaces with Density

It is well known that in the plane the least-perimeter curve that encloses a given area is a circle. But what if we give the plane a density that weights both area and perimeter? The log convex density conjecture says that if the density is radial and its log is convex, then circles about the origin minimize weighted perimeter for given area. We consider the borderline case of density e^r. Our partial results use symmetrization, generalized curvature, and the four vertex theorem to prove that a minimizer is convex and contains the origin in its interior. Furthermore, we give numerical evidence that circles about the origin are isoperimetric.

John Susice, University at Buffalo

Numerical simulation of surfactant-induced shape changes in quantum dots

We implement an unconditionally-stable numerical method to study the formation of quantum dots in a thin-film evolution equation for quantum dot growth. We then use our method to investigate the use of surfactants to generate novel quantum dot shapes. Our results show that, for the thin-film evolution equation, surfactants do not generate substantial changes in the morphology of quantum dots, only adjustments to the aspect ratio.

Michael Trogdon, University of Nebraska - Lincoln

Numerical Approximations for the Null Controllability of Parabolic-Like Partial Differential Equations

The finite element method is used to numerically approximate the null controllability process for certain partial differential equation (PDE) dynamics which exhibit analytic or "parabolic-like" features. These non-standard parabolic equations are particularly: (i) structurally damped elastic equations; (ii) thermoelastic PDE models which are free of rotational forces. It is known that each of these respective dynamics can be described by analytic semigroups. (As such, the problem of steering the PDE variables to the zero state is an appropriate one.) The numerical analysis in the physically relevant situation, when the support of the null controller might exist only on a strict subset of the spatial domain, is investigated (i.e., we are interested in the problem of locally distributed null control). Moreover, we are interested in tracking the asymptotics, or rate of blowup, of the approximating null controllers. The goal is one of gleaning information on the asymptotics of the limiting (infinite dimensional) null controller for the particular parabolic dynamics being considered (assuming that the constructed sequence of approximating null controllers does in fact give rise to a limit).

Wilber Ventura, The University of Texas at Arlington

Resting stages and the population dynamics of harmful algae

Due to their impact on many aquatic ecosystems, harmful algal blooms have been a topic of many recent studies. The unicellular species Prymnesium parvum, known as golden algae, releases potent toxins into its environment, which can kill large numbers of fish. P. parvum has been observed to have motile and non-motile states. The motile state is metabolically active and thought to produce toxin. The non-motile state may be less metabolically active and not produce much toxin. In our research, mathematical models are constructed to represented conversions between motile and non-motile states of P. parvum in a chemostat environment. Ordinary differential equations represent changes of P. parvum, nutrient, and toxin. These models represent either constant transition rates between motile and non-motile states or density dependent rates. We analyzed equilibria, stability, and connections between the population dynamics of motile and non-motile states and toxin concentration. Not much is known about the transition rates between these states; therefore, these simple models suggest patterns to explore experimentally.

Heidi Verheggen, Lafayette College

A Nonlinear Characterization of Ultrametricity

The generalized roundness of a metric space is a geometric property of distances between points in the space determined by a family of nonlinear inequalities. These inequalities are generalized versions of the familiar triangle inequality for metric spaces, but their nonlinear nature often makes the exact computation of generalized roundness a very difficult task. Consequently, the focus of this research was to explore the relationships between generalized roundness and other potential properties of a metric space. Such relationships may help to characterize spaces in terms of generalized roundness with little need for computation. In particular, a major component of the research involved examining the properties of metric spaces with infinite generalized roundness. In examining such metric spaces, we determined that infinite generalized roundness is equivalent to a property called ultrametricity. This result provides a relatively simple geometric characterization of ultrametric spaces. Thus, we present the proof of this characterization, and show how this result, in turn, allows for simpler proofs of several corollaries that were previously known and proven by more complex methods.

This project was joint work done with Timothy Faver (Loyola University Maryland) and Katelynn Kochalski (Canisius College), as well as program TAs Mathav Murugan and Elizabeth Wesson, at the Cornell University Summer Math Institute.

Caitlin VerSchneider, Nazareth College

Coloring Outside the Lines: Finding 4-Chromatic Unit Distance Graphs II

We explore the Hadwiger-Nelson Problem, which is to find the chromatic number of the plane, by describing a family of 4-chromatic unit distance graphs. We then demonstrate a method for finding graphs with certain chromatic properties.

In part II of the talk, we discuss our approach to proving and trying to narrow the bounds of the Hadwiger-Nelson Problem.

Kevin Vissuet, University of California, San Diego

Bounding the Generalized Roundness for Finite Graphs

The notion of the roundness of a metric space was introduced by Per Enflo as a tool to study geometric properties of Banach spaces. Recently, roundness and generalized roundness have been used in the context of group theory to investigate relationships between the geometry of Cayley graph of a group and the algebraic properties of the group. In this talk we discuss the generalized roundness of finite graphs where the distance between vertices are greater than two. Specifically we look at a method to compute the 1 -negative type gap of such graphs and then use this to give a bound for the generalized roundness of all triangulated cyclic graphs as well as some other finite graphs. This research was joint work done with Toyin Alli and Jenny Peterson at the 2011 Cornell University "Summer Mathematics Institute".

Kristina Woodside, Washington and Jefferson College

Tiling Deficient Chessboards with n-Polyominoes

An m x m board is called deficient if a 1 x 1 square is missing from anywhere on the board. An n-polyomino is a geometric shape formed by placing n equal squares edge to edge. With a fixed n, we prove that all deficient m x m boards can be tiled using n-polyominoes such that m^2-1 is divisible by n. We offer results for n=3, n=4, and n=5, and we discuss our progress toward a generalization for all n.

Jing Zheng, University at Buffalo

A Hybrid Radial Basis Function for Numerical Solutions of Vascular Flow and Mesh Generation

The human vasculature sometimes exhibits defects such as bifurcations, stenosis, and aneurysms, which produce turbulent blood flows and can lead to medical problems. Since immediate intervention is often required to treat such problems, it is useful to have accurate models of the blood flow near the problematic areas.

We employ a variety of techniques to create such models with high accuracy and speed. First, we introduce an innovative hybrid method - radial basis function method, which does not require a strict grid and is used to model the irregular parts of the blood vessel. In order to obtain a highly flexible grid for RBF, We implement center generation which make centers well distributed. A final goal is to develop a vascular library to make full computational fluid dynamics-quality result in real time.