

**The Sixteenth Annual
Nebraska Conference
for Undergraduate Women
in Mathematics**

January 31 - February 2, 2014

TALK ABSTRACTS

PLENARY TALKS

Dr. Cynthia A. Phillips
Senior Scientist
Sandia National Laboratories
Sensor Placement For Municipal Water Networks

I will consider the problem of placing a limited number of sensors in a municipal water distribution network to minimize the expected impact over a given suite of contamination incidents. In its simplest form, the sensor placement problem is a p -median problem, a classical facility location optimization problem. Although formally difficult to solve, most real-world p -median problems have structure extremely amenable to exact and heuristic solution methods.

I will describe the solution of real-world instances using integer programming (IP) and local neighborhood search. An integer program is the optimization of a linear objective function subject to linear constraints and integrality constraints. It is a powerful modeling tool for combinatorial optimization problems. There are excellent commercial and free solvers that can handle large instances. I'll also discuss related methods such as randomized rounding, and techniques for solving more complex, more realistic sensor placement models.

These algorithms are or will be incorporated into the TEVA-SPOT toolkit, a software suite that the US Environmental Protection Agency has used and is using to design contamination-warning systems for US municipal water systems.

This is joint work with many colleagues at the EPA and at Sandia National Laboratories.

Dr. Gigliola Staffilani
Abby Rockefeller Mauze Professor of Mathematics
Massachusetts Institute of Technology
From Disorder to Order: How A Mathematician Sees Life and Work

In this talk I will start by recounting how and why I became interested in mathematics on an early age. I will describe some of the obstacles I faced in my career and the encouragements I received along the way and how my taste in mathematics changed also in terms of researches I met through my life. I will also explain with simple example what are the mathematical questions I am interested on and I will present some basic tools that I use in my research.

Talks by Undergraduate Students

Laura Allen, University of Nebraska at Omaha

The Impact of Perturbations on Biochemical Signal Transduction Networks

Anomalies within signal transduction networks can greatly affect a cell's function and result in disease. Dynamic computer models of complex biochemical processes can be simulated in thousands of environments, including diseased states, which can result in novel and improved drug therapies. Here, we present a computational approach to study the systematic effects of perturbations on a network using the Cell Collective platform (www.thecellcollective.org). R statistical tool was used to analyze data of a large-scale dynamic model of signal transduction in generic cells. We have identified proteins that are most influential on the network, and those that are most susceptible to these perturbations. Also, we found proteins that are most sensitive to perturbations. We have also found the combination of protein properties is a better predictor for perturbation effects than each individual property. These results can be used for identifying potential drug targets and the source of side effects in existing drugs.

Elizabeth Annoni, University of St. Thomas

Nicole Lopez, University of St. Thomas

Comparing Methods for Classifying Open Knots

The recent discovery of knotted behavior in proteins has stimulated discussion about how to classify knots in open chains. Topologically speaking, all open arcs are equivalent to a straight line. However, there may still be entanglement present in an open chain that intuitively resembles a knot. The goal of this project is to compare two methods for classifying that entanglement. The first method connects each of the two endpoints of the open chain to points distributed on a sphere to close the knot and calculate which knot type is most prevalently found. The second method creates random arcs that connect the two end points, which again closes the knot and enables the calculation of the knot type found in the entanglement. These two methods are compared to determine the most precise and computationally efficient method for classifying an open knot.

Katherine Boligitz, La Salle University

Distinguished-Color Rainbow Connection in Graphs

In an edge-colored graph G , a path is said to be a rainbow path if no two of its edges share a color. The rainbow connection number of a connected graph G , denoted by $rc(G)$, is the minimum number of colors needed to color the edges of G in such a way that there exists at least one rainbow path between every pair of vertices. We introduce an additional condition involving a distinguished color. It is not always possible to satisfy both this new condition and rainbow connectedness with just $rc(G)$ colors; this leads to the definition of the distinguished-color rainbow connection number of a graph G , denoted by $drc(G)$. We present results for $drc(G)$ for several specific classes of graphs and look at general relationships between $drc(G)$ and $rc(G)$. We also investigate related questions involving path length. We will look at various applications using this new distinguished edge.

Tai-Danae Bradley, The City College of New York
The Distribution of the Greatest Common Divisor of Gaussian Integers

For a pair of random Gaussian integers chosen uniformly and independently from the set of Gaussian integers of norm x or less as x goes to infinity, we find asymptotics for the average norm of their greatest common divisor (GCD) with explicit error terms. We also conjecture results for the higher moments of the norm of the GCD and present computational data which support the conjecture for the second, third, fourth, and fifth moments. The analogous question for integers is studied by Diaconis and Erdos.

Amanda Bright, Westminster College
An Algebraic Approach to Tile Invariants

For a given set of n tiles over a region, a tile invariant is a function of the appearances of the tiles in any tiling of the region. We define the subgroup I of \mathbb{Z}^n to be the differences between the tile counts that can arise from any two tilings of a given region. The tile counting group, $\mathbb{Z}^n = I$, tells us the size of the group of tile invariants of the tile set over our regions. We will discuss how the tile counting group, $\mathbb{Z}^8 = I$, is proven for the tile set of all skew and t-tetrominoes over annular regions of width 2. Our results will show $\mathbb{Z}^8 = I$ is isomorphic to $\mathbb{Z}^3 \times \mathbb{Z}_2$.

Alisha Cardanini, University of California, Merced
Light Propagation in Low Scattering Regions of Tissue

Light propagation in tissues is an emerging topic in biomedical optics with several applications in therapy and diagnosis. In this case we study light propagation in medium composed of both low and high scattering regions. Tissue typically scatters light very strongly, which allows for simplifications in modeling. However, within an infant's brain, there exists an internal region of cerebrospinal fluid with low scattering properties. This discrepancy poses a challenge when modeling photon transport between mediums. Our model incorporates this low scattering region by applying a geometric analysis based on a single scattering approximation. This analysis leads to an expression for the albedo operator which provides the range of light exiting the low scattering region due to an arbitrary distribution of light entering into the region. Using a newly established two-region model, we may begin to develop new approximations leading ultimately to novel models needed for neonatal brain imaging.

Mikaela Cashman, Coe College

Bar Code Localization in Images Using Neural Network and Linear Discriminant Analysis Frameworks

We develop an algorithm for the automatic localization of 1-D bar codes in images using machine learning techniques. Despite the ubiquity of operational bar code scanners, we focus on low resolution camera-based scanners and challenging environments where traditional methods fail. We develop attributes that help distinguish bar codes from other objects in the image such as text and logos. These attributes are based on the discrete wavelet transform (DWT), the discrete Fourier transform (DFT), and gradient analysis. To create a bar code detection process robust to image distortions such as rotation, glare, noise, oblique viewing angle, uneven and dim illumination, and an abundance of surrounding text, we use the information from our individual detection methods in neural network, linear discriminant analysis (LDA) frameworks, and simple boosting. We analyze the effectiveness of these attributes and report on performance for a range of degraded images.

Kelly Cercy, Furman University

Math in the City: Parking Optimization in Downtown Greenville

The city of Greenville, located in upstate South Carolina roughly between Atlanta and Charlotte, owns and operates nine garages that offer monthly parking rates. City representatives from Economic Development say the city is growing, and employees of the Department of Public Works' Parking Services see the parking picture as one that is filling up quickly. Some garages are already reaching capacity, and there will be added pressure as the economy grows. Thus the city asked Furman University to research downtown parking for the more than 4,000 monthly pass holders (primarily from businesses downtown). We set out to answer these questions with the goal to make the commute for pass holders as convenient as possible. Convenience translated to minimizing total walking distance, a perspective that was new to the city. We will study current usage and industry standards to improve logistics, and then analyze efficiency and capacity to determine the need and location for a new garage.

Isabel Corona, Metropolitan State University of Denver

The Algebra of Block Permutations

A *block permutation* of $[n] = \{1, 2, \dots, n\}$ consists of two set partitions $\mathcal{A}, \mathcal{B} \vdash [n]$ having the same number of blocks and a bijection $f : \mathcal{A} \rightarrow \mathcal{B}$. We show that the set of block permutations of $[n]$, BP_n , is closed under multiplication and hence is a monoid. We define a Hopf algebra of block permutations, a generalization of the Hopf algebra of uniform block permutations. Furthermore, we study the subalgebra of planar diagrams, P_n , and give a presentation for both P_n and BP_n . We consider the planar rook algebra RP_n and show that it is isomorphic to P_{n+1} . Using this isomorphism we can give all the irreducible representations for P_{n+1} . In addition, we are in the process of constructing the irreducible representations for BP_n .

Lauren Crider, Arizona State University
Fuse-Analyze Versus Analyze-Fuse

Ongoing work with the University of Michigan has shown that "analysis before fusion" can be advantageous in certain multi-source statistical signal processing situations. This talk explicitly investigates the effect pre-processing to sensor weak channels prior to multi-channel processing on the performance of an established multi-channel signal detection method.

Elizabeth DeCarlo, Duquesne University
Inferring Authorship Through Myers-Briggs Type Inventory and Naive Bayes

In order to solidify our results with the Myers-Briggs personality analyzer, we decided to apply Bayesian Parametric Inference. By using this technique, we calculate the likelihoods of Mitchell or Young having written American Husbandry. Applying this method to the corpora, results were as follows, $P(\text{Mitchell}|\text{AmHus1}) \propto 1.132 \times 10^{-10}$ $P(\text{Young} | \text{AmHus1}) \propto 1.025 \times 10^{-8}$ $P(\text{Mitchell}|\text{AmHus2}) \propto 9.095 \times 10^{-13}$ $P(\text{Young}|\text{AmHus2}) \propto 1.203 \times 10^{-9}$ The distinction between Mitchell and Young is quite apparent in this application of Bayes, with Young as the more likely author of American Husbandry by about 100 times. This novel approach to authorship attribution produced distinct results unlike the distance functions utilized in previous experimentation. These methods will increase accuracy as well as solidify the results of similar, inconclusive inquiries.

Stephanie DeGraaf, Iowa State University
Julia (Ruyue) Yuan, Valparaiso University
Avoiding Permutation Patterns in Ordered Set Partitions

We consider the enumeration of ordered set partitions avoiding a permutation pattern. Recently, many results have been published concerning this topic, including enumerative results by Bruner, Chen et al., Godbole et al., and Kasraoui. We specifically consider Kasraoui's summation formula for the number of ordered set partitions that avoid a pattern of length 3, and analyze it in a variety of ways. Through parameterization, we find the value of i for which the maximum value in the sum occurs. We develop a simplified approximation of the formula, and we then obtain a lower bound for the resulting sum. All results are thus asymptotic but the number of parts in the partition is allowed to grow to infinity with n .

Daria Drozdova, Pomona College
Solvability of Linear Nonhomogeneous Second-Order Two-Point Boundary Value Problems

My thesis is on the topic of ordinary differential equations. I will consider the following BVP:

$$\begin{aligned} -u''(x) &= \lambda u(x) - f(x) \text{ in } (0, \pi), \\ u(0) &= 0, \\ u(\pi) &= 0. \end{aligned} \tag{1}$$

In order to make conclusions about its solvability, I need to prove that the Fredholm Alternative holds for $f(x) \in L^1(0, \pi)$. After reformulating this problem in terms of operators, I will apply the theory of compact operators between Banach spaces.

Kate Ehnis, Texas Tech University
Stacy Philip, Texas Tech University
Sonification of EEGs

Ten patient Electroencephalogram (EEG) recordings were selected from a study conducted at a Lubbock hospital. These recordings include 8 normal and 2 abnormal EEGs, which were stripped of personal identifying information. Recent publications indicate that sonification (converting data to sound) allows the human ear to analyze series data and detect irregularities that might otherwise go unnoticed. Since brain rhythms are typically lower than the human hearing range, signal-processing techniques, including but not limited to modulation, Fourier transforms, wavelet analysis, and digital filtering, will be applied to convert EEGs to sound. Our objective is to demonstrate that in addition to traditional visual analysis, auditory acuity may be useful in the analysis of EEGs and aid in the early detection of abnormal EEG activity. The project will be a success if an algorithmic approach to sonification leads to the identification of important features of the EEGs by listening to the transformed signals.

Elizabeth Galvin, Marist College
Long-Term Behavior of Solutions to a Nonlinear Wave Equation

The goal of our research was to investigate numerically the stability of the one-dimensional nonlinear wave equation $u_{tt} - u_{xx} + u^2u_t = 0$, where $u = u(t, x)$ represents the vertical displacement of a taut thin elastic string at x and time t , with the string fixed at its ends. The nonlinear term models the loss of energy of the oscillations due to friction. Equations of this type have been addressed before, but many questions concerning the dissipation of the energy remain open. Because the friction weakens at smaller amplitudes, it is difficult to prove that the string approaches the equilibrium configuration over time. We began by using a contraction mapping argument to analytically prove existence and uniqueness of solutions for appropriate classes of initial conditions. We then looked at numerical methods for solving this equation, ultimately using a combination of the Finite Element method and a Fixed Point method. After finding solutions, we looked into the energy decay rates of the system.

Yaxi Gao, Harvey Mudd College
The Krasnosel'skii Zero Theorem

We develop a combinatorial proof of the Krasnosel'skii Zero Theorem which shows the existence of a zero of a continuous map from the n -ball to R^n satisfying a particular boundary condition: that the inner product of any point on the boundary with its image is non-negative. Our proof builds a direct connection to Sperner's Lemma and produces an algorithm for approximating zeros. It also suggests a promising way to weaken the boundary condition.

Alessandra Graf, Northern Arizona University
Recent Developments Concerning Two Conjectures by Frucht

A graceful labeling of a graph G with q edges is an injective assignment of labels from $\{0, 1, \dots, q\}$ to the vertices of G such that when each edge is assigned the absolute value of the difference of the vertex labels it connects, the resulting edge labels are distinct. In a 1978 paper, Roberto Frucht made some intriguing conjectures while investigating graceful labelings of coronas $C_n \odot K_1$. We will summarize results from recent papers that address these conjectures, and discuss some newer developments.

Hannah Guth, Marquette University
Launching into Problem-Based Lessons

In this talk I will discuss (1) the characteristics of the introductory segment (launch) of the problem-based lesson and (2) the aspects of the lesson launch that teachers find most difficult as they plan how to introduce the problem-based lesson. The presented results come from the analysis of 32 video recordings of problem-based lessons and 26 interviews with individual teachers.

Kristine Harjes, McDaniel College
Functional Dependence in Strategic Games

My research in game theory examined properties of functional dependencies between strategies of players. If knowing the strategy of player a in a Nash equilibrium of a game, one can predict the strategy of player b, we say that player a functionally determines player b. The main result is an axiomatization of all properties of functional dependence for any given set of strategies and resulting pay-offs for players.

Elizabeth Kelley, Harvey Mudd College
A Combinatorial Approach to the Meunier-Babson Theorem

We present a constructive combinatorial approach to the Meunier-Babson theorem, a generalization of the classical Sperner's Lemma that allows triangulated simplices to have multiple labellings, and asserts the existence of elementary simplices with particular labelling schemes. Our path-following argument solves, and offers a strengthened result for, particular cases of the theorem. This strengthening allows the Meunier-Babson theorem to be applied to questions of fair division, such as rental harmony or cake cutting.

Elizabeth Knapper, Mercer University
Predicting Atlantic Sun Volleyball Tournament Outcomes

Predicting tournament brackets is a favorite activity for many sports fans. Although there is no flawless way for prediction, mathematical models are now being used to predict the outcome of a bracket. In the Colley Matrix Method, each team's rating depends on other team's ratings, instead of a straight win-loss record. The Colley method is often called a "strength of schedule" method. In the Massey Matrix Method, the ratings depend on the margin of victory and win/loss record. Using these methods, we have a different prediction than the standard win/loss record for sports brackets, specifically for the 2012 and 2013 Atlantic Sun Women's Volleyball Conference Tournaments. Keener's Method ranks teams, not on wins and losses, but non-negative statistics that result from the competition. Keener's method measures how strong a team is compared to the strength of its competitors. We chose to use the number of kills from a volleyball match and Keener's method to find another tournament prediction.

Deborah Koch, Sam Houston State University
Mathematical Modeling of Social Dynamics with Applications to Real-World Problems

In this presentation, a mathematical social dynamics model is formulated to describe the interactions of two populations within two regions. The model consists of a system of differential equations which can be applied to various situations. One application of interest is modeling how the concentration of English and Spanish language speakers in neighboring regions changes over time due to the interactions of the residents within the regions. Through stability analysis, it is shown that there are four characteristic scenarios with real-world interpretations. However, when regulation parameters which represent outside factors such as government ordinances are incorporated into the model, the possible scenarios become even more complicated and interesting. Finally, the model is extended to include three interacting regions with results analogous to the two-region model.

Taryn Laird, Northern Arizona University
Trees of Irreducible Numerical Semigroups

A 2011 paper by Blanco and Rosales describes an algorithm for constructing a directed tree graph of irreducible numerical semigroups with fixed Frobenius numbers. We will explain the algorithm, construct examples, present new findings, and state several conjectures about these directed tree graphs.

Alecia Lambert, Western State Colorado University
Exploring Recommender Systems

Using collaborative filtering techniques, I have designed a miniature recommender system, inspired by how I anticipate Pandora operates. There are two types of collaborative filtering strategies that contributed to this investigation: user-based filtering and item-based filtering; depending on the responses from users, one is more advantageous than the other. The algorithm produced from these varying strategies is one that computes how closely related the target song is to the previously rated song. By incorporating varying techniques and attributes of music, a hybrid similarity calculation can be made resulting in an even stronger recommender system!

Sarah Lange, College of Saint Benedict
Colored-Independence

Colored-independence is a form of graph labeling for scheduling problems in which various constraints are placed on elements. These constraints involve restrictions on the pairing of elements and also the forcing of elements to be placed together. A set S is a colored-independent set if, for each color class V_i , $S \cap V_i = V_i$ or $S \cap V_i = \emptyset$. Results for the upper independence-number, $\beta(G)$, the lower independence-partition number, i_{PRT} , and the independence-coupled number, i_{CPL} , will be presented, including paths, grids, and a characterization of tree graphs and a partial characterization of bipartite graphs that achieve $i_{PRT}(G) = |V_1|$ where V_1 is the smaller of the bipartition sets of graph G . The lower independence-partition number, i_{PRT} , regarding the properties of disconnected graphs will also be examined.

Uyen Le, Seattle University
BVP: The Unified Transform Method vs Separation of Variables

Separation of variables is one of the classical techniques for solving partial differential equations. However, separation of variables only works for a restricted class of partial differential equations. The unified transform method, developed by Fokas and his collaborators, is a new technique to solve certain initial boundary value problems in one spatial dimension including some that cannot be solved using separation of variables. In this talk, I will use the unified transform method to find the explicit solution of a heat equation with a forcing term on a finite interval. Then, I will compare the result to the solution that is obtained via classical methods.

Lauren Lembcke, Indiana University-Purdue University Indianapolis
Using Mathematics to Investigate Integrin Activation in Inhibited Cell Migration

The process of wound healing requires the migration of cells into a wounded region to restore tissue function. Cell migration is regulated by a complex signaling network involving the activation of protein structures known as integrins. If integrin activation is too high or too low, cell migration is reduced or inhibited. In disease cases such as necrotizing enterocolitis (NEC), cell migration has been observed to be impaired, likely in part due to an overactivation of integrin proteins. In particular, components of bacterial walls bind with Toll-like receptor 4 on the intestinal epithelium and trigger a signaling cascade that causes integrin activation. This study aims to elucidate the steps in the signaling cascade which contribute most significantly to the overactivation of integrins. A mathematical model of ordinary differential equations is used to investigate the factors that have the greatest influence on integrin activation and consequently cell migration.

Jennifer Loe, Oklahoma Christian University
2-tone Colorings in the Direct Product of Graphs

A variation of graph coloring known as a 2-tone k -coloring assigns a set of 2 colors from the set $\{1, \dots, k\}$ to each vertex of a graph. If two vertices are adjacent, the sets of colors assigned to them have no colors in common, and if two vertices are distance 2 apart, the sets of colors assigned to them have at most 1 color in common. The minimum integer k such that a graph G has a 2-tone k -coloring is known as the 2-tone chromatic number. We study the 2-tone chromatic number of the direct product of graphs. In particular, we give a formula for the 2-tone chromatic number of the direct product of two complete graphs and give bounds for the 2-tone chromatic number of the direct product of any two graphs $G \times H$.

Nicole Lopez, University of St. Thomas
see **Elizabeth Annoni**

Denali Molitor, Colorado College
The Generalized Symmetric Tequila Problem: Influence and Independence in Symmetric N-Player Games

I examine symmetric n -player games that exhibit influence and independence. These games include n dichotomous random variables we call causes, whose values determine the probabilities of the values of n dichotomous effects. We denote the spaces of probabilities that exhibit independence and influence among n players as $Ind(n)$ and $Inf(n)$ respectively. We denote their intersection by $GST(n)$, which stands for Generalized Symmetric Tequila. M. Steel and A. Taylor prove in "The Structure of Symmetric N-Player Games when Influence and Independence Collide" that $GST(n)$ is connected for $n > 8$ and disconnected for $n = 3, 4$. I show that $GST(n)$ is connected for $n = 5, 6, 7$ and $GST(4)$ is comprised of two connected components. These proofs rely on concepts from topology, probability and game theory. I also present several applications that provide examples of scenarios in which the conditions of $GST(n)$ apply.

Aleesha Moran, McKendree University
Factorization Properties of Leamer Monoids

Numerical semigroups have long been studied for their interesting algebraic properties. Given a numerical semigroup Γ and $s \in \Gamma$, the collection of arithmetic sequences with step size s contained in Γ naturally forms a monoid, denoted as S_Γ^s . We refer to these monoids as Leamer monoids. These monoids were originally constructed to study special cases of the Huneke-Wiegand conjecture. We provide foundational results for the factorization theory of Leamer monoids.

Saba Nafees, Texas Tech University
Modeling Positions Coupled to F508, Site of Chief CF Causing Mutation

Cystic fibrosis is a genetic disease that arises due to misfolding of the protein CFTR. Analyses of the mutation data could show the way the various mutations act to produce disease. A typical way to do this would be to use multivariate polynomial regression. We use Orthogonal Polynomials and dual bases for multivariate data. The observed distribution of mutations defines a covariant basis and a contravariant basis. Projecting different responses into these and taking the covariance would yield their interrelation. We will build functions that capture the properties of the mutations of CFTR, so that we can assess each mutation's interaction with other mutation(s). This will provide insight into the mechanism of the misfolding problem. The orthogonal and dual spaces approach conserves intrinsic biological properties of any phenomenon being tested while simultaneously capturing its quantitative properties.

Samantha Petti, Williams College
Applying the Bracket Polynomial to Multi-Crossing Projections

The recently defined n -crossing is a singular point in a projection at which n strands cross so that each strand bisects the crossing. We generalize to n -crossing number the classic result of Kauffman, Murasugi, and Thistlethwaite, which relates the span of the bracket polynomial to the double-crossing number of a link, $span\langle K \rangle \leq 4c_2$. In this paper we find the following lower bound on the n -crossing number in terms of the span of the bracket polynomial for any n :

$$Span\langle K \rangle \leq \left(\left\lfloor \frac{n^2}{2} \right\rfloor + 4n - 8 \right) c_n(K).$$

Stacy Philip, Texas Tech University
see **Kate Ehnis**

Casey Pinckney, Seattle University

A Symmetric Breakfast: Automorphism Groups of Compact Riemann Surfaces

Symmetries of surfaces may be described via group theory. The kinds of symmetries available depend on the number of holes in the surface. For example, a rotation of one third can never be a symmetry of a surface with four holes. When the symmetries of a surface display certain algebraic properties that correspond to some group, we say that this group acts on the surface. These rotation-surface pairs can also be represented numerically. We have identified a certain class of groups that, when acting on given surfaces, give rise to nice numerical representations. In particular, we have identified upper and lower bounds on the number of these groups that can act on a given Compact Riemann Surface. In this presentation, I will present results from the summer 2013 Research Experience for Undergraduates (REU) project at the University of Portland.

Meg Protzman, McDaniel College

Functional Dependence Between Boolean Variables

Functional dependence relations between sets of variables were axiomatized by Armstrong in 1974. I investigated this relation between single variables in a special case when all variables have the same fixed number of values. In the boolean case of just two values we were able to give a complete axiomatization. In a more general case of 3 values we found non-trivial properties, but were not able to prove completeness.

Laura Ramm, Benedictine College

How Middle and High School Students View Equality and the Equal Sign

Equality on a set is an example of an equivalence relation, a relation with three properties: reflexive, symmetric and transitive. A symbol that indicates equality is the equal sign. What students know about equality largely demonstrates in their understanding of the equal sign and the way they use that symbol. In this talk I will discuss how middle and high school students understand and use the equal sign in their mathematical work. The results are based on the analysis of 607 middle and high school students solutions to 8 arithmetic and algebra-based tasks.

Teresa Ratashak, University of Oklahoma

Ranking Math Departments Using the Google PageRank Algorithm

Currently, math graduate departments are ranked subjectively by department heads and directors of graduate studies, so we tried to rank math departments objectively using the Google PageRank algorithm. This algorithm ranks webpages based on the number and quality of the pages that link to a particular webpage. We explored how the Google PageRank algorithm can be applied to ranking math graduate departments by using Ph.D. graduates as the linking structure. We computed different rankings using the algorithm, but because of the differences between webpages and math departments, we were not able to come up with a ranking that adequately compared math programs of substantially different sizes.

Hailee Reist, Wartburg College
A Genome-wide Association Study of Glaucoma and Age-related Macular Degeneration

Genome-wide association studies (GWAS) are popular in locating genetic factors underlying complex human traits. This study involves 400 glaucoma patients and 400 age-related macular degeneration (AMD) patients. The goal of this study is to conduct a GWAS analysis in order to identify genetic factors affecting these two traits. Each patient is genotyped with Affymetrix GeneChip Mapping 500K Array Set or GeneChip Mapping 500K Assay. The distributions of genotypes between glaucoma patients and AMD patients are compared using the Pearson's Chi-Squared Test. Forty-four significant SNP sites were found at a significance level of 10^{-8} . The most prominent signals are located on chromosome 1, 3 and 10.

Sarah Renfro, Sam Houston State University
Knot Mosaics and Hextiling

Knot theory is a rapidly growing field in topology. Consequently, open questions are still being created. Samuel Lomonaco and Louis Kauffman recently introduced a new field in knot theory called knot mosaics, knot diagrams laid onto square tiles. My poster illustrates knot mosaics when expanded to hexagon tiles and compares the hexagon tiling of stacked knots and Montesinos knots.

Jessica Robins, University of Tennessee Knoxville
The Loewner Equation driven by the Weierstrass Function

The Loewner Equation was developed in 1923 by Charles Loewner, and it provides a correspondence between functions (called driving functions) and two-dimensional sets. In 2000, Oded Schramm discovered that if Brownian motion is the driving function, then the Loewner equation gives an important family of curves (named Schramm-Loewner Evolution), which were used in solving long-standing open problems. This motivated our interest in studying properties of the Loewner Equation. In particular, we are studying the properties of the two-dimensional sets when the driving function is a multiple of the Weierstrass function, which is the first published example of a continuous, yet nowhere differentiable function. In our research, we have found that when the driving function is a multiple of the Weierstrass function, then the corresponding sets have at least one phase transition similar to the behavior of Schramm-Loewner Evolution.

Sarah Salmon, Northern Arizona University
A factorization of Temperley–Lieb Diagrams

The Temperley–Lieb Algebra, invented by Temperley and Lieb in 1971, is a finite dimensional associative algebra that arose in the context of statistical mechanics. Later in 1971, R. Penrose showed that this algebra can be realized in terms of certain diagrams. In the cases when diagrammatic representations are known to exist, it turns out that every diagram can be written as a product of “simple diagrams.” These factorizations correspond precisely to factorizations in the underlying group. Given a diagrammatic representation and a reduced factorization of a group element, it is easy to construct the corresponding diagram. However, given a diagram, it is generally difficult to reconstruct the factorization of the corresponding group element. In cases that include Temperley–Lieb algebras of types A and B , we have devised an algorithm for a reduced factorization for a given diagram.

Shan Shan, Agnes Scott College
Periodicity of Third-Order Linear Recursive Sequences

In 2011, Franzel, Psalmond, and Tobiasz provided a necessary and sufficient condition for a number k to be the period length of an integer sequence described by a second-order recurrence relation modulo a prime p . Here, we extend their techniques to sequences described by third-order recurrence relations. We show that any such sequence modulo p has period length dividing $p^3 - 1$, $p^2 - 1$ or $p(p - 1)$. Conversely, any divisor of these three numbers can be realized as a period length for some such sequence.

Allison Smith, Xavier University
Hospital Charge Function Estimation and Study of Some Interactions: A Case Study of Diabetes

In this presentation, the backward elimination regression method is proposed to model ‘charges’ for diabetic patients. Although charges and cost functions are related, literature shows that both economic theory-based methods and regression based-methods found in literature have singularly employed modeling the cost function (Business company’s interest). In this study, an interactive multivariate regression method for modeling charges (Patients’ interest) is found. Moreover, various first order interactions among explanatory variables of ‘charge’ are investigated.

Lindsey Smith, University of Wisconsin, Madison
An Exploration of Food Webs Through Graph Theory

A food web can be modeled by a digraph, D , where there is an arc from vertex x to vertex y if species x preys on species y . The (1,2)-step competition graph of this food web, $C_{1,2}(D)$, introduced in 2010 by Factor and Merz, has the same vertex set as D and has an edge (x, y) if and only if there exists a vertex $z \neq x, y$ such that either $d_{D-y}(x, z) = 1$ and $d_{D-x}(y, z) \leq 2$ or $d_{D-x}(y, z) = 1$ and $d_{D-y}(x, z) \leq 2$. In this presentation we partially characterize the digraphs which generate (1,2)-step competition graphs which are complete on all nonbasal vertices.

Lena Snyder, Arizona State University
Computational Modeling of Glioblastoma Multiforme

Glioblastoma Multiforme is an aggressive and deadly form of brain cancer with a median survival time of about a year. Due to the unique growth of each tumor, it is difficult to anticipate where the tumor will spread in the brain which makes treatment planning difficult. Archival patient data of MRI scans depicting the progress of different tumors have been helpful in developing a model to predict Glioblastoma proliferation, but the scans lack important information from the tumor's initial growth period. Currently the model is being improved to more accurately reconstruct these early stages using a basic mathematical model defined by principles of diffusion to represent the rate of growth and directionality of the tumor over time. The goal of this research is to produce a model capable of predicting patient specific tumor growth under various treatment options such as surgery, chemotherapy, or radiation, to provide insight on which treatment is best for each patient.

Abby Stevens, Grinnell College
The Broken Ptolemy Algebra: A Finite-Type Laurent Phenomenon Algebra

Type A, or Ptolemy cluster algebras are a prototypical example of finite type cluster algebras, as introduced by Fomin and Zelevinsky. Their combinatorics is that of triangulations of a polygon. Lam and Pylyavskyy have introduced a generalization of cluster algebras where the exchange polynomials are not necessarily binomial, called Laurent phenomenon algebras. It is an interesting and hard question to classify finite type Laurent phenomenon algebras. Here we show that "breaking" one of the arrows in a type A mutation class quiver surprisingly yields a finite type LP algebra, whose combinatorics can still be understood in terms of diagonals and triangulations of a polygon.

Brittany Street, Missouri State University
Analyzing Databases for Patterns in Customer Usage for a Company

This project, based on research done at an REU at Worcester Polytechnic Institute in Summer 2013, focused on gleaning information from large databases from a sponsor company for information that may improve their operations. Companies are now able to acquire a vast amount of data but it is useless unless patterns can be obtained and interpreted. This involves the knowledge and discovery in database process. The talk will discuss the steps in this process along with some of the data mining techniques used. In this talk I will explain how these techniques work and how they apply to solving problems dealing with large data in industry.

Kelsey Swerdfeger, Concordia University Irvine
Solving Systems of Equations Using Groebner Bases

In linear algebra, we solve linear systems of equations using matrices. However, solving a general system of equations is a more difficult problem. We can use Groebner bases, an algebraic tool, to simplify this problem. Groebner bases can be used to solve systems of equations in many different applications such as sudoku puzzles, graph colorings, and robotics.

Aubrey Thompson, University of Nebraska-Lincoln
The Role of Inhibition on Dynamics in Clustered Networks

Understanding how cortex behaves when an organism is at rest is a problem under consideration in recent studies. Observations suggest that connections between neurons are not purely random, but exhibit a clustered structure. A recently-developed version of a common mathematical neural model implements this clustered architecture and results in simulations that match experimental data. These models are designed such that the excitation and inhibition of the network is in balance, which can be complicated to disturb. By implementing clusters in simpler neural models, inhibition's effect can be examined more carefully, and thus we can study the clusters' behavior in an unbalanced system.

Wenda Tu, Washington and Lee University
Finding Cycles in The k-th Power Diagraphs Over Integers Modulo A Prime

Given p prime and k a positive integer, we define $G_p^{(k)}$ to be the diagraph whose set of vertices is $\{0, 1, \dots, p-1\}$. There is a directed edge from vertex a to vertex b if $a^k = b \pmod{p}$. Our research focuses on the existence of length- t cycles in $G_p^{(k)}$ given t both prime and composite integers.

Ashley Webber, Arizona State University
Mathematical Modeling of Multi-focal Brain Tumors

This talk will discuss some stochastic modeling approaches for the growth of high-grade malignant brain tumors (glioblastoma multiforme) on realistic geometries. I will describe and justify the addition of an Ornstein-Uhlenbeck process to model the local growth rates of the tumor and will show qualitatively good agreement with actual patient cases of multifocal tumors.

Jordan Whitener, Truman State University
Dynamics and Bifurcations in Variable Population Interactions

The type of interaction between two species is not necessarily fixed, but may vary depending on population densities, environmental conditions, or other biological factors. In this research, parabolic functions will be used to model the interspecific relationship. Existence and local stability of equilibria, bifurcations, periodic orbits, and boundedness are studied. Examples illustrating the results are given and the impact of harvesting is discussed.

Julia (Ruyue) Yuan, Valparaiso University
see **Stephanie DeGraaf**