Abstracts for the MAA Undergraduate Poster Session

New Orleans, LA
January 8, 2011

MAA
MATHEMATICAL ASSOCIATION OF AMERICA

Abstracts for the MAA Undergraduate Poster Session

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Joyati Debnath
Winona State University

Organized by the MAA

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Titles, Authors, Advisors and Abstracts

1. The Calculus Problem

Jessica Bass UAB
Advisor(s): John Mayer, UAB

Every calculus student today uses the method of exhaustion as it provides a formula to evaluate the definite integral of any continuous function. But how far can this idea be pushed while still retaining a geometric flavor?

The project then morphed into two directions producing the following results:

- We look at planar figures that are bounded by a simple closed curve and have Jordan measure, and show that as long as the base of the cone is bounded and has Jordan measure, the volume of the cone is always going to be $\frac{1}{3}A_B h$.
- The volume of a Platonic solid was determined by coning from its center over the faces, and the volume formulas, in terms of face areas, and in terms of edge lengths, were obtained.

We define Jordan measure to be the following: Let M be a bounded set in the plane. The outer Jordan measure of M is the greatest lower bound of the areas of the coverings of M, consisting of finite unions of rectangles with sides parallel to the coordinate axes. The inner Jordan measure of M is the difference between the area of the enclosing rectangle S, and the outer measure of the complement of M in S. The Jordan measure, when it exists, is the common value of the outer and inner Jordan measures of M.

2. Category $\mathcal{O}$ for the Rational Cherednik Algebra of G_{12}

Christopher Policastro MIT
Advisor(s): Martina Balagovic, MIT

The rational Cherednik algebra of a complex reflection group W with reflection representation $\mathfrak{h}$, denoted $H_c(W, \mathfrak{h})$, is a deformation of $\mathbb{C}[W] \ltimes S(\mathfrak{h}^* \oplus \mathfrak{h})$ depending on certain complex parameters. Since little can be said about arbitrary representations of $H_c(W, \mathfrak{h})$ for different parameters, recent study has focused on $H_c(W, \mathfrak{h})$-modules in a certain category $\mathcal{O}_c$. The simple objects in $\mathcal{O}_c$ are indexed by $\widehat{W}$. The basic question is to determine these modules for different parameters, which can be done by giving their description in the Grothendieck group of $\mathcal{O}_c$. In this study, we describe the irreducible representations in $\mathcal{O}_c$ of the rational Cherednik algebra associated to G_{12}, for an arbitrary complex parameter. In particular, we determined semisimplicity conditions on the category, Grothendieck group expressions for irreducible modules in terms of standard modules, and the characters for each irreducible finite dimensional representation. We use computational and algebraic methods that are easily applicable to other 2-dimensional complex reflection groups in the case of equal parameters.

3. The Reduced Cozero-Divisor Graph of a Commutative Ring

Lindsey Mathewson Carroll University
Josh Cain University of Dayton
Amanda Wilkens Beloit College
Advisor(s): Michael Axtell, University of St. Thomas

Afkhami and Khashyarmanesh introduced the cozero-divisor graph of a ring, $\Gamma'(R)$, which examines relationships between principal ideals. We continue investigating the algebraic implications of the graph by developing the reduced cozero-divisor graph, which is a simpler analog.

4. An Exploration of Ideal-Divisor Graphs

Paul M Milner University of St. Thomas
Robert Donovan Worcester State College
Abigail Richard University of Indianapolis
Tristan Williams University of Wisconsin, Eau Claire
Advisor(s): Michael Axtell, University of St. Thomas

Zero-divisor graphs have given some interesting insights into the behavior of commutative rings as seen in [**?**], [**?**], and [**?**]. In [**?**], Redmond introduced a generalization of the zero-divisor graph called an ideal-divisor graph. In this paper, we expand on Redmond's findings to see if additional information about the structure of commutative rings is hidden in ideal-divisor graphs.

5. Mathematical Modeling of Integrin Dynamics in Cell Movement

Michelle Salas University of Portland
Aurora Blucher University of Portland
Nick Williams University of Portland
Advisor(s): Hannah Callender, University of Portland

Cell movement and migration are important functions for a cell to perform. Processes which require cell movement include embryonic development, the immune system response, and the repair of damaged tissue. Proteins which play a major role in this movement are transmembrane receptors known as integrins. Understanding how integrins function in an individual cell can provide insight into the behavior of not just one, but many cells. Through the development of a mathematical model of integrin dynamics, we investigate the relationship between integrins and the rate at which cells move.

6. Computational docking of molecular wires to the reaction center of Rhodobacter sphaeroides

Byong Y Kwon George Mason University
Advisor(s): Igor Griva, George Mason University

Given the worldwide interest in renewable energy, scientists have been exploring the possibility of using bacterial photosynthetic reaction centers to build a new generation of highly efficient photovoltaic devices. To build such devices, molecular wires (MWs) that serve as good conductors to transport electrons from and to the reaction centers are needed. The MWs must dock at specific binding sites within the reaction centers. We explore computational models of docking MWs to the reaction centers. Such models can help in proposing suitable MWs for photovoltaic devices. For our modeling, we use the reaction center of Rhodobacter sphaeroides, a purple photosynthetic bacteria.

7. An Agent Based Modeling Approach to Financial Markets

William Keith Brayer George Mason
Advisor(s): Harbir Lamba, Georege Mason

Standard financial models are inadequate because they make very strong assumptions about rationality and efficiency that imply a Gaussian distribution of price changes. Yet bubbles and crashes frequently occur: thus conventional models severely underestimate the risk of extreme events in financial markets. The standard models use geometric Brownian motion to simulate the evolution of an asset price p over a timestep h via

$$p(n+1) = p(n)\exp(\sqrt{h}\eta - \frac{h}{2})$$

where $\eta \sim N(0,1)$.

We replace this pricing formula with

$$p(n+1) = p(n)\exp(\sqrt{h}\eta - \frac{h}{2} + \kappa\Delta\sigma(n))$$

where the additional term $\kappa\Delta\sigma(n)$ corresponds to changes in demand for the asset amongst M agents who are simulated directly.

Using simple rules, the market generates internal dynamics that correspond to the gradual formation of price bubbles followed by rapid crashes that closely resemble those seen in real financial markets (note that such internal effects are explicitly ruled out in the standard model).

We use this model to test a variety of trading rules germane to technical analysis. We show that technical analysis can produce excess returns and that herding may account for this phenomenon.

8. Perfecting Solar Greenhouse Design for Hudson Valley Winter Agriculture

Abigail Stevens Bard College
Advisor(s): Gidon Eshel, Bard College

The motivation behind developing a feasible solar greenhouse is to grow food organically and sustainably near metropolitan areas in winter. This will extend the growing period, increase productivity, localize production and reduce transportation cost, and reduce greenhouse gas emissions to almost-carbon-neutral agricultural production. We created a matrix of the x-z cross section of the greenhouse, and used this to make a differentiation matrix to take the discrete derivative of state vectors of the space. We plan to apply the differentiated state vector to the heat equation, to find the heated air flow inside the greenhouse. This will help us to optimize the thermodynamics of the solar greenhouse.

9. On the λ-numbers of subclasses of generalized Petersen graphs

Paul Booth F.W. Olin College of Engineering
Advisor(s): Adams/Troxell, Olin/Babson

An L (2,1)-labeling of a graph G is an assignment f of nonnegative integers to the vertices of G such that if vertices x and y are adjacent, $|f(x) - f(y)| \geq 2$, and if x and y are at distance two, $|f(x) - f(y)| \geq 1$. These labelings have been used to model the channel assignment problem when sufficiently different frequencies must be assigned to transmitters operating in close proximity. The λ-number of G is the smallest number k for which G has an L (2,1)-labeling using labels in the set $\{0, 1, ..., k\}$. We determine the λ-numbers of certain generalized Petersen graphs (GPGs). A GPG of order n consists of two disjoint copies of the same cycle C_n together with a perfect matching between the two vertex sets. We designed an algorithm that reduced the computation time required to determine the λ-numbers of GPGs for previously intractable cases. More specifically, we provide exact λ-numbers of all GPGs of orders 9, 10, 11, and 12, bringing down to 6 the known upper bound of 7 for all but one graph. We also provide the λ-numbers of several infinite subclasses of GPGs that have useful representations on Möbius strips.

10. Dynamic Monopolies and k-Conversion Sets in Graph Products and Triangular Grids: Modeling the Spread of Fault in Distributed Network Systems

Connor Stokes F. W. Olin College of Engineering
S. Luke Zinnen F. W. Olin College of Engineering
Advisor(s): Adams/Troxell, Olin/Babson

In a graph theoretical model of faults in distributed computing and communication networks, each element in the network is represented by a vertex of a graph where edges connect pairs of communicating elements, and each colored vertex corresponds to a faulty element at discrete time periods. We will focus on two processes that have been used to model the spread of fault to a certain vertex by checking for faults within its neighbors. These processes have also been used to model the spread of disease and opinion through social networks. In a majority (resp., k-conversion) process, a vertex becomes permanently colored in a certain time period if the majority (resp., at least k) of its neighbors were in the colored state in the previous time period. A dynamic monopoly (resp., k-conversion set) is a set of vertices which, if initially colored, will result in all vertices eventually being colored in a majority (resp., k-conversion) process. We answer several open problems by presenting bounds and some exact values for the minimum number of vertices in dynamic monopolies and/or k-conversion sets for several types of graphs, including Cartesian and tensor products, as well as planar, cylindrical and toroidal triangular grid graphs.

11. The Splitting Fields of Generalized Rikuna Polynomials

Fan Wei MIT
Zev Chonoles Brown University
Advisor(s): Allison Pacelli, Williams College

Fix a positive integer ℓ, and let K be any field containing $\zeta_\ell + \zeta_\ell^{-1}$ but not ζ_ℓ. Rikuna discovered a polynomial F_ℓ over the function field $K(T)$ whose Galois group is $\mathbb{Z}/\ell\mathbb{Z}$. Komatsu recently generalized classical Kummer theory to cover cyclic extensions arising from F_ℓ.

In our work, for each $m \geq 1$, we introduce the *m-th generalized Rikuna polynomial* r_m, which roughly is formed from the m-th iteration of a rational function related to F_ℓ. Let K_m be the splitting field of r_m over $K(T)$. It is known that the tower of K_m's ramifies at finitely many primes of $K(T)$.

We study the tower of K_m's. For any odd $\ell \geq 3$, we show that the Galois group $\mathrm{Gal}(K_m/K(T))$ is a semi-direct product $\mathbb{Z}/\ell^m\mathbb{Z} \rtimes \mathbb{Z}/(\ell^m/b_m)\mathbb{Z}$, where b_m is the order of a certain group of roots of unity in K_m. For even ℓ, the Galois group is one of four possibilities, depending on the field K. We also show that only one prime of $K(T)$ ramifies in the tower of K_m's, and determine this prime explicitly. Then, using the Riemann-Hurwitz formula, we prove that K_m is of genus 0, and therefore has class number 1, for all $m \geq 1$.

12. Interaction of T-Regulatory Cells and Cancer

Suman Sajjan University of Pittsburgh
Kiersten Ruff Ruff Simpson College
Advisor(s): Peter Kim, University of Utah

Many recent papers explore the interaction of cancer tumors and naturally occurring regulatory T-cells (Tregs). Tregs are found in significant proportions around cancer tumors. Tregs suppress the immune response and it is believed that cancer tumors can alter Tregs' effects on immune response, in effect "recruiting" Tregs and turning them against the immune system. After forming a schematic diagram of Treg interactions in the immune system, we developed a differential equation model and performed numerical simulations in Matlab to analyze (1) the role of Tregs in the normal immune system response to pathogens or viruses, (2) the possible effects that cancer can have upon this system and (3) possible treatments to counteract these effects. In particular, we sought to validate a newly researched cancer treatment option — infection of cancer patients with a virus to stimulate a robust anti-cancer T cell response. We were able to show how Tregs work in conjunction with the immune system and how cancer, by recruiting Tregs, is able to continually relapse after being "removed." We also illustrated how a properly coordinated viral infection can temporarily override the effects of Treg suppression and permanently eliminate the tumor.

13. The Subgraph Summability Number of a Graph

Richard George Ligo Westminster College
Miriam Larson-Koester Mount Holyoke College
Advisor(s): Sivaram Narayan, Central Michigan University

Given a graph G, a vertex labeling of G is a mapping $\alpha : V(G) \to \mathbb{N}$, assigning a positive integer value to each vertex. With this we can consider labels of connected induced subgraphs $G[U]$ for $U \subseteq V(G)$, and define $\alpha(G[U]) = \sum_{u \in U} \alpha(u)$. The subgraph summability number of a connected graph G is the largest integer $\sigma(G)$ so that the label sums of connected induced subgraphs cover the integers 1 through $\sigma(G)$. The question of graph labeling is intimately related to ideas in number theory and combinatorics. We investigate summability labelings for cycles, centipede graphs, circulant graphs, and multipartite graphs and generalize their behavior.

14. The Traveling Salesman Problem With Varying Home Points

Natalie Collar Manchester College
Shana Johnson Lynchburg College
Kayse Lee Bethel University
Jaime Jeke University of Pittsburgh
Ashlee Edwards Virginia Wesleyan College
Cathalee Soergel Miami University
Advisor(s): Lakeshia Legette, Johnson C. Smith University

Have you ever wondered how MapQuest ® works? It has the capability of finding the shortest route from one location to another. Suppose you want to visit n cities. In which order would you visit these cities to travel the shortest distance? We explore the Traveling Salesman Problem with both three and six cities on a two-dimensional plane. In both cases, we consider a varying Home point, **H**. It turns out that the plane is divided into distinct regions such that for each region there is a unique minimal circuit to travel. We find that some regions become disconnected, or *split*. This split suggests that it is not always optimal to travel an intuitive circuit. We find all the city arrangements where this phenomenon occurs. Furthermore, we find a particular arrangement of six cities that guarantees only six distinct minimal circuits of the 720 possibilities.

15. Polynomials of Graphs on Surfaces

Clark W Butler The Ohio State University
Advisor(s): Sergei Chmutov, The Ohio State University, Mansfield

A graph embedded cellularly in a surface can be represented as a ribbon graph, a surface with boundary that is a regular neighborhood of the graph. The recently introduced Bollobás-Riordan polynomial generalizes the Tutte polynomial to ribbon graphs. We use planar projections of ribbon graphs to obtain a new relation between the Bollobás-Riordan polynomial to another generalization of the Tutte polynomial to relative plane graphs, which are planar graphs with a distinguished subset of edges. We also present an expansion of the Krushkal polynomial on ribbon graphs along 1-face subgraphs. We demonstrate a new method of representing embeddings of ribbon graphs in surfaces which relates orientable and non-orientable ribbon graphs. This relation connects embeddings of links in thickened surfaces with ribbon graph representations of virtual links. The corresponding papers are in preparation.

16. Statistical Estimation: Improving the Range Rule of Thumb

Alfredo Ramirez University of Tennessee at Martin
Charles Cox University of Tennessee at Martin
Advisor(s): Chris K. Caldwell, University of Tennessee at Martin

A common estimate for the standard deviation of a population is the range of the sample divided by four. For example, if we guess the high score on the first test in a class will be 100, and the low 40, then the rule estimates that the standard deviation will be $(100 - 40)/4 = 15$. This estimate is reasonable with normal populations and sample sizes near 30, but fails miserably for small samples as well as large samples (including many of the examples in the books that introduce it!) We first use the R programming language to simulate the sampling distribution of the statistic

$$\zeta = \frac{\text{range}}{\text{standard deviation}}$$

for different distributions (such as normal and uniform). From this we develop empirical models and suggest alternative rules of thumb.

17. The Power Cauchy Distribution: Derivation, Description, and Composite Models

Brian Thomas Rooks University of North Carolina at Chapel Hill
Amy Clare Schumacher Birmingham-Southern College
Advisor(s): Kahadawala Cooray, Central Michigan University

First, a new two-parameter member of the Transformed Beta family, called the Power Cauchy distribution, is derived and described. The new model has increased statistical usefulness when compared to other members of the Transformed Beta family because of the considerably thicker upper tail of the density. Second, this distribution is combined with the Pareto distribution using the procedure introduced in Cooray and Ananda (2005). This combination increases the thickness of the right tail of the distribution in order to more accurately fit highly positively skewed data. Third, this model is improved upon with the addition of a mixing parameter as was recommended by Scollnik (2007). Using medical data sets, parameter estimation by the maximum likelihood method and related goodness of fit tests are performed in order to compare the models with other known models.

18. Residual Analysis in Modeling Electroosmotic Flow

Ava Hamilton Skidmore College
Advisor(s): Rachel Roe-Dale, Skidmore College

Electroosmotic Flow (EOF) is the motion of liquid induced by an applied potential across a capillary tube or microchannel. In order to predict EOF trends for the real-time data, a mathematical model is needed. A variety of mathematical functions were fit to several sets of experimental data. An exponential function and a biexponential function, the sum of two exponential terms, have been the most effective models of EOF during discontinuous buffer conditions. During the fit, we estimate the parameters in each equation. In order to assess the strength of the fit, the residuals of this fit data are analyzed. Specifically we consider the lag plot, a histogram plot, a normal probability plot, and an autocorrelation plot. The residuals of the fit data with an exponential function are examined even further; they are fit with a triexponential function, the sum of three exponential terms. We hope to establish through more testing whether an exponential or a biexponential function best fits the EOF data.

19. Analysis of Microfluidic Mixing in a Drop

Dylan Owen Marriner Harvey Mudd College
Advisor(s): Andrew Bernoff, Harvey Mudd College

The dynamics of microfluidic mixing are of great interest because of the application to lab-on-a-chip technology. We study chaotic mixing in a 2D model problem and a 3D sessile drop. Flows were induced by a time-periodic forcing along the boundary of the 2D drop and at the base of the 3D drop. The velocity field for the 3D drop was calculated via lubrication theory which yielded the velocity components in terms of a numeric approximation for the pressure gradient. Finite time Lyapunov exponents (FTLEs) were used to quantify mixing for both drops. Mixing in the 2D model problem was found to have an optimal switching time of the forcing direction, even when diffusion was introduced. Mixing in the 3D drop was seen to remain along shells within the drop, and diffusion would be necessary to induce good mixing.

20. Elastohydrodynamic Instabilities in Gravity-Driven Flow

Wanyi Li Macalester College
Cat Kealey Beloit College
Charlie Talbot University of Connecticut
Advisor(s): Daniel Flath, Macalester College

The dynamics and stability of gravity-driven flow of a thin Newtonian fluid down an inclined plane covered with either a topographical trench feature (Case i) or a deformable elastic gel (Case ii) is studied. For both cases, mathematical models are derived starting from the Navier-Stokes equations coupled with appropriate boundary conditions. The complicated governing equations are first nondimensionalized, and then reduced to a system of coupled, nonlinear partial differential equations (PDEs) describing the time evolution of the interfaces by an asymptotic procedure called lubrication theory. Case i focused on the effects of the trench shape, inclination and surface tension on the steady state air/liquid interface shapes, as found numerically by Matlab. Case ii investigated the stability of the air/liquid and liquid/gel interfaces. Steady interfacial shapes are found and used as a base state, the dynamics of which (perturbed) is simulated in Matlab for a given set of parameters. If the initially small perturbation grows with time, the base state is said to be unstable for the given parameters. Otherwise, the base state is stable. Linear stability analysis is performed to identify potential unstable parameter sets as well as verify the numerical code.

21. Improving on the Black-Scholes model to account for kurtosis risk when pricing options.

Daniel Quinton Matovu Illinois Institute of Technology
Advisor(s): Fred Hickernell, Illinois Institute of Technology

The Black-Scholes model for financial derivatives makes the assumption that the underlying asset (stock or option or other derivative) follows a geometric Brownian motion with constant drift and volatility; such that the underlying asset is lognormally distributed since the log returns are normally distributed. Market trends have, however, shown the above assumption to be questionable. I investigate the effect of the above assumption by pricing European call options and observing whether the volatility of the stock behaves as the model suggests it would. Then I present improvements to the Black-Scholes model; making the assumption that the underlying asset derivative follows a fatter tail distribution and investigate whether this model would price options better.

22. Algorithm Development for Gang Rivalry Classification

Adeline Kornelus University of New Mexico
Samik Adhikari Saint Peter's College
Advisor(s): Alethea Barbaro, UCLA

In this RIPS 2010 project, we develop a model and techniques to help the police predict gang involvement in crimes. Gang-related crime records from the Los Angeles Police Department show that there are cases in which the offender's gang affiliation is not known. Given information about the location and time of a crime and information about gang set spaces (center of activities) and rivalries, we provide algorithms that predict the possible suspects' gangs for that particular crime. Initial work on creating our algorithm was done utilizing the 1999-2002 data on gang-related aggravated assaults in Hollenbeck. Utilizing this model, we ran our algorithm on the data set containing gang-related crimes from 2005-2010, which focused on the same region and consisted primarily of the same gangs, but did not have victim information on every crime record due to some technical issue in getting that information from the database.

We were able to come up with a new algorithm that works without utilizing victim information, but with about the same accuracy as the first algorithm. This new algorithm also works for a larger set of data which includes gang related non-aggravated assaults, such as traffic violation, vandalism, or kidnapping. Further, we provide a method for efficacy checks.

23. Galois Groups of Schubert Problems on $G(2, n)$

Christopher J Brooks Texas A&M University
Advisor(s): Frank Sottile, Texas A&M University

The Schubert calculus is a branch of algebraic geometry that studies enumerative solutions to certain geometric problems. The main goal of our work is to determine or gain insight into the structure of these problems (called Schubert problems). We have found that the Galois group of a certain class of Schubert problems always contains the alternating group. In other words, there is no special geometric structure for Schubert problems in any Grassmannian of 2-planes. This is in contrast to Schubert problems in more general Grassmannians, of which there are known examples possessing smaller Galois groups and thus more interesting geometry. This result in this poster was obtained by building on work done by Sottile, Vakil, et al. In particular, we studied a recursion for intersection numbers in which the behavior of terms is related to the Galois group of the corresponding Schubert problem. Then we discovered a simple asymptotic formula for the terms in this recursion, which led us to the result.

24. The Lonely Runner Conjecture and Intersection Problems

Christopher Horvat University of Pittsburgh
Matthew Stoffregen
Advisor(s): Frank Beatrous, University of Pittsburgh

The Lonely Runner Conjecture is a number theory problem, dating to 1964. It asserts:

Given n disjoint real numbers, v_i:

$$\exists t \in \mathbb{R} : ||v_i|| \geq \frac{1}{n+1}.$$

This conjecture has been proven to $n = 8$. Using dynamical systems theory, we show almost all sets of velocities solve the conjecture. Furthermore, any "traditional" approach of Diophantine approximation cannot solve the problem, and we offer a short list of reformulations of the problem in different fields.

The conjecture is a member of a class of so-called "Intersection Problems", which have nice dynamical interpretation. We offer results which indicate that many problems (including conjectures of Euler and Littlewood) may be classified and discuss progress towards a total classification of I.Ps in the hope that this will reduces the number of open problems in number theory.

Furthermore, we show an interesting "grand" reformulation of the conjecture which is enticing in it's simplicity, the proof of which would solve Littlewood's Conjecture and LRC in their entirety.

25. Sharpe Ratio Versus the Information Ratio: Capturing Minimum Variance Portfolios

Alexa Atamanchuk Wesleyan University
Zesong Liu The University of Texas at Austin
Advisor(s): Marcel Blais, Worcester Polytechnic Institute

Traditional portfolio theory predicts that if a stock carries additional risk it also promises higher levels of expected returns. Clark, de Silva, and Thorley (2006) and Blitz and Vliet (2007) show that in regional and global contexts low volatility stocks outperform high volatility stocks and have a higher realized Sharpe ratio. The Sharpe and Information ratios are measures of excess return per unit of risk relative to the risk-free rate or one's investment universe benchmark, respectively. We construct a variety of portfolios based on ratio rankings and compare future returns. Ultimately, the performance of these portfolios will help test whether the customary focus on benchmark-driven performance within delegated asset-management creates exploitable investment opportunities.

26. Elliptical Variations on a Theme by Trefethen

Praveen S Venkataramana Syntonix, Inc.
Advisor(s): Mohan Venkataramana, Syntonix, Inc.

Nick Trefethen proposed a problem wherein four bugs are initially placed on the vertices of a 2×1 rectangle, and each bug chases the one immediately to its left with a constant speed of 1, a variation of a famous Martin Gardner puzzle of four bugs on a square in cyclic pursuit. Even this simple breakdown of symmetry renders the dynamics highly bizarre: the bugs' paths freeze into essentially one dimension before the bugs circle their midpoint once. Trefethen showed that after the first circuit the scale has shrunk by a factor of $10^{427907250}$ while the aspect ratio has shrunk by a factor of $10^{10^{427907250}}$, and with each circuit these factors go through four exponentiations. Trefethen postulated that a similar law holds for the change in orientation of the bugs with each circuit. In this poster I prove this conjecture by imagining that the bugs are dancing on a rotating and shrinking ellipse. More precisely, I show that the change in orientation after each quarter-circuit is asymptotically equal to the aspect ratio at the start of the quarter-circuit. It follows that the sum of these changes, which describes the final orientation, converges remarkably rapidly – perhaps the fastest convergence I have seen in an *applied* math problem.

27. Symbolic dynamics with overlapping partitions

Fabio Ariel Drucker Dickinson College
Advisor(s): David Richeson, Dickinson College

We investigated methods to calculate entropy bounds of dynamical systems using symbolic dynamics when the regions $\{N_i\}$ are allowed to overlap. The problem is well understood when the sets are disjoint, but the overlapping case has been unexamined. We developed a number of methods to do this, with the relative merits of each varying from case to case: (1) Breaking the graph into primitive components, and getting lower bounds for each; (2) Pruning "less useful" vertices; (3) Pruning vertices by brute force: trying all independent sets, checking which lower bound is higher; (4) Treating the system as a sofic shift; (5) Examining higher shifts of the graph; and (6) Detecting intersections that could never cause problems.

We wrote a program to automate all of these procedures. It allows us to enter matrices describing the systems and it produces a lower bound of the systems entropy, calculated using the method of your choice from the ones explained above. It also provides information regarding intermediate steps and explains how some parts are being calculated. These results were developed during joint student-faculty research during the Summer/Fall of 2010.

28. Fractals and Frieze Groups

Hayley Suzanne Miller University of Central Arkansas
Derek Anderson University of Central Arkansas
Advisor(s): Fred Hickling, University of Central Arkansas

Friezes are relief sculptures on the entablatures of classic architecture. They have linear repeating patterns. In mathematics they go by the same name. A group is a mathematical object that describes the symmetries of something. The patterns from geometric friezes are so constructed that various translations, rotations, and reflections move a single portion of the pattern along a line. The collection of all such rigid motions is the group associated to the linear tiling. Though there are an infinite number of different tilings, each is associated with only one of 7 different groups, the Frieze groups. We introduce yet another operation to the actions of translation, rotation, and reflection. If the initial frieze is tiled with a fractal shape that can itself be tiled by smaller versions of itself, then this allows for the pattern to be rescaled, thus extending the frieze group. We will describe the symmetry groups for tiling the plane with shapes that can be tiled by rescaled versions of themselves.

29. An Improved Immersed Boundary Approach for Solid-Fluid Interaction

Emilie Naccarato Bryn Mawr College
Kelly Spendlove Montana State University
Ashley Beck Central College
Tim Dannenhoffer North Carolina State University
Advisor(s): Long Lee, University of Wyoming

Many current algorithms for modeling incompressible fluid dynamics problems involving complex geometries rely on structured or unstructured grids that conform to the specific geometry or body. Generating these body-conformal

grids can be extremely computationally intensive. An Immersed Boundary (IB) approach relieves the computational demands by utilizing a virtual force to account for the geometries, and thus allowing for a uniform Cartesian grid throughout the computational domain. Despite the progress made in approaches using moving boundaries on body-conformal grids, the simplicity of the IB Method allows its computational costs to remain significantly lower.
Previous work includes using the IB method with the projection method. However, the projection method as a fluid solver does not account for virtual force directly and thus cannot maintain the divergence-free condition required for incompressibility. This research improves upon these methods by incorporating a Marker and Cell (MAC) fluid solver with the Immersed Boundary approach. The MAC algorithm directly includes a term accounting for virtual force in the equations. This combination produces a new, more accurate algorithm just as efficient as the previous methods upon which it expands.

30. Computation of Fixing Numbers

Kara Greenfield Worcester Polytechnic Institute
Advisor(s): Peter Christopher, Worcester Polytechnic Institute

The fixing number of a graph is the smallest number k for which there exists a set of k vertices such that assigning a unique label to each of those k vertices removes all but the trivial automorphism. We begin by proving that the fixing number of a graph is equal to the fixing number of its complement. A previous attempt at an algorithm to determine the fixing number of a graph was a greedy fixing algorithm. We provide a class of counter-examples to prove that this algorithm is not well-defined. We then propose a new algorithm and prove its correctness. We also examine the distribution of fixing numbers of various categories of graphs.

31. Patterns in the Sand

Maranda Franke Coe College
Advisor(s): Calvin VanNiewaal, Coe College

Sona drawings are an art form of storytelling originating from both the Angola (African) and Tamil (Indian) cultures. A Sona drawing is created by making a grid of dots and tracing a line diagonally through the grid, reflecting 90 at each edge. Traditional drawings almost always enclose all the dots of a grid with a single line, not easily accomplished through trial and error. Patterns can be found, in aspects such as linearity (the number of lines required to enclose all the dots of a grid), by changing an existing grid with the addition and removal of dots as well as the introduction of mirrors. The effects of the addition of a single mirror on linearity are known. This project focuses on the introduction of multiple mirrors at once. To facilitate the tracing of the grids, a simulation program was created using Greenfoot.

32. Stability Analysis and the Role of Non-Self Adjointness

Anna Scott University of Chicago
Advisor(s): Gidon Eshel, Bard College

Stability analysis addresses the reaction of a non-linear dynamical system system to an outside perturbation, that is, one not addressed by the original model. The system can have two broad classes of responses: the perturbation subsides and the system returns to its original trajectory, or the perturbation grows and the system follows a new trajectory. Traditional modal anlysis only considers stability after the perturbation, in the $t \to \infty$ limit. However appropriate for certain dynamical systems, for others, this time scale only allows the introduction of more perturbations, that is, ones not assumed by the $t \to \infty$ analysis. Such perturbations can either push the system away from or drive it back towards its equilibrium. This project examines the stability of one non-linear dynamical system, and shows that for ecological systems, stability must be considered in both the short and long term, $t \to 0$ and $t \to \infty$, respectively.

33. Fast approximation of derivatives using the LU factorization of Vandermonde Matrices

Darlena Kern Pepperdine University
Advisor(s): David Strong, Pepperdine University

A basic problem in numerical analysis is to approximate the kth derivative $f^{(k)}(a)$, for $k = 0, 1, 2, ..., n-1$, of a function f at any value a using n distinct values of the function f. Finding a general formulae for these approximations involves finding the inverse of a variation of a Vandermonde Matrix, the LU factorization for which has been found in the past. In this formula, entries of U were defined recursively, which was expensive and more importantly meant that

to find a single column of U (which is what is often desired), one had to find the entire matrix U up to that column. We have devised and implemented an efficient algorithm which allows for explicitly finding individual entries of U, which of course allows us to find a single column of U. Our work builds on results from a NASA technical paper published in the 1960s.

34. ADAM: Analysis of Discrete Models of Biological Systems Using Computer Algebra

Bonny Guang Harvey Mudd College
Madison Brandon University of Tennessee - Knoxville
Advisor(s): Franziska Hinkelmann, Virginia Tech

Many biological systems are modeled qualitatively with discrete models, such as probabilistic Boolean networks, logical models, bounded petri-nets, and agent-based models. Simulation is a common practice for analyzing discrete models, but many systems are far too large to capture all the relevant dynamical features through simulation alone. We convert discrete models into algebraic models and apply tools from computational algebra to analyze the dynamics of discrete systems. The key feature of biological systems that is exploited by our algorithms is their sparsity: while the number of genes (or agents) in a biological network may be quite large, each gene is affected only by a small number of other genes. This allows for fast Gröbner basis computations in the algebraic models, and thus efficient analysis. All algorithms and methods are available in our package Analysis of Dynamic Algebraic Models (ADAM), a 'modeler friendly' web-interface that allows for fast analysis of large models, without requiring understanding of the underlying mathematics or any software installation.

35. Modeling the Big Bubble

Bethany E Wentzky King College
Advisor(s): Andrew Simoson, King College

Freely rising air bubbles in water sometimes assume the shape of a spherical cap, a shape also known as the big bubble. Is it possible to find some objective function involving a combination of a bubble's attributes for which the big bubble is the optimal shape? Following the basic idea of the definite integral, we define a bubble's surface as the limit surface of a stack of n frustra (sections of cones) each of equal thickness. Should the objective function's variables correspond to the n base lengths of the frustra, then the critical points of the objective function might yield an optimally shaped bubble for which the limit as n approaches infinity exists. One simple objective function which appears to model the big bubble is a linear combination of the bubble's upper and lower surface areas. Furthermore, with a computer algebra system, we can see in real time the shape of these critical bubbles as we vary the parameters of the objective function.

36. Modeling synaptic plasticity in a thalamocortical relay neuron

Olivia Walch College of William and Mary
Advisor(s): Greg Smith, College of William and Mary

Thalamocortical relay (TC) neurons in the lateral geniculate nucleus receive both retinal and cortical input; however, the two pre-synaptic signals are filtered in significantly different ways. Using a three-compartment model of a TC cell, with distinct equations for the proximal and distal dendrites, we model the facilitation of signals from the cortex and depression of input from the retina. Additionally, we present several model-generated cross-correlograms that lend insight into the interplay of the driving and modulating afferents.

37. Targeting-Based Control Methods for Physical Simulations of Fluids in Animation

Visala Rani Satyam Tufts University
Advisor(s): Jacob Bedrossian, UCLA

When working on movies, animators use physics-based models to create simulations of effects with realistic appearances, such as fluids. However, to satisfy artistic goals, animators want the simulations to behave in a specific way, so they experiment with different parameters. They work in low resolution first because high-resolution simulations take longer to run. Artists would then like to preserve the same behavior when increasing the resolution. However, the behavior of fluids changes as we change resolution, making it difficult to predict the result. Our goal is, then, to develop methods that ensure the features of low-resolution simulations are retained in high-resolution. We use two different methods in controlling fluids: both of which use a set of constraints on the fine grid (high resolution), to

ensure it behaves like the coarse grid (low resolution). Our first method uses constrained Lagrangian mechanics to enforce constraints on the fine grid, and the the second one uses the constraints as a guiding force for the fine grid. We compare the results of each method—pictures and videos of smoke and waves—to the low-resolution original. The result of our methods should match the original closely but with more detail.

38. On the Relationship Betwen Lattice Knots and Hexagonal Prism Knots

Kristen Chockley The University of Texas at Tyler
Advisor(s): Jennifer McLoud-Mann, The University of Texas at Tyler

The relationship between minimal lattice knots and minimal cube knots is known in the cubic lattice. The aim of this research is to extend this knowledge into the simple hexagonal lattice, that is, to determine the relationship between minimal lattice knots and minimal hexagonal prism knots. After doing several example knots where we started with a lattice knot and expanded it into a well-formed hexagonal prism knot by increasing the volume using the minimum number of prisms possible, we reached the conjecture that the minimum prism number (M_K) is exactly twice the minimum step number (m_K); thus, $M_K = 2(m_K)$. To prove this, we broke the statement down into $M_K \leq 2(m_K)$ and $M_K \geq 2(m_K)$. We proved the first inequality by saying that we can "double up" the lattice knot to create a prism knot to show that the volume is at most twice the minimal step number. We will discuss approaches we have taken in attempting to establish the second inequality. Once we can prove both inequalities, we will know the exact relationship between a minimal lattice knot and a minimal prism knot in the simple hexagonal lattice, and we will then extend this work into other lattices.

39. A solvable hyperbolic free boundary problem modeling tumor recurrence

Dian Yang College of William and Mary
Advisor(s): Jianjun Tian, College of William and Mary

Recently Tian, Friedman et al have developed a model about brain tumor glioblastoma recurrence after resection. The model is a hyperbolic free boundary problem with two nonlinear partial differential equations. It integrates clinical data and suggests some optimal protocols of radiotherapy and chemotherapy by numerical study. In this paper, we analyzed this hyperbolic system. We proved the local and global existence and uniqueness of the solution. It is well known that most free boundary problems are unsolvable in terms of explicit analytical solutions. However, our free boundary problem is solvable, and we found the explicit solution by using backward characteristic curve method. This explicit solution agrees with our numerical simulations. Another interesting property is that the system can be treated as an hyperbolic system defined in an infinite domain and the initial function with one first-type of discontinuity.

40. The modeling of the excitation of drum heads by the wave equations with numerical solutions using a second generation wavelet based finite element method

Phanuel Mariano Western Connecticut State University
Advisor(s): Xiaodi Wang, Western Connecticut State University

The excitation of the top drum head can be modeled by an extension of the wave equations. In this project, we wish to extend the model for the excitation of both the top and the bottom drum heads and for the wave propagation of a wooden cylindrical shell. We consider the PDE that models the excitation of a circular membrane which is used to model the excitation of the top drum head. These equations are then used to derive a system of PDE's, which models the excitation of the bottom drum head once the top drum head is struck. Numerical solutions are then given by a wavelet based finite element method using second-generation wavelets.

41. Self-Intersections of Space-Filling and Fractal Curves, with applications to genome-folding

Adrian Sanborn Harvard
Advisor(s): Sarah Koch, Harvard University Mathematics Department

Intuitively, one may think that a "curve" has no volume because it is infinitesimally thin. However, in 1890, Giuseppe Peano discovered the first "space filling curve": a curve that maps from a one dimensional domain and fully covers a higher-dimensional region, such as a square or cube. Evidence has recently emerged suggesting that such "space-filling" curves may help describe how the two-meter-long human genome folds up inside the six-micron-wide cellular

nucleus. In particular, it was found that the genome's tendency to collide with itself at various distances closely resembles a similar behavior that is seen in space filling curves.
The purpose of my project is to characterize the frequency of "collisions", or self-intersection, in space-filling curves by exploiting their self-similar fractal structure. How often do two points in the domain map to the same point in the range? We rigorously compute the Hausdorff dimension of the set of collision points, present a method for extracting collision points, and study how the frequency of collisions changes as a function of the distance between the two points. These results elucidate a new property of fractal curves and will help place the interpretation of ongoing experiments on a solid theoretical foundation.

42. A Particle Based Model for Cell Movement

Haema Nilakanta Iowa State University
Sahil Shah Columbia University
Noah Haibach University of Pittsburgh
Stephanie Cook Georgia Institute of Technology
Advisor(s): Sharon R. Lubkin, North Carolina State University

Biologists, studying morphogenesis and tissue engineering, cannot run the same type of tests in the lab as they can with a computer model. For example, they cannot expose a cell in vitro to extreme conditions without killing it and they do not have granular control over parameters.

One way to simulate a cell in silico is with the particle method, which represents a cell as a group of sub-elements. These sub-elements, or particles, maintain fixed and equal volumes in three dimensional space. Simulations are run by applying appropriate forces to each particle.

To test the capabilities of this technique, we built a model using the particle method. In implementing this model, we calibrated it so that the cell preserves volume and we included random noise, force cutoffs, and an efficient implementation.

We were able to simulate a single cell as an equilibrated sphere, adhere the cell to a plate, make the cell move, and elongate the cell. The ability of the particle method to simulate a moving cell is the best demonstration of its capabilities. Future extensions of this model would enable further testing of the particle method.

43. Statistical Modeling of the Fat-Fraction in Magnetic Resonance Imaging (MRI)

Anne Miriam Calder California State University, Fullerton
Eden Ann Ellis California State University, Fullerton
Li-Hsuan Huang California State University, Fullerton
Kevin Park California State University, Fullerton
Advisor(s): Angel R. Pineda, California State University, Fullerton

Our project studies the quantification of the uncertainty in fat-fraction estimates using Magnetic Resonance Imaging (MRI). The fat-fraction is $\frac{|F|}{|F|+|W|}$, where F is the fat signal and W is the water signal obtained using MRI. The fat and water signal magnitudes have a Rician distribution. However, the fat-fraction has an unknown distribution. One medical application of the fat-fraction is to diagnose Non-Alcoholic Fatty Liver Disease (NAFLD). Knowing the fat-fraction distribution will provide us with a better understanding of the uncertainty of fat-fraction estimates used for the diagnosis of liver disease. Our current research focuses on finding the analytic distribution of the fat-fraction and numerical simulation using Monte Carlo methods. In the analytic approach, for simplicity, we explored the fat-fraction where the fat and water magnitudes follow a normal distribution because the normal distribution approximates a Rician distribution for large signal-to-noise ratio (SNR). In the numerical approach, we applied Monte Carlo methods to optimize the fat-fraction estimation, studied the distribution and compared analytic with numerical results.

44. Image Compression Using M-Band Wavelets

Sam Ling Zeng Danbury Math Academy
Ray Lai Chen Danbury Math Academy
Advisor(s): Xiaodi Wang, Western Connecticut State University

In recent years, we have observed a massive expansion in wavelet analysis to fit our demanding need for faster and more accurate signal processing. Different types of wavelets have been developed to solve problems in signal and image analysis, medical diagnostics, statistical analysis, pattern recognition, and many other problems. In the age

informatics, compressions are essential to the rapid transfer of information. In this research, we explore data compression by focusing on image compression, which is an essential part of everyday computing. We utilize M-band wavelet transforms to compact the image and preserve the energy. To achieve this, we perform a wavelet transform of the signal and then set all values less than a predetermined threshold equal to zero. We then transmit only non-zero values obtained from the previous transform. Finally we apply the inverse wavelet transform on the data transmitted to get an approximation of the original signal.

45. Tangle Tabulation

Guanyu Wang The University of Iowa
Danielle Washburn
Advisor(s): Isabel Darcy, The University of Iowa

A knot is the image of a circle (i.e, a closed arc) embedded in 3-dimensional space. Tangles are similar to knots, but consist of strings whose endpoints are "nailed down" on the boundary of a 3-dimensional ball. In knot tabulation, knots are tabulated using crossing number (the minimal number of crossings needed to draw the diagram of a knot/tangle). In a similar manner to knot tabulation, we are creating a table of two string tangles ordered/categorized by crossing number. A sequence of numbers is used to represent a tangle which can be visualized by using the software KnotPlot. From there, code is being implemented to generate various invariants, each of which is a quantity that is the same when computed from different descriptions of a knot/tangle. A webpage is being developed in which users can create a table of tangles and their different invariants.

46. Mathematical Modeling of Glioblastoma Multiforme and Coordinate Transformations

Eric Aaron Adams Arizona State University- School of Mathematical and Statistical Sciences- CSUMS Program
Maple So Arizona State University- CSUMS Program
Advisor(s): Eric Kostelich, Arizona State University

Glioblastoma multiforme (GBM) is a high-grade glioma that significantly lowers patient survival to under two years. The research focuses on the implementation and visualization of the growth of GBM tumors. The model, developed by Steffen Eikenberry and co-workers, is a coupled set of four partial differential equations that runs on a static (but realistic) brain geometry. The model considers two classes of tumor cells, proliferating and migrating, and assumes that the transition between cell classes is stochastic. During the study, an implementation in MATLAB to simulate treatment by surgery and radiation has been developed. The simulation shows a "pseudo-MRI" that can be visually compared with actual patient scans. Serial MRI's from actual patient scans have been processed to obtain volumetric measurements of the tumor based on the Talairach Transformation. Repeated measurements of the tumor size using the Talairach Transformation by making small perturbations on the anterior-posterior commissure line in three-dimensional space provides a better estimation of the glioma volume. Continuous data measurement will provide a better estimation of the glioma growth rate in mathematical simulations.

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48. Measuring Patterns in a Coupled Ricker Patch Model

Benjamin Robert Holman The College of William and Mary
Advisor(s): Sarah Day, The College of William and Mary

Ecologists use Ricker patch models to study meta population dynamics for populations undergoing growth and dispersal in a patchy environment. We discuss a modified model in which patch wise extinction thresholds are used to model local extinction events. Numerical simulations for certain parameters exhibit a decoupling of the system into small regions with periodic dynamics prior to extinction. To further analyze this high dimensional system we focus on computational homology as a tool for measuring spatial patterns as extinction occurs.

49. Planar Isotopy in Tight Knot Diagrams and Hexagonal Knot Mosaics

Andreana Natalie Holowatyj Benedictine University
Advisor(s): Timothy Comar, Benedictine University

An n-ring hexagonal grid consists of a regular hexagon surrounded by n adjacent concentric rings of regular hexagons. A hexagonal knot mosaic is a knot diagram that lies in an n-ring hexagonal grid in a particular way such that the intersection of the knot diagram and the interior of one of the hexagons is one of 27 basic types. We enumerate planar isotopies of hexagonal knot mosaics in a 2-ring hexagonal grid. A tight hexagonal knot mosaic is one such that the knot diagram cannot be contracted to a diagram of shorter length via planar isotopy. We then enumerate the tight hexagonal knot mosaics for some knots in a 2-ring hexagonal grid.

50. Classifying Regions of the Coefficient Space of Polynomial Knots

Kavi Gupta Adelphi University
Salvatore Giunta Adelphi University
Advisor(s): Lee Stemkoski, Adelphi University

A polynomial knot is the image of a parametric function whose components are polynomials. For a parameterization of fixed degree, the coefficient space is the set of values of coefficients of the polynomials that yield polynomial knots. We classify the regions of specific coefficient spaces by finding algebraic equations for their boundaries, and determine the knot types corresponding to these regions. We also present an algorithm for compactifying polynomial knots using spherical inversion and removing any cusps that arise, resulting in a rational parameterization.

51. Invariants of graphs in three-space

James Edward Tipton California State University, Fresno
Advisor(s): Carmen Caprau, California State University, Fresno

We construct invariants of 3-valent rigid vertex embeddings of graphs in three-dimensional space from known polynomial invariants for knots and links (specifically, the 1-variable Homlfy and 2-variable Kauffman polynomials). The resulting invariants for graphs induce well-defined polynomials for planar 3-valent graphs, via certain graphical calculi. Moreover, these calculi for planar graphs may be regarded as generalizations of the Hecke and Birman-Wenzl algebras (and their combinatorial context) associated with the n-strand braid group.

52. Compressed Zero-Divisor Graphs and Zero-Divisor Lattices of Finite Commutative Rings

Darrin Weber Millikin University
Lane Bloome Millikin University
Advisor(s): Joe Stickles, Millikin University

The zero-divisor graph of a commutative ring R, denoted $\Gamma(R)$, is a graph whose vertices are the nonzero zero-divisors of a ring and two vertices are connected if their product is zero. These graphs have been studied for a number of years in the hope that the graph-theoretic properties of $\Gamma(R)$ can help us understand more about the ring-theoretic properties of R. We slightly alter the definition of the zero-divisor graph to obtain the compressed zero-divisor graph, $\Gamma_c(R)$. Also, we look to expand on the idea of zero-divisor graphs of rings into lattices on those rings. We take the zero-divisors of a ring, examine their annihilator sets, assign an order to them, and then place these annihilators into a lattice structure. We then observe the relationships between the zero-divisor graph, compressed zero-divisor graph, and the zero-divisor lattice.

53. Equilaterally k-isotoxal tiles

Ruby Chick The University of Texas at Tyler
Advisor(s): Casey Mann, The University of Texas at Tyler

A *tile* is a closed topological disk, and a *tiling* of the plane is a covering of the plane by tiles without overlap. A *symmetry* of a tiling is a transformation of the plane that preserves the tiling by mapping tiles to tiles, edges to edges, and vertices to vertices. A *transitivity class of an edge* in a tiling is the set of edges in the tiling which may be mapped to one another via a symmetry of the tiling. If a tiling has n transitivity classes of edges, it is called n-isotoxal. We define a single tile T to be equilaterally n-isotoxal if T is equilateral and tiles the plane so that every tiling admitted by T is n-isotoxal and edge-to-edge. We will present equilaterally 2- and 3-isotoxal tiles.

54. Asymptotic behavior of solutions to minimum-maximum delay recurrences of higher-order

Scott Michael Rabidoux Wake Forest University
Advisor(s): Kenneth S. Berenhaut, Wake Forest University

In this poster, we consider asymptotic behavior of solutions to minimum-maximum delay recurrences of higher-order. Some new results are given and open questions posed regarding convergence, in terms of the array of delays.

55. Recursively Constructible Families of Ribbon Graphs

Jordan Keller Louisiana State University
Advisor(s): Neal Stoltzfus, Louisiana State University

An infinite sequence of ribbon graphs, $\{\mathbb{D}_n\}$, is called recursive if the Bollobás-Riordan-Tutte (BRT) polynomials $R(\mathbb{D}_n; x, y, z)$ satisfy a linear recurrence relation whose coefficients are integral polynomials in $\mathbb{Z}[x, y, z]$. Using a method based on transfer matrices, denoted T, pioneered by N. Biggs for the Whitney-Tutte polynomial, we show recursiveness in the form: $R(\mathbb{D}_n; x, y, z) = V \cdot T^n \cdot \mathbf{1}$ (where V and $\mathbf{1}$ are initialization vectors) for a broad class of ribbon graph sequences. We implement the method in *Mathematica* with a substantial reduction in computational time. Finally, we apply this method to the computation of the Jones polynomial of certain link families using the known specialization.

56. Partition Problem for Sets of Permutation Matrices

Jeffrey Soosiah College of William and Mary
Advisor(s): Gexin Yu, College of William and Mary

Given a set of all permutation matrices of a fixed dimension conforming to a set of forbidden positions, we conjecture that we can always perfectly partition such a set. We explore the problem for specific dimensions and forbidden positions, and consider ways to generalize specific results to prove the result for classes of matrix dimensions.

57. Clifford Algebra Filtrations and Supersymmetry

Samantha Sirignano Baylor University
Nathaniel Rook Wesleyan University
Advisor(s): Gregory Landweber, Bard College

The poster provides a background on supersymmetric concepts in mathematics and physics. The research is focused on objects called Clifford algebras, a generalization of the real numbers, complex numbers, and quaternions. We study Clifford algebras using Adinkras, continuing the work carried out by Doran, Faux, Gates, Hubsch, Iga, and Landweber. This poster targets $\mathbb{Z}_2$-graded filtrations of irreducible representations of the Clifford algebra, defining equivalence maps between filtrations and investigating the resulting equivalence relations. The equivalence classes for $N = 0, 1, 2, 3$, and 4 are fully classified, while significant progress is made toward the classification of $N = 7$ and 8. For $N = 0, 1, 2, 3, 4$, and 8, the relevant equivalence maps are constructed explicitly. The poster culminates in a general condition: all equivalences may be constructed from left multiplication and conjugation by an element of Spin (N) (up to a constant). Spin (N) is a double cover of the group SO (n) of orthogonal transformation with determinant one.

58. Random Trinomials and Lower Binomials

Kenneth Brian Ascher SUNY Stony Brook
Advisor(s): J. Maurice Rojas, Texas A&M

There is no general formula, using rational functions and radicals, to determine roots of polynomials of degree 5 or more. We show how to compute the number of real, non-zero roots of trinomials (of arbitrary degree) using a simple logarithmic inequality. Using the log-uniform distribution for the coefficients, we then prove that the number of real roots is 3/2 on average. We present possible generalizations of this result to polynomials with an arbitrary number of terms (t-nomial). Finally, we show how an "Archimedian" Newton Polygon gives an algorithm to efficiently approximate the roots of f.

59. Disrupting Terrorist Networks

Danika Lindsay CSU Channel Islands
Advisor(s): Susan Martonosi, Harvey Mudd College

The organization of terrorist networks suggests that removing key members of a network may be an effective method of disrupting said network. In practice, locating key members is very difficult. This paper investigates increasing the visibility of a key member of a network by removing a more accessible member, thus increasing communication flow through the key member. Previous research has shown that some nodes are better to remove than others and that there is consistently a best node to remove from a graph. We focus on investigating which nodes, when removed, do not increase communication through the key member. We implement an algorithm to quickly identify those nodes and eliminate them from node removal consideration. This algorithm is compared against a straightforward brute force removal algorithm, and significant improvement in running time is shown for certain graph types. We also create four new types of randomly generated graphs that more accurately represent the characteristics of covert networks.

60. Insurance Risk: An Application of Gambler's Ruin in Transient States

Charles A. Turner Lamar University
Advisor(s): Kumer Pial Das, Ph.D, Lamar University

The Gambler's Ruin Problem is widely applicable to actuarial science. It is a Markov Chain that has been proven useful in insurance fields and in modeling financial risk. Gambler's Ruin can be used to determine the solvency of an insurance company by contrasting its capital gains from premiums received with the probability of suffering losses through insurance claims. With this method we can calculate the expected amount of time spent in an arbitrary transient state, or a state that might not be revisited once the process leaves that state. Furthermore, the Gambler's Ruin problem can ultimately be utilized to establish the probability that the insurance company will either prosper or be ruined.

61. Equipping RSA for Another Euclidean Domain

Brian David Larson Wheaton College
Amy Nussbaum Wheaton College
Advisor(s): Stephen Lovett, Wheaton College

The RSA algorithm is a public-key cryptography algorithm so common that most browsers use some version of it for secure online transactions. Regular RSA is defined for use within the ring $\mathbb{Z}/n\mathbb{Z}$, where n is the product of two primes. The RSA algorithm can be modified to work in certain types of Euclidean domains. In our work, we investigate the RSA algorithm over $F[x]/(N(x))$, where F is a finite field and where $N(x)$ is the product of two irreducible polynomials. After discussing how to implement RSA in this new context and illustrating with an example, we discuss some possible advantages and potential disadvantages in comparison to the regular RSA over the integers.

62. Equations of convolution type with shaped-restricted coefficients

Elizabeth Drummond Skinner Wake Forest University
Advisor(s): Kenneth Berenhaut, Wake Forest University

In this poster we consider convolution-type linear difference equations with coefficients satisfying some shape constraints. Equations of this form arise in matrix analysis, probability and the theory of formal power series. Among the constraints considered for the sequence $\{b_i\}$ are sign patterns, monotonicity, and convexity.

63. Deriving Blackjack Win and Bet Rates for the OPP Counting System

Adam Schimpf Gettysburg College
Advisor(s): Darren Glass, Gettysburg College

This presentation derives a model for determining win and bet rates for the game of blackjack. Using Gary Gottlieb's framework, a stochastic process is used to obtain these advantages for the OPP counting system. Results of this process are then compared against simulation software to test their accuracy. An analysis using Mathematica is used to compare the new OPP count to older forms of blackjack counting.

64. The NTRUEncrypt Cryptosystem and the Supporting Lattice Framework

Elliott Rosner Gettysburg College
Advisor(s): Darren Glass, Gettysburg College

This project provides an explanation and analysis of the NTRU encryption algorithm and the mathematical models from which it draws both its security and vulnerability. The NTRUEncrypt process is a public key cryptosystem which uses multiple convolutional polynomial rings to securely encrypt and decrypt information for use in numerous technological systems. While the computational aspects of the system rely solely on these rings and ring operations, there is a lattice interpretation of the cryptosystem which allows for the use of the Shortest Vector Problem in an attempt to break the encryption. The remainder of the presentation discusses this linear algebra approach and the lattice reduction algorithms that challenge the integrity of NTRUEncrypt.

65. Incorporating Protein Interaction Networks into the Bateson-Dobzhansky-Muller Model of Speciation

Karen MacPherson Trinity University
Kerry Seitz Trinity University
Advisor(s): Kevin Livingstone, Trinity University

The development of reproductive isolation is an important area of research in the field of evolutionary biology. Orr's population genetic model of Bateson-Dobzhansky-Muller (BDM) interactions in speciation (Orr, Genetics 139: 1805-1813) introduced a theoretical approach to mathematically quantifying the rate of species' divergence based on the number of allelic substitutions that have accumulated in a population. Orr's model assumes that each protein in a species' genome can interact with every other protein in that species, potentially causing a negative interaction. Studies have shown, however, that this assumption is not valid. Using the protein interaction network of Saccharomyces cerevisiae, it was found that the expected number of interactions between proteins follows a beta-binomial distribution. An additional parameter, α, was added to Orr's probability of speciation equation, where α is the probability of finding an interaction between any two proteins. Defining α allows the model to better explain differences in speciation rates among taxa based on their protein interaction networks.

66. Modeling Photropism in Dicots

Ashley Green Trinity University
Quentin Funk Trinity University
Advisor(s): James Shinkle, Trinity University

Photropism is a plants tendency to curve due to changes in light environment. Positive (towards the light source) phototropic responses are induced by blue and UV light in dicots. Our working hypothesis is that the response to each component of the light spectrum is regulated by a different light sensor. One predictor of this hypothesis is that the timing and magnitude of differential growth that results in curvature are different in response to the two light stimuli. The phototropic response of pea and cucumber seedlings to UV-B (315-280 nm) light was analyzed and differential growth data was attained by analyzing pictures. Both pea and cucumber rates of curvature development were found to be logarithmic, with most differential growth occurring within the first 200 minutes of UV illumination. The lit side of the cucumber seedlings was found to contract, while the shaded side had an exponentially decaying growth rate. The form of blue light phototropism most comparable to the UV-B response we are studying is elicited by a brief pulse of light. First phototropism experiments were done with 51 $\mu mol \cdot m - 2$ fluence. A limited first phototropic response was seen in the cucumber seedlings, and the first phototropic response in the peas was finished within two hours of illumination. A continuous blue light response (second positive phototropism) was seen in cucumbers, with significant curvatures ($\sim 10 - 12\cdot$) developing after six hours of steady illumination. Mathematically modeling this differential growth will require the use of the Lockhart equation an equation that estimates growth rates of plants as a function of

cell parameters, namely turgor pressure, extensibility and yield threshold. Our goal is to fit the Lockhart equation to our data to see how these parameters change in response to blue and UV light, showing the different effects present in each phototropic response. Mathematical manipulation of the Lockhart equation yielded a simple way to compare the ratio of extensibilities of the lit and shaded side of an illuminated plant. This ratio was consistent with one for control runs after efforts were made to eliminate the effects of nutation. The ratio for UV illuminated cucumber plants showed an asymptotic approach to zero from a negative starting point, indicating that the lit side of the plant is contracting before growth stops completely.

67. *Withdrawn.*

68. Niche Modeling Using Mathematical Models

Sam Keller Trinity University
Rick Simpson Trinity University
Advisor(s): David Ribble, Trinity University

Niche modeling is an ecological tool that uses species occurrence and environmental data to map out the ranges that a species occupies. These models use algorithms to predict the ranges of the species based on the environmental factors present at each occurrence point. Our project was designed to include a mathematical function that allows for more than just a range of the species as a product. The model is designed to produce the rate of growth for the species based on the environmental factors at that point(R1) and the intra-specific(A1) and inter-specific(B1) competition between the species modeled and other species present. Most niche modeling systems do not account for competition between or within species, which we believe is an important factor in species ranges. In the math program, Maple, we used our model to generate a sample set of occurrence data using random parameters. We then plugged the sample set of occurrence data back into the model to test if the model was able to produce accurate parameters from the data. The parameters the model produced were fairly inaccurate, despite the model producing similar occurrence data. The same inaccuracy occurred when using real occurrence data. We are currently working on fitting the model with variables that take environmental factors into account for rate of growth, and testing different models to check for more accurate parameter estimation techniques.

$$x1(t+1) = \frac{R1 \cdot x1(t)}{1 + a1 \cdot x_1(t) + b1 \cdot x2(t)}$$

69. Mathematical Classification of Tight Junction Protein Images

Caitlin Troyer Trinity University
Robert Doss Trinity University
Advisor(s): Jonathan King, Trinity University

The coupling of Biology and Mathematics is often applied to the arena of microscopic imaging. Image acquisition and analyses rely heavily on mathematical applications. In particular, these analyses can be utilized to answer a variety of biological questions that might otherwise be evaluated with a large degree of subjectivity. The goal of this study was to be able to mathematically quantify and describe the localization of various endogenous tight junction proteins to the membrane of Madin-Darby Canine Kidney II (MDCK II) cells. Through indirect immunofluorescent staining of tight junction proteins, including claudin-1 and ZO-1, with Alexa 488 fluorescence, protein localization was visualized and captured using a Nikon epifluorescent microscope. The images taken of these localizations were analyzed using a photo editing and analysis program known as ImageJ. These pictures were converted into 348x260 grids of individual pixel intensities and analyzed using a variety of mathematical calculations including: the gradient between one pixel and the pixel directly next to it, standard deviation between pixels, average pixel intensities, conditional probability testing, counting of membrane pixels, and comparison of pixels within a small (9x9) neighborhood. Once these data were collected, the images were grouped into five classes: blurry, noisy, typical claudin-1 staining, typical ZO-1 staining, and typcial Alexa 488 secondary antibody only staining. Using the Neural Network Toolbox in MATLAB, a classifier was developed that can determine the class of any of these types of images with a success rate of between 90-95%. While further analysis is needed, this classifier demonstrates that the ZO-1 and Claudin-1 tight junction proteins localize differently to the membrane.

70. Stick Number of Knots in the Cubic Lattice

Stephanie Ann Jensen Williams College
Advisor(s): Colin Adams, Williams College

The stick number of knots, defined as the least number of straight sticks glued end-to-end needed to construct the knot, is a long-studied invariant of great interest to synthetic chemists. We now study the stick number of knots in the cubic lattice. Previous to this work, cubic lattice stick number was known only for the trefoil, the figure-eight, and $9_4 7$. We use bridge index and construction to prove the lattice stick number of the infinite class of $(p, p+1)$-torus knots as well as of three other prime knots. Additionally, we find the lattice stick number for their compositions, cable satellites, and several links. Finally, we present upper and lower bounds in terms of crossing number.

71. *Withdrawn*

72. *Withdrawn*

73. Improving Abundancy Bounds

Elizabeth McCaslin McDaniel College
Advisor(s): Spencer Hamblen, McDaniel College

We will examine the percentage of integers n such that $\frac{\sigma(n)}{n}$ is at least x, where $\sigma(n)$ is the sum of all positive divisors of n. It is known that the bounds for the solutions to $\frac{\sigma(n)}{n} \geq 2$ are 0.2474 and 0.2480; however, the previous best known bounds for some x are much wider. We explore methods for improving these bounds.

74. Pattern Avoidance in Ternary Trees

Katie Peske Concordia College, Moorhead MN
Nathan Gabriel Rice University
Sam Tay Kenyon College
Advisor(s): Lara Pudwell, Valparaiso University

This project considers the enumeration of ternary trees (i.e. rooted trees in which each vertex has 0 or 3 children) avoiding a contiguous ternary tree pattern. We begin by finding the recurrence relations for several simple ternary trees; then, for more complex trees, we extend a known algorithm for finding the generating function that counts n-leaf binary trees avoiding a given pattern. After investigating bijections between these trees' avoidance sequences and other common combinatorial objects, we conclude by finding a bijective method to restructure specific tree patterns that give the same generating function, and generalizing this process to all ternary trees.

75. Mosaic Arithmetic

Stephanie Lynn Adamkiewicz Augustana College
Megan Cornett Indiana State University
Advisor(s): Rick Gillman, Valparaiso University

The mosaic of an integer n is the array of prime numbers resulting from iterating the Fundamental Theorem of Arithmetic on n and on any resulting composite exponents. Bildhauser, Erickson, Gillman and Tacoma generalized several arithmetic functions and attempted to define divisors on mosaics. We continue their work by investigating several possible definitions of arithmetic on mosaics.

76. A Monte Carlo Algorithm for Computing Dot Products

Mary Katherine Solbrig Reed College
Sylvester Eriksson-bique University of Helsinki
Sarah Warkentin Harvey Mudd College
Michael Stefanelli The College of New Jersey
Advisor(s): Ilse Ipsen, NCSU math department

Our project is focused on computing dot products of vectors by means of randomized algorithms. Randomized algorithms have been successful in applications that require fast computations on massively large data sets, such as text processing, image compression, and signal processing. These randomized algorithms sacrifice accuracy for speed in

computation. The randomized algorithms for dot products achieve their speed by sampling only a small subset of the vector elements — rather than working with all the elements — and then computing the dot product from this small subset. We have developed a new algorithm that samples the vector elements so that the computed dot product has minimal expected error. Our algorithm can be viewed as a generalization of existing randomized algorithms for dot products. We show experimentally and analytically that our algorithm can be more accurate than existing algorithms, but without any sacrifice in speed. We illustrate the performance of our algorithm on a text processing application, where for a given query vector and document matrix one wants to find the documents that best match the query.

77. Distance comparison and the Dirichlet problem for curve shortening flow in convex domains

Katharine Tsukahara Lewis and Clark College
Adam Layne Lewis and Clark College
Advisor(s): Paul T Allen, Lewis and Clark College

The curve shortening flow (CSF), which evolves a curve in the normal direction with velocity proportional to its curvature, has been explored extensively for curves in the Euclidean plane. It is known that embedded, closed curves shrink to round points in finite time. The case of curves with fixed endpoints remains largely unexamined. We prove results for the evolution of a curve under curve shortening flow on the plane and the sphere.

78. Lower Bounds for the Ropelength of Reduced Conformations

Robert McGuigan San Jose State University
Advisor(s): Rollie Trapp, California State University San Bernardino

This project generalizes the results of Sadjadi (2007) and Alley (2010) by providing an algorithm to find a lower bound for the ropelength of any knot which admits a reduced diagram. This lower bound is found by changing this problem of geometry into one of linear programming, which is then solved by the simplex algorithm.

79. Benford's Law for Coefficients of Modular Forms and Partition Functions

Larry Rolen University of Wisconsin-Madison
Theresa Anderson Brown University
Advisor(s): Ken Ono, Emory University

It has long been observed that many naturally occurring statistics and arithmetic functions have surprising properties. For example, if we examine the first digits of a sequence in base 10, instead of the a priori estimate that each digit should appear equally often we find that the first digit is a 1 about 6 times as often as it is a 9. Although this is a well-known heuristic, it has only been proven for a relatively small class of arithmetic functions. Using recent results of Ken Ono and Kathrin Bringmann on coefficients of harmonic Maass forms as well as classical theory of uniform distribution, we prove that the coefficients of an infinite class of modular forms satisfy the Benford distribution. This allows us to generate large classes of sequences which were previously unknown to be Benford. In particular, we will show this for the partition function $p(n)$ as well as numerous classes of natural partition functions.

80. Bishop's Lemma and Boundaries of Lipschitz Function Algebras

Robert Allan Silversmith Williams College
Ann Kathryn Johnston Harvey Mudd College
Advisor(s): Aaron Luttman, Clarkson University

A well-known result from complex analysis states that a function that is analytic inside the unit disk is uniquely defined by its values on the unit circle. This somewhat surprising result - that the function values on the entire domain can be deduced from those on a "small" subset, or boundary - can be extended to other function algebras. Bishop's Lemma is a theorem that guarantees the existence of a minimal closed boundary in some function algebras. We provide a sufficient condition for this theorem to hold in a given function algebra. In addition, we show an algebra where the theorem does not hold, yet the minimal closed boundary does exist.

81. Investigating Equitent Problems

Payton Evan Lindsay Southern Illinois University Carbondale
Advisor(s): Gary R. Lawlor, Brigham Young University

Equitent problems ask what is the figure that minimizes perimeter for a given area or volume and a fixed boundary. This research investigates the equitent problem in $\mathbb{R}^2$, specifically connecting the vertices of regular polygons while also enclosing a given area. We utilize a new method of optimization called metacalibration, which was first developed by Gary Lawlor of Brigham Young University. Equitent problems in the plane can be thought of as a combination of a Steiner problem and an isoperimetric problem, and as such are very intriguing to study.

82. Numerical Modeling for Capillary Equations: The Small Angle Case

Allison Kate Cullen University of Detroit Mercy
Kaitlyn Brady Worcester State University
Advisor(s): Chad Westphal, Wabash College

Capillary action occurs when surface tension causes a fluid to rise along a wall with which it has come into contact. The Laplace-Young equation is a nonlinear elliptic partial differential equation that is used to model this. We are particularly interested in the situation of a domain with a geometric corner; in the small angle case the solution is unbounded and little is known analytically. Our research takes a computational approach. We design a way to linearize and reformulate the PDE, strategically design a mesh, and use the finite element method and least squares approach to approximate the exact solution. Our formulation is designed to produce a sequence of approximations that converge to the exact solution.

83. Algebraically Modified Simple Random Walks on The Integer Lattice $\mathbb{Z}^d$

Charles Joseph Morrissey Michigan State University
Advisor(s): Aklilu Zeleke, Michigan State University

Historically it is known that for a simple random walk on $\mathbb{Z}^d$ with $d \leq 2$, are recurrent, whereas for $d \geq 3$ all walks are transient. Given any fixed $d \in \mathbb{N}$ a modified simple random walk is contructed by moving positively or negatively along each axis in one move, as opposed to only moving along one axis in one movement. Given this new construction of a walk, the property of recurrence is then examined. The claim is made that all walks of this nature are recurrent for all $d \in \mathbb{N}$

84. Modeling the Effects of Predator Exclosure on the Western Snowy Plover

Christina Marie Watts Montana State University
Jing Cao Humboldt State University
Advisor(s): Christopher Dugaw, Humboldt State University

In Humboldt County, California, nest exclosures were used between 2001 and 2006 as a management tool in the recovery of the threatened local population of western snowy plovers. Due to a sudden increase in adult mortality in 2006, field biologists monitoring the species abandoned the use of nest exclosures. This poster will describe a project designed to assess the efficacy of nest exclosures by constructing a mathematical model using a discrete time stochastic model to predict the change in the plover population. The model uses beta distributions to model demographic parameters. Whenever possible, these distributions were fit to survey data on these populations. The model showed nest exclosures to be effective in increasing egg survival. However, the model also showed that an increase in adult mortality potentially caused by the nest exclosures would counteract this increase in egg survival. The model predicts that if exclosures decrease adult survival to seventy percent of its natural state, the population is negatively impacted and the nest exclosures are no longer beneficial.

85. A Weighted Least Squares Method for Elliptic Problems With Degenerate and Singular Coefficients

Matthew Hassell SUNY Binghamton
Stephen Bidwell Tufts University
Advisor(s): Chad Westphal, Wabash College

We consider second order elliptic partial differential equations with coefficients that are singular or degenerate at an interior point of the domain. This paper presents formulation and analysis of a novel weighted-norm least squares

finite element method for this class of problems. We propose a weighting scheme that eliminates the pollution effect and recovers optimal convergence rates. Theoretical results are carried out in appropriately weighted Sobolev spaces and include ellipticity bounds on the weighted homogeneous least squares functional, regularity bounds on the elliptic operator, and error estimates. Numerical experiments confirm the predicted error bounds.

86. A Mathematical Model for Antibiotic-resistant Nosocomial Infections with the Application of Optimal Control Theory

Shujing Wang Colgate University
Advisor(s): Joaquin Rivera-Cruz, Colgate University

Healthcare associated infections caused by antibiotic-resistant bacteria have become a costly problem in hospitals in the USA. The appearance of these resistant strains compromises medical care worldwide. We developed a five-level population mathematical model to investigate key parameters in hospital-acquired (nosocomial) infections. Our model considers the case with a single bacterial strain resistant to antibiotics with direct transmission between patients, and healthcare worker-patient. The effect of mutation is also incorporated into the model. By reformulating the model as an optimal control problem, with the control defined as treatment other than the drug, the primary transmission rate between patients is reduced. We were able to find numerically the optimal control that reduces significantly the number of patients infected with the resistant strain of the bacteria.

87. Minimal surfaces and planar harmonic mappings

Amanda Rae Curtis Wellesley College
Rachel M. Messick Brigham Young University
Advisor(s): Michael Dorff, Brigham Young University

A minimal surface in $\mathbb{R}^3$ is a regular surface for which the mean curvature equals zero at every point. In the theory of minimal surfaces, theWeierstrass representation provides a formula using complex analysis for the local representation of a minimal surface. One new approach to investigating minimal surfaces is to use results about planar harmonic mappings, $f = h + \bar{g}$, where h and g are complex analytic functions. In particular, we can reformulate the classical Weierstrass representation using the harmonic univalent map $f = h + \bar{g}$.We will discuss some results about minimal surfaces by using theorems about planar harmonic mappings.

88. Multiscale Adaptively Weighted Least-Squares Finite Element Methods for Convection-Dominated Elliptic PDEs

Bridget Kraynik College of Wooster
Yifei Sun Wabash College
Advisor(s): Chad Westphal, Wabash College

We consider a weighted least-squares finite element approach to solving convection-dominated elliptic partial differential equations, which are difficult to approximate numerically due to the formation of boundary layers. The new approach uses adaptive mesh refinement in conjunction with an iterative process that adaptively adjusts the least-squares functional norm. Numerical results show improved convergence of our strategy over the standard approach and a prior method. We also apply our strategy to solving the Navier-Stokes Equations.

89. Classifying Complemented Subspaces of L_p, $2 < p < \infty$ with Alspach Norm

Shawn Peters University of Wisconsin- Eau Claire
Becky Sippert University of Wisconsin- Eau Claire
Advisor(s): Simei Tong, University of Wisconsin- Eau Claire

Understanding the complemented subspaces of L_p has been an interesting topic of research in Banach space theory since 1960. In 1999, Alspach proposed a systematic approach to classifying the subspaces of L_p by introducing a norm given by partitions and weights. We will show that with the Alspach Norm we are able to classify some complemented subspaces of $L_p, 2 < p < \infty$. We have a complete classification of subspaces of L_p with the Alspach norm with one partition, and we also have a partial classification of L_p with two partitions.

90. Mathematical modeling of interface-dominated materials properties.

Russell Mahoney George Mason University
Advisor(s): Maria Emelianenko, George Mason University

Many materials used today are polycrystalline aggregates composed of large numbers of minuscule grains. These grains are separated by grain boundaries which determine the properties of the material, such as elasticity or conductivity. A combination of macro- and mesoscopic tools such as the finite element microstructure analysis package OOF2 and in-house grain growth evolution models is used to perform a comprehensive study of the dynamical effects grain coarsening has on these materials properties. By analyzing how these materials respond to stress, electricity, or heat, we learn more about the impact of grain boundary distributions.

91. Modeling complex physical phenomena using energy minimization principle.

Robert DeHart Hill George Mason University
Advisor(s): Igor Griva, George Mason University

Modern modeling languages and optimization tools make it possible to analyze complex physical phenomena. The following two examples are driven by the energy minimization principle, and thus can be modeled using optimization: First, we consider a problem of docking a molecular wire to a bacterial photosynthetic reaction center (RC). To assemble efficient photovoltaic devices, it is critically important to explore how to dock highly conducting molecular wires to the RC. Second, we consider the problem of constructing phase diagrams. Phase diagrams illustrate the conditions in which thermodynamically distinct phases (e.g., gas, liquid or solid) can occur in equilibrium for a material or a mixture of materials. We build optimization models for both examples using AMPL and solve them using interior-point method and sequential quadratic optimization technique.

92. Investigations in Linear Algebra and Combinatorics related to Biclique Decompositions of Graphs

Shadiyah Amani Mangru George Mason University
Advisor(s): Walter Morris, George Mason University

We formulate five new propositions related to the Graham-Pollak Theorem. The first four illuminate properties of both biclique edge covers of the edge set of K_n, and nullspace basis vectors of a matrix representation of such covers. These four propositions motivate the recursively-defined sparse null space basis we present, as proposition five, for a particular subset of matrices of interest in Algebraic Graph Theory.

93. Cops and Robbers on Planar Graphs

Silviya D Valeva Mount Holyoke College
John M McCauley Haverford College
Advisor(s): Andrew Beveridge, Macalester College

In the game of *Cops and Robbers* on a graph $G = (V, E)$, k cops try to catch a robber. On the cop turn, each cop may move to a neighboring vertex or remain in place. On the robber's turn, he moves similarly. The cops win if there is some time at which a cop is at the same vertex as the robber. Otherwise, the robber wins. The minimum number of cops required to catch the robber is called the *cop number* of G, and is denoted $c(G)$. The game of Cops and Robbers has applications in robotics and in search and rescue operations.

A classic result of Aigner and Fromme shows that if G is planar then $c(G) \leq 3$. We characterize the following families of planar graphs as having $c(G) \leq 2$: series parallel graphs, outerplanar graphs, maximal 2-outerplanar graphs, and maximal planar graphs with maximum degree at most 5. We also show that every graph G with $|V| \leq 9$ has $c(G) \leq 2$. This bound is tight, since the Petersen graph (on 10 vertices) requires 3 cops.

94. A Stability Study of Asset Price Equilibrium Models

Arjun Sanghvi George Mason University
Advisor(s): Harbir Lamba, George Mason University

A previously developed heterogeneous agent model is used to simulate the price of a financial asset and successfully captures statistical properties standard to actual financial data. These stylized facts include: volatility clustering, fat tail distributions, and power law decay of price changes. Such properties are often absent from models that implement the

neoclassical assumptions of Economics. These neoclassical equilibrium models are derived from geometric Brownian motion with drift:

$$y(t) = y_0 e^{(r-\frac{1}{2}\sigma^2)t+\sigma B_t}$$

The proposed model invokes price thresholds to simulate agent behavior over a long timescale. Agents often act, rationally or irrationally, based on the choices of others in the system—a characteristic called herding.

By introducing adjustable parameters to the Efficient Market Hypothesis (EMH) baseline model, we control and thereby determine the effect of such variables on the market dynamics. Using a bifurcation parameter we analyze the stability of the equilibrium model and find the point at which it becomes unstable. We find that for low levels of herding, the EMH becomes unstable; and as the level of herding is increased, the model achieves the most important stylized facts.

95. Finite Difference Methods for Solving the Coupled Non-Linear Euler-Bernoulli Beam Equations, with applications to modeling the wing of a Micro Air Vehicle.

James Hickman Shippensburg University
Advisor(s): Padmanabhan Seshaiyer, Shippensburg University

Over the past decade the development of Micro-Air-Vehicles (MAV's) has been of interest to several groups. In particular the military envisions it as a potentially vital aspect of their intelligence division. This however is certainly not the only function for this emerging technology, private companies also envision applying it to a variety of applications as well. This paper will focus on using a non-linear form of the Euler-Bernoulli beam equation in an attempt to model the batons of a flexible winged MAV. First the equations which constitute the core of this research will be derived using the principles of Hamiltonian Mechanics combined with ideas from Continuum mechanics. After the derivation is completed a numerical algorithm will be discussed which consists primarily of finite difference approximations which use iterative methods to solve this coupled system. Further advances in this area of study could incorporate a model which encompassed the entire wing, simulations based on material constraints, and finally integration of the principles of fluid mechanics into the problem to make it more relevant and applicable. This work has been completed as a part of the 2010 REU Program at George Mason University funded by the NSF-REU and DOD-ASSURE Programs.

96. Skew-Tsankov algebraic curvature tensors in the Lorentzian setting

Kaetlin Taylor Rhodes College
Advisor(s): Corey Dunn, California State University, San Bernardino

In the study of differential geometry, an object is measured by how much it curves in space. To measure this curvature, we will utilize a portrait of the Riemann curvature tensor known as the *algebraic curvature tensor*. We determine the possible Jordan normal forms for a skew-adjoint operator in dimension four with a Lorentzian metric, i.e., a metric of signature $(1, q)$. We utilize the skew-symmetric curvature operator, and say $\mathfrak{M}$ is *skew-Tsankov* if the skew-symmetric curvature operator commutes. Furthermore, we study the decomposability of skew-Tsankov models with these properties.

97. Holey Shircles, Batman! That Shape is Close!

Anyastassia F Seboldt California State University San Bernardino
Ace White Whittier College
Li-Hsuan Huang California State University Fullerton
Advisor(s): Kathryn Leonard, California State University Channel Islands

In problems of shape recognition, we want to minimize the information required to accurately depict shapes so that computers can perform recognition as efficiently as possible. Using ε-balls, we construct an optimal ε-covering of the metric space of circles in a $w \times h$ rectangular region in the $\mathbb{R}^2$ plane, where distance between shapes is measured using the Hausdorff metric. Any circle in our region will be at least ε close to one of our ε-ball centers. Thus, we are able to compute an optimal ε-approximation of any circle in our region.

98. Classification of 3-Dimensional Shapes Using Distance Histograms

Laura Maki Winona State University
Advisor(s): Joyati Debnath, Winona State University

The objective of this research is to manipulate distance histograms of different 3-dimensional shapes in order to find ways to classify the shapes in a unique mathematical way. This research can potentially aid in object recognition in 2-dimensional and 3-dimensional medical images. The classifications are done up to rigid motion since transformations of rotations or translations do not change the distance histograms. The 3-dimensional surfaces are discretized using parameterizations so that points on the surface can be used for calculations. Local distance histograms refer to the set of distances found by fixing one point and then varying a second point. Global histograms refer to the set of distances found by varying both points. Triangles can also be created within a 3-dimensional shape by taking 3 points on the surface and finding the sets of the 3 distances of the triangle. Plotting the different sets of distances shows how different shapes are in terms of their distance histograms. Norms can also be calculated to numerically see the differences and then an array plot is created to see how the norms differ when comparing different shapes.

99. An International Study of Mathematics in the Middle Grades: China, Russia, and the United States

Chelsey Drohman University of Wisconsin Eau Claire
Ying Yang University of Wisconsin Eau Claire
Alice Oswalt University of Wisconsin Eau Claire
Advisor(s): Kate Masarik and Simei Tong, University of Wisconsin Eau Claire

Education and economics are global issues; as such, we need to learn from other countries to enhance K–12 education. The study focuses on the algebraic concept of inequalities and the geometric concept of angles formed by the intersection of a transversal with non-parallel and parallel lines. The poster presents the results of middle grade mathematics curriculum from China, Russia, and the United States to determine the similarities and differences in the texts. Examples and sample textbooks will be displayed.

100. Metacalibration on Manifolds

Amelia Hancock Washington State University
Amber Verser Lawrence University
Advisor(s): Gary Lawlor, Brigham Young University

We examine the isoperimetric problem, minimizing the perimeter or surface area required to bound a fixed area or volume, on multiple manifolds using a new method called metacalibration, a generalization of more traditional calibration methods. We solve the isoperimetric problem in full on the hyperbolic plane and the flat 2-torus and examine the problem on the flat 3-torus.

101. Minimal Surface Transformations

Jamal Eric Lawson Loyola University New Orleans
Ryan Donald Viertel Brigham Young University
Advisor(s): Michael Dorff, Brigham Young University

A minimal surface in $\mathbb{R}^3$ is a surface whose mean curvature vanishes at each point on the surface. Thus, minimal surfaces look like saddle surfaces and can be modeled by soap films spanning a wire frame. We can parameterize minimal surfaces using the classical Weierstrass Representation. In this paper, we will discuss how one-to-one complex-valued harmonic mappings can be used with the Weierstrass Representation to parameterize minimal graphs in $\mathbb{R}^3$. We will then use the shearing technique developed by Clunie and Sheil-Small to construct a one-parameter family of harmonic univalent mappings that lift to minimal surfaces under the Weierstrass Representation. Specifically, we will show that this parameter results in a continuous transformation of Scherk's First Surface with $2n$ ends to a minimal surface with n helicoidal ends. Each of the intermediate surfaces will be minimal graphs.

102. Bifurcation Structure of External Cavity Mode and Compound Laser Mode Solutions

Christina Battista Rochester Institute of Technology
Jeannette Benham Bard College
Advisor(s): Tamas Wiandt, Rochester Institute of Technology

External cavity semiconductor lasers are commonly used in various important fields such as optical fiber communications and data recording. The main model in the understanding of the dynamics of these lasers is the well-known

Lang-Kobayashi equations, consisting of two delay differential equations for the complex electrical field E and the carrier number density N. The model contains five parameters and exhibits various bifurcations. In our research, we were interested in special solutions, called External Cavity Mode (ECM) solutions. These solutions appear through saddle-node bifurcations as the feedback parameter is changed, then lose stability through a Hopf bifurcation at higher feedback levels. We investigated the structure of these bifurcations on the feedback level-external cavity roundtrip time parameter space and established the possibility of the coexistence of stable ECM solutions. In the more difficult case of delay-coupled lasers, solutions of analogous form are called Compound Laser Mode (CLM) solutions. We also studied the stability of these solutions and the bifurcation possibilities as the detuning parameter changed. Our goal is to extend this analysis to describe the full bifurcation structure of CLM solutions.

103. An investigation of solutions to a non-linear suspension bridge model

Mary Kastning Central Washington University
Advisor(s): Stuart Boersma, Central Washington University

In continuation of the work done by Lazer and McKenna, and furthered by Humphreys and Shammas, we categorized solutions to a nonlinear model for a suspension bridge. Earlier results predicted the existence of 5 different periodic solutions. By examining the long-term behavior of 840,000 different initial conditions, we relied on the numerical solutions generated by Mathematica to identify, save, and color the initial value pairs tested. Thus we have a five color initial position $y(0)$ versus initial velocity $y'(0)$ graph. This graph provides some new insight into the nature of the solutions.

104. The Effect of Localized Oil Spills on the Atlantic Loggerhead Turtle Population Dynamics

My Thanh Huynh Arizona State University
Margaret-Rose Leung Oregon State University
Advisor(s): Jos Flores, The University of South Dakota

In this work, we analyze the population dynamics of loggerhead turtles (*Caretta caretta*) affected by localized oil spill events. We develop a spatial, stage-classified matrix model and apply it to the three primary nesting regions in the area. Oil spills are simulated deterministically in each nesting region, with oil-induced mortality ranging from 25% to 100% and affecting stage classes either differentially (via simple kernels) or equally. The results of this study are intended to provide insights into the population dynamics of the Atlantic loggerhead turtles and suggest conservation techniques appropriate in each oil spill case.

105. Existence of solutions to the modified Sylvester equation

Daniel Joseph Corey University of Notre Dame
Javier Rafael Jaramillo University of Rochester
Advisor(s): Fernando de Teran, Universidad Carlos III de Madrid

Since 1952, necessary and sufficient conditions have been known for the solvability of the Sylvester equation, a matrix equation of the form $AX - XB = C$. A solution exists if and only if the matrices

$$\begin{pmatrix} A & 0 \\ 0 & B \end{pmatrix} \qquad \text{and} \qquad \begin{pmatrix} A & C \\ 0 & B \end{pmatrix}$$

are similar. With this relationship as our motivation, we postulate that a related necessary and sufficient condition exists for $AX + X^T B = C$, which we call the modified Sylvester equation. We hypothesize that a solution exists if and only if the matrices

$$\begin{pmatrix} 0 & A \\ B & 0 \end{pmatrix} \qquad \text{and} \qquad \begin{pmatrix} C & A \\ B & 0 \end{pmatrix}$$

are congruent. While we have not established whether our conjecture is true for the most general form of the modified Sylvester equation, we have shown it is true for special cases when restrictions are placed on the matrices A and B. In particular, the condition is true when $B = A^T$. Proceeding from this special case, we show that the proposed condition of congruent matrices — combined with a second condition — *is* necessary and sufficient for the existence of a solution to $AX + X^T B = C$. A natural direction for future research consists of determining whether the two conditions are the same.

106. Numerical Characterization of Quality of Compressive Sensing Matrix Generated through Different Random Methods

Charles Drake Poole University of Massachusetts at Dartmouth
Advisor(s): Steven Leon, University of Massachusetts at Dartmouth

Compressed sensing is a method of recovering interesting images from sparse sampling. To get an ideal reconstruction we want to recover as many entries of x as possible with as few as K measurements. (Emmanuel Candes) We want $\partial_{2S} + \theta_{S,2S} < 1$ to hold for large values of S, ideally of the order of K. By THM 3.1 and 3.2 in Compressive sampling. (Int. Congress of Mathematics, 3, pp. 1433–1452), they show that a trivial randomized matrix construction will obey the UUP for large values of S.

Using this knowledge of compressed sensing matrices we explore the phase space of possible sensing matrices completely for a small problem, seeing which matrix is quantitatively best. We then try to extrapolate those findings onto larger sensing matrices where the phase space is too large to fully computationally explore and attempt to show this method leads to a better sensing matrix than a fully random matrix. With prior knowledge of the images general interesting features, we then compare results with different methods of randomly populating the sensing matrix in accordance with our earlier extrapolation to show the numerical quality, or performance of the given method.

107. Numerical Modeling of Gravational Waves Accelerated by CUDA and OpenCL

Justin P McKennon University of Massachusetts Dartmouth
Advisor(s): Gaurav Khanna, University of Massachusetts Dartmouth

Modern scientists in the field of astrophysics have become extremely fascinated by the study of Gravitational Waves (GWs) . These GWs were predicted by Einstein's theory of relativity but have never been directly observed. GWs (until recently) have been too weak to measure. GWs are of interest to the scientific community due to the information about the far reaches of the universe that they provide. The study and simulation of the sources of these waves has been greatly limited by the sheer mathematical complexity of the equations governing their behavior and evolution. Our work alleviates this issue by using the programming languages CUDA and OpenCL to accelerate these computations on the GPU.

108. Optimal Movement Strategies for Thermoregulating Snakes and Lizards within a Habitat

Curtis Alan Balusek Sam Houston State University
Casey Hartnett Sam Houston State University
Kristen Pelo Sam Houston State University
Advisor(s): John G. Alford, Sam Houston State University

Reptiles are poikilotherms whose body temperatures are governed by ambient environmental temperature. Some species of reptiles use behavioral thermoregulation to maintain a preferred body temperature while others simply thermoconform to the thermal environment. Movement and thermoregulatory behaviors are often influenced by sit-and-wait or active foraging strategies. Huey and Slatkin present a qualitative analysis of optimal thermoregulatory strategy that we examined quantitatively with algebraic equations. We used a piecewise linear function, a differential equation and a computer simulation to mathematically investigate Huey and Slatkins' theoretical model of thermoregulation. This research allowed for evaluating the cost and benefits associated with thermoregulatory strategy of a snake species, the timber rattlesnake, Crotalus horridus.

109. Estimating Survival Functions for Symmetric Distributions Under Peakedness Order Constraints

Alexandra (Sasha) Scarlett Indarte Macalester College
Advisor(s): Javier Rojo, Rice University

The problem of estimating distribution functions F and G when F is more peaked than G and F and G are symmetric about 0 is addressed by Rojo and Batun-Cutz (2009). These estimators correct for violations in the peakedness order of the empirical distribution functions, F_n and G_m. When applying this estimation process to survival functions, the partial censoring of F and G creates greater inaccuracy in these estimators. By using the Kaplan-Meier estimator in place of the empirical distribution functions in the estimators proposed by Rojo and Batun-Cutz (2009), the impact of changing the weights in their benchmark function can then be investigated. Here, two new benchmark functions are proposed for use in their estimators. Through Monte Carlo simulations, the estimators built from the new benchmark functions are compared in terms of mean squared error and bias with the original estimators proposed by Rojo and Batun-Cutz (2009).

110. The impact of non-reproductive groups in two-sex demographic and epidemic logistic models without pair-formation

Jill Marie Jessee Simpson College
Michael Covello Loyola University
Advisor(s): Daniel Maxin, Valparaiso University

Mathematical models in demography need to incorporate population effects in the mortality rates whenever they are used for long term predictions. Logistic two-sex models that include single females, single males and couples have been already analyzed in several recent papers. Those models were extended to an STD epidemic model that included non-reproductive groups. The couple formation/dissolution mechanism together with the influence of non-reproductive groups was proved to be essential in the spread and/or containment of the disease. In this paper we establish a logistic two-sex model without pairs and investigate whether similar or different results hold true in the new framework compared to those obtained in populations with stable couples. This approach is particularly relevant in the context of gender structured animal populations that do not form stable pairs except for reproduction.

111. Substructures with Unity of Endomorphism Near-rings

Corey Jones University of North Carolina, Asheville
Advisor(s): Greg Boudreaux, University of North Carolina, Asheville

Endomorphism near-rings generalize the familiar endomorphism rings of abelian groups to the non-abelian setting. For a group G and a subgroup K, we define subnear-rings $E(G, K)$ and $H(G, K)$ of the endomorphism near-ring, $E(G)$. These subnear-rings allow us to translate certain properties of the subgroup structure of G to the subnear-ring structure of $E(G)$. Building on previous results of G. Boudreaux, we prove a result that characterizes when these subnear-rings have a multiplicative unity, and then demonstrate how the existence of a unity implies that the endomorphism near-ring is decomposable as a direct sum of ideals.

112. An Application of Orthonormal Functions to the Probability of Games

Louisa Normington University of North Carolina at Asheville
Advisor(s): Samuel Kaplan, University of North Carolina at Asheville

Orthonormal functions are used in Fourier analysis to approximate functions that are often too difficult to work with. We demonstrate a method that enables us to find the necessary weight function, $G(x, y)$, that forces two generalized functions, $f(x)$ and $g(y)$, to become orthonormal to one another. We use that orthonormal construction to approximate a best fit generalized probability function to our original data from the men's singles matches in this past Wimbledon Championships. Thus we can calculate what percentage of the matches were evenly 50-50, and what percentage were uneven.

113. Solutions for a Sixth Order Nonhomogeneous Boundary Value Problems on a Discrete Domain

Paul A. Parks University of CentraL Oklahoma
Advisor(s): Britney Hopkins, University of Central Oklahoma

This poster illustrates the existence of solutions for the sixth order difference equation, $\Delta^6 u(t-3) = \lambda h(t, u(t), \Delta^2 u(t-1), \Delta^4 u(t-2))$, for $t \in (0, N+2)_{\mathbb{Z}}$, satisfying the nonhomogeneous conjugate boundary conditions: $u(0) = \Delta^2 u(-1) = \Delta^4 u(-2) = 0$, $u(N+2) = a$, $\Delta^2 u(N+1) = -b$, and $\Delta^4 u(N) = c$ where $h : [0, N+2]_{\mathbb{Z}} \times [0, \infty) \times (-\infty, 0] \times [0, \infty) \to (-\infty, 0]$ is continuous, $a, b, c, \lambda \geq 0$, and $a + b + c \neq 0$. By substitution and transformation we can change the 6th order difference equation into a system of second order homogeneous boundary value problems and then, utilizing the Guo-Krasnosel'skii Fixed Point Theorem, we insure the existence of at least three positive solutions.

114. Parity of k-regular Partition Functions

Liem P Nguyen University of Wisconsin Oshkosh
Advisor(s): David Penniston, University of Wisconsin Oshkosh

A k-regular partition of a positive integer n is a partition of n whose parts are not divisible by k, and we denote $b_k(n)$ as the number of k-regular partitions of n. We are interested in the parity of this class of function, in particular the exact criteria for when $b_k(n)$ is even. In this presentation, we will give such criteria for $b_7(n)$ and $b_{13}(n)$, and also prove that these functions satisfy Ramanujan type congruences modulo 2.

115. The Energy of Graphs

Audrey M. Hubbard Ave Maria University
Christian M. Woods University of Pittsburgh
Advisor(s): Sivaram K. Narayan, Central Michigan University

Let M be a matrix associated with a graph G on n vertices. Let $\sigma(M) = \{\mu_1, \mu_2, \cdots, \mu_n\}$, and let $\bar{\mu} = Tr(M)/n$ be their average. The M-energy of G is defined as

$$E_M G = \sum_{i=1}^{n} |\mu_i - \bar{\mu}|$$

The energies of several matrices associated with a graph have been studied, in particular, the adjacency energy, Laplacian energy, distance energy, and, more recently, the normalized Laplacian energy.

We will explain the relationship between the normalized Laplacian matrix and the Randić matrix of a graph. We will also present some relations we have found concerning several types of energy. In particular, we will derive algebraic expressions and bounds for the effects of various graph operations on normalized Laplacian energy. Among these are binary operations such as the join, Cartesian product, strong product, and corona of two regular graphs, as well as a unary operation we call the "shadow" of a graph.

116. Model Development for Lignocellulosic Biofuels

Amir Yousef Ahmadi Morehead State University
Helen Vo University of California, Berkeley
Advisor(s): Dr Ralph Smith, North Carolina State University

Searching for an efficient and economical alternative to petroleum-based fuel products is of great recent concern. In the past, first generation biofuels generated controversy in its exorbitant usage of food product. Second generation biofuels bypass this controversy and have potential to yield a greater quantity of usable products via lignocellulosics agricultural waste products. Unfortunately, the production process of lignocellulosic biofuels is variable and production has yet to be fully optimized.

Previous models attempt to understand the production process but have yet to offer consistent results. Although the model by Luo, et al. demonstrates some success, this poster provides suggestions to their equations and seeks a more accurate representation of the production process of bio-oil. This is done through optimization of process parameters and a more complete implementation of biomass characteristics and thermal properties. The model utilizes the dynamics of the circulating fluidized bed (where the reactions take place) and possible reactions resulting from its flash pyrolysis which past research has deemed as the most efficient and economical for future large-scale production.

117. Abscissa of convergence functions for self-similar measures supported on unit cubes

Nina Alyssa Cerutti California State University, Stanislaus
William Hall California State University, Stanislaus
Scott Roby California State University, Stanislaus
Advisor(s): John Rock, California State University, Stanislaus

The abscissa of convergence functions of certain self-similar measures supported on subsets of the unit interval have been shown to recover, for instance, the Hausdorff dimension of the Besicovitch subsets of the support. In this poster, we determine the abscissa of convergence function for a self-similar measure supported on the unit square using a sequence of partitions which have mesh tending to zero. The method used will be shown to extend to similar measures supported on unit cubes in higher dimensions.

118. The Fairest of Them All: Using Variations of Beta-Binomial Distributions to Investigate Robust Scoring Methods

Karen Nielsen University of Oklahoma
Mary Good Bluffton University
Christopher Kinson Albany State University
Mame Fatou Thiam University of Wisconsin River Falls
Advisor(s): Emily Murphree, Miami University

Contestants in subjective competitions often encounter the issue of unfair or inconsistent judging. Scores are awarded to contestants and winners are determined, but how do we know that the best contestants win? By assuming there exists

a well-defined order of the contestants' abilities, we can explore which scoring method best captures the true order of the contestants. We use variations of beta-binomial distributions to model the contestants' abilities and the judges' scoring tendencies. We use Monte Carlo simulations to investigate seven scoring methods (mean, z-scores, median, raw rank, z rank, Olympic, and outliers) and determine which method, if any, works best for various judge panels. We apply our model to the scenario of a scholarship competition with 20 contestants, where the top three contestants receive equal monetary awards.

119. Multifractal analysis of a measure when the open set condition is not satisfied

Scott Alan Roby California State University, Stanislaus
Nina Cerutti California State University, Stanislaus
William Hall California State University, Stanislaus
Advisor(s): John Rock, California State University, Stanislaus

Results regarding the attractor of an iterated function system (IFS) for which the open set condition (OSC) is satisfied are well-known and relatively abundant. However, somewhat less is known in the case of measures which are defined by a weighted IFS that does not satisfy the OSC. In this poster, we consider a popular example of such a measure where the IFS that defines the support has fixed scaling ratio given by the reciprocal of the golden ratio and the contracting similarities do not satisfy the OSC. The approach taken is to determine the partition zeta functions and use the corresponding abscissa of convergence function to define a multifractal spectrum.

120. Partition zeta functions of measures with unusual coarse Holder regularity decomposition

William Hall California State University Stanislaus
Scott Roby California State University Stanislaus
Nina Cerutti California State University Stanislaus
Advisor(s): John Rock, California State University Stanislaus

The coarse Holder regularity values attained by a self-similar measure with respect to a natural sequence of partitions are well-understood when the scaling ratios and probability vector which define the mass distribution satisfy one of two relatively restrictive conditions. However, the breakdown of coarse Holder regularity has not been determined for self-similar measures where the mass distribution does not behave so nicely. We present an example of such a self-similar measure for which the coarse Holder regularity results in an unfamiliar family of partition zeta functions. The long term goal is to extend known results regarding partition zeta functions to larger classes of self-similar measures, in particular, the recovery of the multifractal spectra.

121. 2-Dimensional Shape Modeling

Christine E Caples Fairfield University
Carlos Fernando Hernandez California State University Fullerton
Advisor(s): Kathryn Leonard, California State University Channel Islands

In order to perform automated shape recognition, a computer must be given a representation of each shape. One such representation is the medial representation, which can be thought of as the skeleton of the shape. This project compares different medial representations based on optimality, which is determined by computing the minimum the number of bits required for the representation of a particular shape. Specifically, we explore variants of the Blum medial axis in order to obtain the most optimal medial representation for an ellipse and a class of near-ellipses.

122. Enabling Physiologically Representative Simulations of Pancreatic Beta Cells

Sidafa Conde University of Massachusetts Dartmouth
Advisor(s): Matthias K. Gobbert, University of Maryland, Baltimore County

Within the endocrine system of the pancreas lie clusters of cells called the islets of Langerhans. Each islet is composed of four cell types, the most prevalent of which being the beta cell. We aim to continue the development of a computational islet and simulating the behavior of these cells. There exists a set of deterministic Ordinary Differential Equations (ODEs) that model insulin secretion within the beta cells. We consider cell dynamics on a cubic lattice of, on average, 1000 heterogeneous cells with key parameters including ionic fluxes, calcium handling, metabolism, and electrical coupling. By using sophisticated software, careful consideration of robust numerical methods, and efficient programming techniques, physiologically representative simulations of pancreatic beta cells become feasible. We provide an extensible, efficient, and functional computational islet simulator to aid research in beta cell dynamics.

In particular, we adapt an existing dual electrical and glycolytic oscillator model into a numerically robust, modular set of Matlab files.

123. Chains of Rings with Local Formal Fibers

Sean Carlos Pegado Williams College
Advisor(s): Susan Loepp, Williams College

Let R be a local (Noetherian) commutative ring with unity. If R is complete, its structure is understood; however, less is known if R is not complete, and thus the relationship between a ring and its completion is a subject of current research. It is known that if R is an excellent local ring, then R shares many algebraic properties with its completion. We construct excellent rings that behave strangely with respect to their completions. In particular, we construct chains of excellent rings such that each ring has a local formal fiber at a specified prime ideal, a property one would not expect an excellent ring to have.

124. Geometric objects with a more combinatorial flavor

Andreea Luisa Erciulescu Colorado State University
Advisor(s): Anton Betten, Colorado State University

We are studying geometric objects, defined over finite fields, with a more combinatorial flavor and present the results of the investigation of classification problems in geometry and combinatorics. Objects called BLT-sets, living in a vector space over a finite field, are of great interest to finite geometry, as they provide access to most of the objects that have been studied for a long time (translation planes, generalized quadrangles, flocks). On the other hand, there are objects that are invariant under a finite group. An example is the Coxeter groups, which act as symmetry groups of root systems, and have been classified. They are very important because their connection to Lie Algebras. Coxeter groups turn out as symmetry groups of BLT-sets. For example, the automorphism group of BLT sets in characteristic 23 and 47 is a Coxeter group of type F4 or order 1152 (or closely related to this group). Similar behavior can be found with other examples. In terms of geometry, we consider an example of a transitive BLT-set in the finite field of order 67 and present the results of two pairs of elements in the 2-dimensional projective linear groups corresponding to the generators for the groups of order 17 and 4, respectively.

125. The Evolution of Cooperation in the Face of Competitive Forces

Taylor Stockdale Simpson College
Sean Kelly
Clay Daggett
Advisor(s): Rick Spellerberg, Simpson College

From an evolutionary perspective, cooperative behavior is an observed trait that is difficult to fathom, especially when it involves unrelated individuals. For years, researchers have attempted to explain how cooperation may have started and persisted over time. Insight in this regard may prove to be vital given that the solutions to many of the major hurdles facing the world today will require cooperation on many levels. This poster is intended to give the audience an overview of the research and theories developed and some of the difficulties involved. An emphasis will be placed on the important role mathematical modeling has played in the research process.

126. Facial Recognition Using Conformal Geometry

Meghan Galiardi Stonehill College
Miguel Lugo Florida State University
Shawn Witte Central Michigan University
Advisor(s): Brad Safnuk, Central Michigan University

A 3-D scan of a face is taken and transformed into a hyperbolic surface with constant curvature using conformal geometry. The goal is to see if conformal geometry is useful in analyzing and distinguishing faces. Each vertex of the data is assigned a radius to create a circle packing metric. These radii are adjusted using Ricci flow to reduce the curvature of the face, yielding a smooth hyperbolic surface. Geodesics are extended from the boundaries of the hyperbolic surface until collisions occur, forming a ribbon graph. The shape of the ribbon graph and the length of its edges are used to provide a unique signature for the face. We will compare the signatures of different faces to determine the effectiveness of our methods.

127. An Application of Time Scales Calculus to Growth Rates in Musca Domestica

Blaise Adam Mikels Simpson College
Stephen Henrich
Jeanie Mullen
Advisor(s): Heidi Berger, Simpson College

Development of poikilotherms, such as insects, is highly dependent on temperature regimes rather than the passage of time. Due to temporal temperature fluctuations over the growing season, sampling at regular time intervals may incorrectly estimate population parameters. The project will assess standard sampling regimes in insects, which are typically evenly spaced temporally. Our hypothesis is that sampling with evenly spaced time intervals alone will skew resultant population growth estimates of house flies in Iowa. Discrepancies between real and apparent population growth rates can result in incorrect estimates of pest populations that pose a health risk to livestock.

We will test our hypothesis by using time scales calculus to construct mathematical models of exponential growth. Due to the nature of biological sampling, discrete analysis is necessary to effectively model the growth rate in house fly populations. We will discuss introductory concepts of time scales calculus, delta derivatives, integration and our application of a time scales exponential function.

128. Pebbling on Cartesian Product of Graphs

Zhiwei Steven Wu Bard College
Advisor(s): Greg Landweber, Bard College

Let n pebbles be distributed onto the vertices of a simple graph G. A pebbling move consists of removing two pebbles from a vertex and then placing one pebble at an adjacent vertex. We call a distribution of pebbles on a graph solvable if it is possible to have a pebble at any given vertex after a series of pebbling moves. The pebbling number of a graph, denoted $\pi(G)$, is the minimum number of pebbles needed to guarantee that every distribution of $\pi(G)$ pebbles is solvable. A famous conjecture on graph pebbling number proposed by Graham states that $\pi(G \times H) \leq \pi(G)\pi(H)$, in which $G \times H$ is the cartesian product of graphs G and H. Our research work is to prove Graham's conjecture for a specific family of graphs.

This work was done by the author while participating in DIMACS summer REU 2010 under the mentorship of Eugene Fiorini. It is also a joint work with Ryan Ward, another REU participant.

129. Properties of Fractals Generated by Arbitrary 2 and 3 State Diagrams

Brian Klatt Saint Joseph's University
Advisor(s): Sandra Fillebrown, Saint Joseph's University

A large class of fractals, including the well-known Sierpinski Triangle, can be represented using the language of finite automata: points in a fractal are those points that have a binary representation that does not reach the fail state in the state diagram corresponding to the fractal. It is then interesting to ask the question in reverse: What fractals can be generated by state diagrams which are chosen arbitrarily, and what are the connections between the state diagram and the fractal it generates? This research built on previous work concerning fractals generated by 2-State Diagrams to clarify the geometric structure of the fractals generated and determine the uniqueness of the state diagram that generates the fractal. It also includes work on the classification of 3-State Fractals, and establishes that there exist distinct 3-State diagrams which collapse to generate identical 2-State Fractals. The work then shows how to impose conditions on the state diagram to ensure that the fractal generated is a "true" 3-State fractal, and determine that 3-State Diagrams have "dual diagrams," and thus fail to inherit the uniqueness property of 2-State Diagrams.

130. Theoretical Analysis and Numerical Implementation of the 1D Interface Problem

Racheal L Cooper Virginia Commonwealth University
Ashley Sanders Jackson State University
Ke Zeng Zhejiang University, China
Eric Aspinwall Florida State University
Paul Kuberry Clemson University
Advisor(s): Zhilin Li, North Carolina State University

In this poster, we explore interface problems. These equations can be solved using finite difference or element methods. Specifically, we focus on 1D problems with discontinuities and singularities. The discontinuities arise in the parameters while singularities arise when a delta function is involved. We study how d functions will affect the solution of and

what kinds of implications such irregularities have. Theoretical solutions arise in simplified cases and we explore the effect of the d functions and its relation with boundary conditions. The addition of a discontinuous parameter will affect the complexity and make it difficult to find analytical solutions. Matlab is then used to solve numerically and we also examine the cases when the interface moves to the boundary and the relations of the delta function to these boundary conditions. Besides, using the definition of weak derivative and integral transformations, we also derive the jump condition essential in the immersed interface method when the derivative of the d function is applied which may give further insights to higher-dimensional cases. We then apply the immersed boundary and interface methods as well as other discrete techniques.

131. Computational Modeling of Borate Glasses

Tiffany Myers Coe College
Advisor(s): Cal Van Niewaal, Coe College

Recent advances in fitting experimental NMR data for borate glasses have improved the understanding of the structural components of the glasses. We have mathematically modeled various meso-structural units in borate glasses using computational chemistry. These structures range from B (OH)3, a simple triangle, to B17H5O28, a series of rings. This process involved optimizing the geometry of the unit with a variety of model chemistries and determining the electric field gradient to obtain the NMR parameters, ?, the asymmetry parameter, and Qcc, the quadrupole coupling constant. These parameters are then compared to experimental data. Results suggest that calculations using smaller basis sets, though computationally efficient, do not show good agreement with experimental data. Good agreement is seen on larger fragments when expanded basis sets are used. These results suggest computational results can accurately reflect experimentally determined structures.

132. Tiling Partitions with Squares and Dominoes

Danielle Marion Chomic Pepperdine University
Advisor(s): Kendra Killpatrick, Pepperdine University

We will discuss tilings of partition shapes with squares and dominoes. We will first give a recursive formula for Dn, m, the tilings of a partition with two parts, n and m. We will discuss results for partitions containing a 2×2 Durfee square and conjectures for partitions with $n \times n$ Durfee squares.

133. Ramsey Numbers and Ramsey Saturation of Bistars

Timothy Scott Spencer UNC Asheville
Advisor(s): Patrick Bahls, UNC Asheville

Abstract: The *Ramsey number* of a graph G, denoted $r(G)$, is the number of vertices in the smallest complete graph K such that any arbitrary edge two-coloring is guaranteed to contain at least 1 monochromatic copy of G. If there exists a graph of the form $G + e, e \notin G$ such that $r(G + e) = r(G)$, the graph is called *Ramsey unsaturated*, and *Ramsey saturated* otherwise. We will discuss some proof methods and results concerning Ramsey numbers of *bistars*, the development of new lower and upper limits for $r(G)$, and the Ramsey saturation of *bistars*.

134. Stabilizer Formalism and Symmetric States

Laura Marie Snyder Lebanon Valley College
Advisor(s): David W. Lyons, Lebanon Valley College

In this poster, we discuss the stabilizer formalism of quantum error correction and n-quantum bit (qubit) symmetric states (states invariant under qubit interchange). Specifically we discuss the size of the Pauli stabilizer subgroup. There are only 5 stabilizer sizes that symmetric states can possibly have, $\{1, 2, 4, 2^{(n-1)}, 2^n\}$. This is a direct result of the symmetry of these states and the way in which the Pauli stabilizer subgroup acts.

135. On an extremal problem of Polya

Tuan Le Worcester Polytechnic Institute
Advisor(s): Zair Ibragimov, California State University of Fullerton

The notion of transfinite diameter of planar sets was introduced by M. Fekete around 1920s. It is defined the limit of n-diameters of the set. For each $n \geq 3$, the n-diameter $d_n(E)$ of E is given by $d_n(E) = max \left\{ \prod_{1 \leq i < j \leq n} / z_i - z_j /^{\frac{2}{n(n-1)}} \right\}$, where the maximum is taken over all n-tuples $\{z_1, z_2, \cdots, z_n\}$ of points in E. The following is the extremal problem of

G. Pólya: among all n-tuples $E = \{z_1, z_2, \cdots, z_n\}$ with $|z_i| \leq 1$, find one with the largest n-diameter. The solution of this problem by Polya is given as $d_n(E) \leq n^{\frac{1}{n-1}}$, and the equality holds for n-tuples of equally spaced points on the boundary of the unit disc D. While investigating the transfinite diameter of sets of constant width, Zair Ibragimov was led to the following stronger version of Pólya's problem: among all n-tuples $E = \{z_1, z_2, \cdots, z_n\}$ with $/z_i - z_j/ \leq 2$ $(1 \leq i < j \leq n)$, find one with the largest n-diameter. He conjectured that the extremal configuration will also be the vertices of a regular n-gon, at least when n is odd. In this poster, we will show that this is indeed true in the cases of 5-tuples and 7-tuples, in which the vertices of the regular 5-gon and 7-gon both have the maximum 5-diameter and 7-diameter, respectively. We will also show that among all special 4-gon configurations with diameter 2 (i.e: square, rectangle, diamond,parallelogram, trapezoid and isosceles trapezoid), the isosceles trapezoid and the square both have the maximum 4-diameter.

136. Sum-set Bounds on Graphs

Michelle Delcourt Georgia Tech
Advisor(s): Xingxing Yu, Georgia Tech

By looking at interactions between additive combinatorics and graph theory, I found a nontrivial improvement for bounding the cardinality of sum-sets of graphs from below. For situations where information is being transferred over a limited spectrum, optimization is necessary when allocating resources globally, but locally, signals must be distinct to avoid signal conflict. Finding a minimal sum-set labeling yields an optimal solution and could be used to find configurations for radio transmissions and Wi-Fi networks. This research was conducted as a part of the 2010 Georgia Tech REU, supported by NSF grant DMS-0739343.

137. Finding Cliques

Leanne Silvia University of Massachusetts Dartmouth
Advisor(s): Gary Davis, University of Massachusetts Dartmouth

In a graph, a clique is a subset of vertices such that every two vertices are connected by an edge. We implement a novel algorithm, in Mathematica, to find all cliques in a simple graph. The run-time of this algorithm depends more on the maximum degree in a graph than on the total number of vertices. Up to a maximum degree of around 60 it appears to be faster at finding maximum cliques than the current algorithm in Combinatorica. It is important that the algorithm described finds all cliques and not just maximum cliques, since in some biological applications, such as protein-protein interactions, (see e.g. Sun & Gao, 2009) finding all cliques is biologically significant.

138. Realizable Graphs of Equivalence Classes of Zero Divisors

Chelsea Johnson Brigham Young University
Advisor(s): Erin Martin, William Jewell College

In 2007, Sandra Spiroff and Cameron Wickham introduced an equivalence relation $\sim$ on the set of zero divisors of a commutative Noetherian ring R by $x \sim y$ if x and y have the same annihilator ideal. Spiroff and Wickham then defined the graph of equivalence classes of zero divisors, $\Gamma_E(R)$, to be the graph whose vertices are the euivalence classes determined by $\sim$, with $[x]$ adjacent to $[y]$ if $[x][y] = 0$. This poster presents research examining all possible graphs on four, five, and six vertices, in which we determine which graphs are realizable representations of rings and demonstrate examples of rings which have these graphs. This research was conducted at the 2010 Brigham Young University REU.

139. Polynomial Equations over Matrices

Bret David Meier UW-Eau Claire
Austen Isaac Ott UW-Eau Claire
Advisor(s): Colleen Duffy, UW - Eau Claire

We are investigating the solutions of polynomial equations over matrices. This is done using a geometric approach with diagrams and diagonalizable matrices. Previous research has shown that most, but not all, numbers of solutions between 1 and $k\,n$ choose k, where k is the size of the matrices and n is the degree of the polynomial, can be attained. This has led us to focus on three main questions. First, which numbers of solutions are not possible to achieve with only diagonalizable solutions? Second, can we always achieve those numbers with nondiagonalizable solutions that we could not achieve with diagonalizable solutions? Each diagram has a minimum and maximum number of solutions,

which gives rise to the third question. Which numbers in between the minimum and maximum are also associated with the diagram?

140. Immigration Laws and Immigrant Health: Modeling the Spread of Tuberculosis in Arizona

Laura Lynn Catron East Tennessee State University
Advisor(s): Baojun Song, Montclair State University

The US has observed a decline in the number of Tuberculosis (TB) cases in the past fifty years, but many states, such as Arizona, have had rates consistently above the US average. TB has been regarded as a disease of the disadvantaged, where poverty, overcrowding and malnourishment are responsible for much of the continued spread. The majority of TB cases in Arizona occur in the foreign-born population, whose households usually fall below the poverty line and have less access to adequate health care. Among this population, undocumented immigrants are the most economically deprived. Therefore, immigration laws are likely to cause further marginalization as the increased fear of deportation will discourage undocumented individuals from seeking work and healthcare. Such laws could exacerbate the spread of TB among undocumented immigrants and the low-income communities in which they reside, eventually extending to all socioeconomic classes. To observe this potential spread, an epidemic model that considers low and high income groups and accounts for different degrees of interaction within and between these socioeconomic classes is used. Model parameters are adjusted to simulate changes in behavior of undocumented immigrants before and after the implementation of an immigration law.

141. *Withdrawn.*

142. Exploring the Weighted Composition Operators on the Hardy and Bergman Space

Wenling Shang Washington and Lee University
Advisor(s): Paul Bourdon, Washington and Lee University

We studied weighted composition operators and their adjoints in different Hilbert Spaces.Our work was motivated by the characterizations of the normal weighted composition operators on the Hardy space contained in 'Normal weighted composition operator on the Hardy Space' (Bourdon, Narayna, 2010) such as the following the generalization of normal weighted composition operator on the Hardy Space. We provided a different proof of the result using the eigenvectors and eigenvalues of the operators. The generalizations of normal weighted composition operator applicable to the weighted Bergman Spaces was obtained during our research. We also found a sufficient and necessary condition for a weighted composition operator to be unitary on the weighted Bergman Spaces, also by using the eigenvector-eigenvalue method. Additionally, we found a sufficient and necessary condition for a weighted composition operator on the weighted Bergman Space to be unitary.Finally, we explored the properties of isometric weighted composition operators on the Bergman Space. We found an example of an isometry $W_{\psi,\phi}$ (weighted composition operator) with ψ unbounded. We showed the sufficient and necessary condition for a bounded weighted composition operator on the Bergman Space to be an isometry.

143. A New Perspective on Modeling Forest Fires

Arturo Vargas University of California Irvine
Advisor(s): Benjamin, Morin

We present three models to heuristically study the spread of forest fires: mean field equations (MF), pair approximation (PA), and cellular automata (CA). Each model is constructed with two layers to capture the differential behavior exhibited by fire on the top and bottom layers of a forest. We address fire control interventions as changes to the parameters. This research provides a discussion as to where effort can appropriately be placed.

144. A Hybrid RBF/Fourier Method for Correcting Fourier Co-efficients from Irregular Wavelengths

Zachary James Grant University of Massachusetts Dartmouth
Advisor(s): Sigal Gottlieb, University of Massachusetts Dartmouth

Fourier Series approximations are well known for their spectral convergence of data reconstructions on smooth and periodic functions. Common practice when one gathers information for these function approximations is to collect them on integer π wavelengths in Fourier Space. However when collecting our data on frequencies that are not on these ideal wavelengths the approximations fail to achieve high accuracy.This problem is relevant due to methods in collecting data by MRI machines where collection is solely through Fourier waves; but not always on ideal wavelengths.

Our work tries to minimize the errors caused through these irregular wavelengths by using Radial Basis Functions to correct our coefficients. We show this method minimizes error caused by irregular wavelengths on common problems.

145. The Mathematical Model for Stress Detection in Mammalian Cells

Jordan Cates University of Richmond
Ian Setliff University of Richmond
Advisor(s): Ovidiu Lipan, University of Richmond

Stress acting on a mammalian cell represents a time-dependent variable that acts as an input function on the cell's sensor. This input function is subsequently transformed by the cell's internal molecular biocircuits into a functional form that is able to control the network responsible for cell's defense. We present a theory for the mathematical processing of the stress signal based on our experimental data collected on Chinese Hamster Ovary cells subjected to thermal stress. The class of thermal stress consisted of one or two pulses of variable height and variable lengths. The cells response was measured at single cell level.

146. Exceptional ABC Triples for Frey Curves with Torsion Subgroups $Z_2 \times Z_4$ and $Z_2 \times Z_8$

Alexander Jesus Barrios Brown University
Advisor(s): Edray Goins, Purdue University

The ABC Conjecture is an open problem that has been around since 1985. It states that, given three relatively prime positive integers A, B, C such that $A+B=C$, that C is rarely larger than the product of the primes which divide these integers (the quality). It is well known that there exists many ABC triples with quality greater than 1. We investigate the behavior of the quality of families generated from the Frey curve $y^2 = x(x-A)(x+B)$ in relation to its torsion subgroup.

147. Generalizing Identities of the Stirling Numbers

Mckenzie Rachel West St. Olaf College
Advisor(s): Kristina Garrett, St. Olaf College

Many identities of the Stirling Numbers of the Second Kind have been found. In 2002 the Legendre-Stirling numbers were discovered when examining a Legendre differential expression. Andrews and Littlejohn provide a combinatorial interpretation of these numbers in terms of special set partitions, which resulted in a more general version of the Stirling Numbers of the Second Kind. We generalize these special set partitions and define the generalized Stirling numbers in terms of them. Using the known identities of Stirling numbers, we find identities of the generalized Stirling numbers.

148. Fractional Nabla-Difference Calculus

Nicole Gaswick University of Nebraska-Lincoln
Kaitlin Speer Baylor University
Samuel McCarthy University of Illinois at Urbana-Champaign
Brent McKain Nebraska Wesleyan University
Jeffery Hein Purdue University Calumet
Advisor(s): Allan Peterson, University of Nebraska-Lincoln

We study some foundational properties of difference calculus with respect to the reverse, or nabla, difference operator. We can relate some of our findings to analogous properties which use the forward difference operator, but we found that using the nabla operator highlights several features of difference calculus, such as the importance of domain choice. Beginning by establishing a Fundamental Theorem of Discrete Calculus for the nabla operator, we use this and several other properties of the nabla operator to proceed to establish a generalized Leibniz's Rule, Power Rule, Composition Rules, and Binomial Theorems. Building on these properties, we derive a solution to a general initial value problem, establish a Laplace transformation for nabla difference equations and use it to verify several of the preceding properties.

149. Mathematical Modeling of the BMP4 and FGF Signaling Pathways during Neural and Epidermal Development in Xenopus

Amie B Albanese University of Houston-Downtown
Advisor(s): Edwin Tecarro, University of Houston-Downtown

During embryonic development, ectodermal cell fate in Xenopus laevis is determined by the mitogen-activated protein (MAP) kinase and bone morphogenetic protein-4 (BMP-4) signaling pathways. In an attempt to further understand the interactions between these two pathways, a mathematical model consisting of coupled, nonlinear ordinary differential equations has been developed. Linear stability analysis and bifurcation theory are used to describe the properties of this model. Numerical computations, including bifurcation studies have been carried out to elucidate the interaction between the two signaling pathways.

150. Application of PBPK Modeling to a Mixture of TCE and CCl_4: Implication for Metabolism

Edward S Lee The College of New Jersey
Ashley Walls North Carolina State University
Paige L Epps Spelman College
Joseph Garcia Slippery Rock University
Advisor(s): Marina V. Evans, U.S. Environmental Protection Agency

Carbon tetrachloride (CCl_4) and trichloroethylene (TCE) are hepatotoxic volatile organic compounds and environmental contaminants. Previous PBPK models describe the kinetics and metabolic clearance of each chemical for target organs. Metabolism of the chemicals in the liver causes biological damage. The goal was to model the coexposure to both chemicals. The metabolism of coexposure of CCl_4 and TCE was quantified using gas-uptake experiments. The results in rats suggest a simultaneous increase of CCl_4 metabolism and inhibition of TCE metabolism. The kinetics of the main enzyme CYP2E1 are mathematically described by considering the possibility of two binding sites since it cannot be described by competitive inhibition. This interaction is modeled using a mechanism that describes activation and inhibition by incorporating α, β descriptor constants. These constants, the maximum metabolic velocity, and affinity for each chemical are optimized using Nelder-Mead simplex method. Preliminary results are consistent with the hypothesis of multiple sites and help explain the metabolic flexibility of this unique enzyme. Sensitivity analysis is used to prioritize its sensitivity coefficients to identified parameters. (This abstract does not necessarily reflect EPA policy.)

151. Theory and Applications of Benford's Law of Leading Digits

Allison Lewis University of Portland
Advisor(s): Steven J. Miller, Williams College

Benford's Law of Leading Digits contributes to the analysis of a variety of real-life data sets, providing us with a method to detect abnormalities in data resulting from rounding errors, data collection methods, or even nefarious activities such as fraud. We perform an in-depth analysis on several diverse, natural data sets, including data from Climategate, results from the 2009 Iranian elections, and streamflow statistics, analyzing the conformity of each data set to Benford's Law and other digit distributions. We develop a set of general techniques that can be applied to large data sets in a Benford analysis, and discuss the issues encountered due to a lack of significant digits, the sensitivity of the chi-square analysis, and simply non-Benford behavior. Exploring the theoretical implications of Benford's Law, we expand upon previous results from Miller and Nigrini (regarding the Exponential distribution) and generalize to the Weibull distribution, investigating how the variation of its parameters affects its conformity to the expected leading digit probabilities. The major goal of this study is to determine which data sets should be governed by Benford's Law, based on factors such as size and the presence of data entries spanning multiple orders of magnitude.

152. Structure and Evolution of a Mathematical Collaboration Network

Monisha Narayan Michigan State University
Antonio McInnes Oakwood University
Brianna Richardson Oakwood University
Steve Fassino University of Tennessee
Advisor(s): Reinhard Laubenbacher, Virginia Tech

We investigate the collaboration network of mathematicians using data from Mathematical Reviews between 1985 and 2007. Several tools that are common to social network analysis are used to explore this collaboration network

and compare it to other real-world networks. Throughout our study, we track the changes in the structure of this network over time using sliding windows. Finally, we investigate the effects on this network by external factors such as programs hosted by various mathematical institutes.

153. Biologically-Based Lumping Methodology of a Quaternary Fuel Mixture

Mauntell Ford University of Kansas
Advisor(s): William LeFew, Environmental Protection Agency

Biologically-based lumping methodology (BBLM) developed at the EPA provides an effective way to efficiently analyze large systems of chemicals or variables. Chemicals are lumped together into pseudochemicals to reduce the number of total chemicals in the system. This process reduces the number of chemicals, variables, and differential equations involved in the system. Each differential equation represents the behavior of the chemicals in the compartments of the body. Sensitivity analysis of the benzene, toluene, ethylbezene, and m-xylene (BTEX) mixture studied shows that chemicals are most sensitive to the metabolic terms: the Michaelis constants for enzymatic reaction (Km) and the maximum enzymatic reaction rate (Vmax). The formation of BBLM is based on these two sensitive parameters. The proportion of each chemical within a lump is described as weight. Each chemical within the lump is weighted equally. Error is calculated based on a comparison of the lumped and unlumped chemicals. We have applied BBLM to a set of four chemicals, which shows that the system may be reduced to one chemical. The error found during exposure within the lump was .3005% for ethylbenzene and .5262% for m-xylene. Error after exposure in ethylbenzene was 1.1174% and 1.4315% in m-xylene.

154. Distance to uncontrollability with Hermitian matrices

Eugene Cody University of Kansas
Advisor(s): Hongguo Xu, University of Kansas

Controllability is a concept that plays a fundamental role in systems and control. If a system, (A, b), where A is a square matrix and b is a column vector, is controllable, how large a perturbation is necessary so that the resulting system is uncontrollable? This can be algebraically expressed by the distance to uncontrollability, which is a minimization problem over the complex field.

We consider the distance problem with a special case when the matrix A is Hermitian. In this case, the system (A, b) is reduced to the pair (Λ, z), where Λ is a real diagonal matrix. By using the real diagonal matrix structure we prove that when A is Hermitian, the search field for the minimization problem of the distance to uncontrollability is reduced to the real field.

155. New lower bounds for kissing numbers using codes

Byron Heersink Adams State College
Advisor(s): Stephanie Vance, Adams State College

The kissing number problem asks for the maximum number of spheres in $\mathbb{R}^n$ that can be placed tangent to, or "kissing", a central sphere such that all the spheres have the same radius and none of their interiors overlap. This number is called the kissing number for dimension n. Today, the dimensions for which the kissing number is known are 1–4, 8, and 24; and only upper and lower bounds are known for the kissing number in all other dimensions. Using binary and ternary codes, we have developed a new method of constructing kissing configurations (i.e. configurations of spheres that touch a central sphere and have non-overlapping interiors). In even dimensions 88–122, this method yields configurations that are larger than any other configurations that we are aware of, and thus are likely to improve upon previous lower bounds for the kissing number in their respective dimensions.

156. Overtwisted Contact Structures

Deirdre M Scully College of the Holy Cross
Advisor(s): David Damiano, College of the Holy Cross

A contact structure on a 3-dimensional manifold is a completely non-integrable plane field. In this project we study overtwisted contact structures, that is, which contain overtwisted disks. Contact structures without overtwisted disks are called tight. In particular we consider the complements of closed curves tangent to the contact structure in Dymara's overtwisted three-dimensional sphere. The goal of this project is to prove that the complement of certain closed curves tangent to Dymara's contact structure has no overtwisted disks.

Our method for proving the complement has no overtwisted disks is to decompose it by cutting along convex Seifert surfaces. A Seifert surface is a surface whose boundary is the closed curve in question. A Seifert surface is convex, if the contact structure is a product in a product neighborhood of the surface. Then we analyze the family of curves or foliation induced by the contact structure on the resulting boundary surfaces. Techniques that we have used in this process include simple perturbations and manipulation theorems from Eliashberg and Fraser.

157. Asymptotic Herbivory and Optimal Resource Allocation: A Cause for Masting

Molly S. Eickholt Ohio Northern University
Alyssa G. Kent Lewis and Clark College
Kallyn K. Buschkamp Briar Cliff University
George M. Shakan Worcester Polytechnic Institute
Laurel A. Ohm St. Olaf College
Advisor(s): Glenn Ledder, University of Nebraska-Lincoln

Masting in perennial plants is a periodic phenomenon in which plants have years of low reproduction followed by a year of abundant seed-setting, or a mast year. The mechanisms that cause masting in nature are not well understood, even by biologists. Several theories are proposed including one in which masting is explained by herbivory. We set out to construct a life history model for perennial plants which incorporates the effects of herbivory, or the predation on plant seeds. In particular, we extend the life history model presented by Iwasa and Cohen in order to include the effects of herbivory on plant fitness. We consider a reasonable, general class of growth functions and, based on the optimal perennial storage function found by Iwasa and Cohen, focus on a specific class of storage functions. Through our life history model, we found that the optimal reproductive strategy is a periodic one such that a mast year occurs every J years. The optimal J is based on the amount of herbivory, c, and one can determine the minimal amount the plant needs to store in order to reproduce.

158. A graph family with maximal radio number range

Matt Porter The University of Iowa
Ben Sporrer Albright College
Advisor(s): Cynthia Wyels, California State University Channel Islands

A radio labeling is an assignment c of positive integers to the vertices of a graph so that each pair of vertices u, v satisfies the condition

$$\text{distance}(u, v) + |c(u) - c(v)| \geq \text{diameter}(G) + 1.$$

The radio number of a graph is the minimum integer M for which there exists a radio labeling with $c(v) \leq M$ for every vertex v.

Among all graphs with n vertices, it is known that the complete graph, K_n, has the smallest possible radio number and the path graph, P_n, has the largest. We provide the radio numbers of a family of graphs $R_{s,t}$ that is obtained by identifying the middle vertex of a path graph, P_t, with one of the vertices of a complete graph, K_s. Both K_n and P_n are members of this family, so these graphs provide a first step toward identifying all integers that are possible radio numbers of graphs on n vertices.

159. *Withdrawn.*

160. A Cable Equation Model for the Effects of Tissue Deformation on Transmission of Electrical Signals in Single Nerve Cells

Anarina Le Murillo Arizona State University
Emily Hendryx Angelo State University
Advisor(s): Marco Herrera-Valdez, Arizona State University

The presence of a cerebral aneurysm, tumor, or other abnormality may cause structural deformation to surrounding neurons that could affect voltage propagation. To better understand how abnormal growth may affect the flow of electrical signals in single cells, we modify the cable equation to include a spatially-dependent radius. If the radius changes as a linear function of x, the cable equation takes the form of Lommel's equation, which yields solutions consisting of modified Bessel functions. A more realistic representation of deformation includes hyperbolic functions for the radius and results in an adapted form of Ince's equation. For the cases of the cylinder and frustum, steady state solutions are found analytically with boundary and initial conditions, then verified numerically. The modified Ince's

equation is solved with numerical methods. The three methods presented are combined to examine the effects of damage on voltage propagation through a larger dendrite segment. Implications of this research can be further applied to gain insight on the physiological properties of a deformed dendrite.

161. Modeling the Evaporation of a Tear Film over a Contact Lens

Kevin Talbott George Mason University
Advisor(s): Daniel Anderson, George Mason University

A contact lens is porous and thus fluid can flow between the Post-lens Tear Film (PoLTF), which is the fluid between the corneal surface and the contact lens, and the Pre-Lens Tear Film (PrLTF), which is the fluid on top of the contact lens exposed to the air. Our tear film model allows for fluid transfer through the lens and includes the effects of evaporation of the PrLTF. Governing equations include Navier-Stokes equations, heat equation and Darcy's equation for the fluid flow and heat transfer in the fluid film and porous layer. In a one-dimensional tear film model, parameters are changed to find possible steady state solutions and the time it takes to reach them. Also of interest is the possible depletion of the PoLTF via evaporation of the PrLTF. The one-dimensional model can be reduced to an ODE that can be solved numerically or analytically. We also explore a two-dimensional tear film model described by a PDE that is first order in time and fourth order in space.

162. Constructing Equiangular Lines with Applications to Coding Theory

Kyle Stephen Rollins Coastal Carolina University
Advisor(s): James Solazzo, Coastal Carolina University

In this poster presentation, we will discuss how the characteristic polynomial of a Seidel adjacency matrix can provide information on the number of equiangular lines in $\mathbb{R}^k$. Given a certain class of Seidel adjacency matrices, a precise method for constructing the associated set of equiangular lines as well as a closed formula for the set of lines will be presented. In addition, we will discuss the importance of equiangular lines (or equivalently equiangular tight frames) in coding theory and how they can be used to minimize the error in the case of two erasures.

163. Twin Irreducible Polynomials over Finite Fields

Benjamin Cooper Boniece Skidmore College
Advisor(s): Gove Effinger, Skidmore College

Like many classical problems in mathematics, the Twin Primes Conjecture has an appropriate analogue in a different setting—in this case, polynomials over finite fields. This conjecture in the polynomial setting is realized as follows: "For every finite field, there exist infinitely many twin irreducible polynomial pairs." This has been proven for all fields except the field of two elements due to the fact that twins are defined differently over this field. This poster introduces some background about the original Twin Primes Conjecture and about irreducible polynomials over finite fields, and discusses various conjectures regarding the final case of this problem.

164. Modeling Energy Allocation in a Generalist Predator, Nerodia sipedon

Stephen Quinn Truman State University
Advisor(s): Philip Ryan, Truman State University

Understanding ecological system has often been left to population level modeling. However, with the introduction of computer modeling into ecological studies, study can be done at the individual level of the population. Focusing on the individuals of a population, we developed a model to simulate energy allocation in Nerodia sipedon, the Northern Water Snake. By studying their metabolic costs and foraging behavior, we were able to parametrize the model and estimate lifetime fitness. Optimizing their fitness means understanding the trade offs between energy allocated to growth and reproduction.

165. Using computer aided proofs to find the roots of a class of spectral density functions

John Costanzo Rochester Institute of Technology
Advisor(s): David S. Ross, Rochester Institute of Technology

We are interested in the existence and location of the roots of the class of functions, $\varphi_N = \int_0^\infty e^{-x^N} \cos(\xi x) dx$. We can write these functions in closed form when N is 1, 2, or ∞; no closed-form expression exists for any other value

of N and these functions are very difficult to approximate numerically. The original thought was that for $N > 2$, the Nth function had N roots. This was proven false, and it was found in fact that these functions had infinitude of roots when N is even and finitely many roots when N is odd. What we are interested in is how quickly the number of roots grows for odd N as N increases, and the approximate location of these roots. We analyzed this problem using computer-aided proofs.

166. Resistant and Robust Clustering Methods for High-Throughput Data

Jenny Nguyen University of Californa, Los Angeles
Advisor(s): Johanna Hardin, Pomona College

Gene-expression microarrays allows researchers to examine thousands of genes relationships in one experiment. This allows scientists to have comprehensive view of the genes involved in a specific cellular event. The data collected from this experiment is categorized as high-throughput data, and is large, susceptible to noise, non-normality, and large variance. There is need to create a systematic, robust, and resistant method of analyzing gene relationships found within this data. Using false discovery rates, clustering algorithms, adjusting them to weights, and normalization, we have developed robust, and resistant methods and algorithms to filter through noise, and also a method for estimating the number of clustered relationships between genes. Using simulated data, we have found each method to work as well, or better than commonly used filtering methods, and clustering estimators. We hope to use these methods to find gene-relationships in real data, as well as hope to develop further post-clustering filtering methods to create strong, informative clusters.

167. Scheduling Prison Guards and Faculty: Examples Using Linear Programming

Stephanie Bobo Belmont University
Advisor(s): Andrew Miller, Belmont University

The poster will present the solutions of scheduling problems using linear programming to find an optimal solution. In particular, we look at a scheduling problem dealing with prison guards in which the objective is to minimize the number of overtime hours; this problem is based on a UMAP module published by COMAP. We re-implemented a solution of this problem in MATLAB. In addition, we look at an unsolved scheduling problem: assigning faculty to classes so that the workload is fairly distributed. We solve this problem with real data from Belmont's math and computer science department as an example and compare to past schedules.

168. Permissible Plane Embeddings of Ribbon Graph Blow-Ups

Sarah Jane Loeb Harvey Mudd College
Advisor(s): Neal Stoltzfus, Louisiana State University

Ribbon graphs have been constructed from link projections and their invariants used to construct link invariants. We study the question of reversing the construction. From each ribbon graph we construct a three-valent partially oriented graph (called the blow-up) by replacing each vertex by an oriented circle and attaching the edges around the circle according to the rotation system. A characterization of which blow-ups have permissible plane embeddings, i.e., those with embeddings where the orientation of the circles is determined by their nesting level, is given in terms of two forbidden topological minors: $K_{3,3}$ and a second partially oriented planar graph that does not have a permissible embedding. The proof uses Kuratowski's Theorem as well as an argument by cases based on connectivity. As an application we obtain a complete characterization of which ribbon graphs arise as a state smoothing of a link diagram.

169. QA/QC Data Analysis and Procedure Development at SATURN-03

Eduan Martinez Soto Universidad Metropolitana (UMET)
Advisor(s): Juan Arratia

Quality Assessment and Quality Control are different tools used to monitor and evaluate the SATURN-03 system. SATURN-03 is a complex system to measure multiple water variables with Conductivity Temperature (CT), and Thermistor (Therm) instruments. CT and Therm detect and measure the temperature, salinity, turbidity, and nitrates. This research used SATURN-03 to measure temperature, because is the most important variable to detect pump system status. Flow Meter is an instrument for detecting and eliminating data errors in the system readings. The data acquired was processed in the Center for Coastal Marging Observation and Prediction (CMOP) using MATLAB. In this research, we analyzed the Columbia River Estuary features, behaviors, and changes before and after August 2009. There

are two different data sets: uncleaned data (CT and Therm before August 2009) and good data (CT13m and Therm13m after August 2009) due to Flow Meter installation on August 2009. We developed different methods for cleaning up CT and Therm data using the good data CT13m and Therm13m as standard. The data was successfully cleaned and present similar pattern as the standard data.

170. Pandemic of AH1N1 Influenza Virus and Vaccination Effectiveness

Giancarlo Mendoza Universidad Metropolina (UMET)
Advisor(s): Juan Arratia, Universidad Metropolitana

The AH1N1 virus, commonly known as the swine flu, has come to everyone's attention since it reappeared in 2009, in Mexico. The virus shares the same behavior with "avian flu" in 1918, this is the main reason why the virus is still present today. Since every type of flu mutates over the years, the populations needs to be vaccinated every year. Our goal in this research is to predict the number of people needed to be vaccinated to prevent an outbreak. We used a system of nonlinear differential equations to study the behavior between H1N1 virus, the population and effectives of a vaccine present. We calculated the Basic Reproductive Number, Ro, to determine the values for the parameters and to compare the vaccinated's and susceptible's behaviors. Numerical simulations were run using MATLAB with different scenarios to find the percent of people that must be vaccinated.

171. Malaria a model with loss immunity and control of disease.

Victor Hugo Molina Lopez Universidad Metropolitana
Advisor(s): Juan F. Arratia, Universidad Metropolitana

Many strategies to control malaria infection are focused on preventing the contact between mosquitoes and humans. The spread of malaria and re-infection with possible control strategies where studied. We developed a mathematical model with two populations: one for the host and one for the vector population. A system of nonlinear differential equations was used to describe the change and the behavior of humans and mosquito populations. The Basic Reproductive Number, R0, was computed to determine the parameters and relation of both populations in the system. Numerical simulations using reported values for the model parameters were carried out. The tendencies of a population having an epidemic spread of malaria where given by the conditions for the R0. Results indicate that by controlling the mosquito infection rate, malaria can be controlled as well.

172. Why won't my garden hose stay put? Stability of coiled elastic filaments.

Matthew Frank Lapa Cornell University
Advisor(s): Burt S. Tilley, Worcester Polytechnic Institute

We consider the stationary states and stability of an elastic filament which is held at both ends and coiled around a cylinder. This could be a model for a coiled garden hose or a wire coiled on a spool. If we assume that the radius of our filament is much smaller than the radius of the cylinder, then we can apply Kirchhoff rod theory to this problem. We formulate a model of the elastic filament using Kirchhoff rod theory in the limit when bending moments and tensile forces in the rod are comparable. We use this model to derive a nonlinear boundary value problem for the curvature. We solve this equation numerically and from the Euler angles of the filament's tangent vector, we find the shapes that the filament takes with Dirichlet (homogeneous and non-homogeneous) boundary conditions on the curvatures at the ends of the filament. In the special case of periodic boundary conditions, we find that constant curvature and torsion is a solution. We perform a linear stability analysis on these helical solutions and find that they are unstable to two different modes for low wavenumber (large wavelength) perturbations. These instabilities are more likely to become important when many turns of the filament are accumulated on the cylinder.

173. Translating analyses of continuous glucose monitoring data into the clinic via the Diabetes Graphical User Interface (DGUI) software

Lo-Hua Yuan University of Michigan, Ann Arbor
Hang (Helen) Shi University of Michigan, Ann Arbor
Advisor(s): Patrick Nelson and Renata Rawlings, University of Michigan, Ann Arbor

For many Type 1 Diabetes (T1D) patients, continuous glucose monitors (CGMs) provide a reliable and informative method to track personal glucose dynamics and maintain detailed glucose regiments. While CGMs afford copious

amounts of data, existing methods for describing CGM data may be difficult for patients, clinicians, and researchers to readily compute in a rigorous and systematic manner. We create a user-friendly Diabetes Graphical User Interface (DGUI) software as a compilation of the latest techniques, including MODD, CONGAn, and MAGE, that assess and categorize CGM data. In addition, we introduce in DGUI a novel graphical profile that considers the dynamics of transitions between glucose states. By presenting these metrics in an aggregate, concise format, DGUI provides a useful tool that facilitates researchers ability to compare quantitative measures and glean insight into the connection between glucose variability and clinical complications associated with diabetes.

174. A Mathematical Model for the Dynamics of Iron Homeostasis in E. coli

Adam Hake University of Richmond
Advisor(s): Ovidiu Lipan, University of Richmond

Bacteria invading a human organism must have the ability to multiply successfully in order to establish an infection. Bacteria need iron for growth and successful bacterial pathogens have therefore evolved to compete successfully for iron. Thus an understanding, in particular a mathematical understanding, of iron homeostasis is fundamental in determining the key processes in pathogenic bacteria. We synthesized the available genetic knowledge of iron homeostasis into a genetic circuit as well as conducted our own wet lab experiments. Relying on this genetic circuit and data from our own experiments, we present a mathematical model of the transcription factor (iron-Fur complex) activity that globally regulates iron homeostasis.

175. A selection of numbers whose irrationality can be determined by Diophantine approximation

Eric John Jones Rowan University
Advisor(s): Tom Osler, Rowan University

The irrationality of the number e can be shown by simple methods. Another method, (also simple) for demonstrating this irrationality is to use Diophantine approximation. In this paper we explain Diophantine approximation and use it to demonstrate the irrationality of e. We then find an interesting selection of other numbers whose irrationality can be explained in the same way.

176. Relationship of Lotic Macroinvertebrate Communities to Phosphorus and Suspended Solids with Linear Regression.

Natalia Cristal Santiago- Merced Universidad Metropolitana
Advisor(s): Juan Arratia, Universidad Metropolitana

Aquatic macroinvertebrate communities reflect land use and nutrient inputs from the surrounding watersheds. The use of benthic macroinvertebrates as biological indicators is a well-established approach to evaluate ecologic quality of fluvial systems. The purpose of this research was to study the biodiversity of macroinvertebrates in different sinuous urban streams making linear regression for see the patron of this relationship. Phosphorus (P) and Total Suspended Solids (TSS) were also studied as direct measures of water quality. The hypothesis that more urban streams would have lower biological diversity and higher P loading was tested. Benthic metrics were further evaluated as potential response variables to P and TSS. Finally, the hypothesis that filtering collectors would increase as TSS increased was tested. Hydropsychidae abundance was positively associated with total phosphorus; this demonstrated that there is a good correlation and for that reason a very strong patron.

177. Games on Graphs: Pursuit and Evasion

Raymond Theodore Perkins Morehouse College
Advisor(s): Duane Cooper, Morehouse College

We investigate the game of cops and robbers between two players on a finite connected graph. To start the game the cop chooses a vertex on the graph, then the robber chooses a vertex. For the rest of the game, the two players alternate moving from their current position to any adjacent vertex. The cop wins the game by occupying the same vertex as the robber. The robber wins only if he is able to evade capture for infinitely many moves. After studying the findings of Aigner and Fromme [1], Frankl 2] [3], Neufeld and Nowakowski [4], and Quilliot [5] natural questions arise. It has been proved that the cop number (the minimal number of cops needed for the cop to win) on a planar graph is always less than or equal to three [1]. We research bounds on cop number for certain classes of graphs such as Cayley graphs,

directed graphs, graphs of a specified genus, and the product of multiple graphs. Additionally, computer simulations have generated data about the number of turns per game when players have limited information about their opponents' position. Both computer simulations and exploration of related fields such as group theory and knot theory have been helpful in forming new conjectures.

178. Comparison of Continuous and Discrete Kernel Eigenvalue Problems

Michael Benjamin Machen Illinois Institute of Technology
Advisor(s): Greg Fasshauer, Illinois Institute of Technology

Kernels are an important tool for obtaining accurate approximations in areas such as numerical analysis (meshfree methods), machine learning, and statistics. In many problems, one uses discrete kernel matrices K, where the entries of $\mathsf{K}$are given by $\mathsf{K}_{ij} = K(x_i, x_j)$, $i, j = 1, 2, 3, \ldots, N$, with K a positive definite kernel. The points x_i, x_j are often referred to as data points and centers and lie within the domain of the kernel K.

Associated with this kernel *matrix* K is the discrete eigenvalue problem

$$mKbu_j = \lambda_j^* bu_j, \ j = 1, \ldots, N,$$

where the bu_j are the corresponding eigenvectors and the λ_j^* the eigenvalues.

Associated with the kernel *function* K is the continuous eigenvalue problem

$$\int_b^a K(s,t)\phi(t)dt = \lambda\phi(s),$$

where ϕ denotes an eigenfunction and λ the corresponding eigenvalue.

We investigate the connection between the continuous and the discrete eigenvalue problem in hope of approximating λ by λ_j^*. Similarly we study the behavior of bu to discover a way of representing ϕ.

179. What Lies On The Surface? Getting Your Hands On Multi-Variable Calculus

Benjamin Alwin Johnson Winona State University
Advisor(s): Aaron Wangberg, Winona State University

Multivariable calculus extends the simple ideas of slope, change and cumulative change into more than one dimension. These concepts are well illustrated with physical surfaces made of wood cut on a CNC machining center. This poster will show how abstract concepts such as gradient, path independence, LaGrange multipliers, optimization and directional derivatives can be explored using physical surfaces. These surfaces help connect the abstract ideas with geometric intuition.

180. Ultraproducts of Finite Groups

Ben Reid Virginia Tech
Advisor(s): Peter Linnell, Virginia Tech

We explore the construction of ultraproducts of different sets of finite groups, such as the integers modulo p and $p-1$ for primes p, with respect to nonprincipal ultrafilters. We also show that the ultraproduct preserves several structural features in various situations, for example when the groups involved are the dihedral groups of order $2p$. In general, we show that given a collection of groups, and a corresponding collection of normal subgroups, that the ultraproduct of the normal subgroups is itself a normal subgroup of the ultraproduct of the groups.

181. Bilinear programming and protein structure alignment

Daniel Kamenetsky Hamilton College
Noah Lavine Haverford College
Advisor(s): Al Holder, Rose-Hulman Institute of Technology

The three-dimensional structure of a protein largely determines its biological function. Protein structure alignment compares the structure of a protein with known function to that of a protein whose function is unknown. A smooth piecewise-linear sigmoid function can be used to map data on the structure of a protein into a real symmetric contact matrix that represents the relationship between components of the protein. We address the protein alignment problem as a minimization of the 2-norm difference between two proteins' contact matrices. The minimization is presented

as a bilinear program, and spectral bounds for best- and worst-case alignments are provided. Further conditions for a perfect alignment and heuristics for finding quality solutions are also given.

182. Minimal Dynamical Systems on Cantor Spaces

Evan Kwiatkowski Binghamton University
Advisor(s): Benjamin Itza Ortiz, Universidad Autonoma del Estado de Hidalgo

Cantor spaces have unique properties; the purpose of our study is to investigate minimal dynamical systems on Cantor Spaces. We examine Kakutani equivalence and flow equivalence of the systems, and prove that they imply each other. In addition, we discuss topological conjugacy between two specific types of Cantor minimal systems, namely, Denjoy systems and Sturmian subshifts.

183. The Number of Independent Sets and Graph Homomorphisms

Yufei Zhao MIT / Cambridge
Advisor(s): Michel Goemans, MIT

We prove a conjecture of Alon (1991) and Kahn (2001) on a tight upper bound to the number of independent sets in a regular graph. We also generalize our results to graph homomorphisms, extending works of Galvin and Tetali. Specifically, we provide an upper bound to the number of graph homomorphisms from G to H, where H is a fixed graph with certain properties, and G varies over all N-vertex, d-regular graphs.

184. Building a Diatom Succession Model for a Mitigated Wetland

Glenda Libby Thammavongsa UHD
Cori Ali University of Houston-Downtown
Lassanna Samarakoon University of Houston-Downtown
Advisor(s): Bradley Hoge, UHD

Diatoms are photosynthetic algae living in water and soil. Diatom death assemblages can be used as indicators of diversity and richness in wetland ecosystems. In this study, a statistical analysis was used to model the succession of an artificial wetland, Greens Bayou Wetland Mitigation Bank (GBWMB), to that of a natural wetland, Anahuac National Wildlife Refuge (ANWR), by comparing the diatom death assemblages. From the beginning of this study in 2004 until 2008, the diatom death assemblages of GBWMB showed no correlation to that of ANWR. However, the GBWMB diatom death assemblage does show a positive correlation to that of ANWR from 2008 through 2010. Other trends that have emerged in GBWMB include a decrease in genera richness and stabilization of diversity. These trends suggest that wetland succession is occurringand reaching a stable assemblage approximately ten years after the establishment of the GBWMB.

185. Vertex Identifying Codes

Ari Cukierman College of William and Mary
Advisor(s): Gexin Yu, College of William and Mary

For a graph, G, and a vertex $v \in V(G)$, let $N[v]$ be the set of vertices adjacent to and including v. A set $D \subseteq V(G)$ is a vertex identifying code if for any two distinct vertices $v_1, v_2 \in V(G)$, the vertex sets $N[v_1] \cap D$ and $N[v_2] \cap D$ are distinct and non-empty. We consider the minimum density of a vertex identifying code for the infinite hexagonal grid. In 2000, Cohen et al. constructed two codes with a density of $\frac{3}{7} \approx 0.428571$, and this remains the best known upper bound. Until now, the best known lower bound was $\frac{12}{29} \approx 0.413793$ and was proved by Cranston and Yu in 2009. We present three new codes with a density of $\frac{3}{7}$, and we improve the lower bound to $\frac{5}{12} \approx 0.416667$.

186. Achievable Radio Numbers

Luis David Contreras CSU Channel Islands
Adriana Mendoza Central Washington University
Advisor(s): Cynthia Wyels, CSU Channel Islands

A radio number is a graph parameter with positive integer values. This project consists of finding which integers are achievable as radio numbers of graphs on n vertices. We present a collection of new results showing that all integers between n and $4n - 11$ are achievable radio numbers. We also show that $\frac{(n-1)^2}{2} + 2$ is unachievable when n is odd.

Lastly, we present a new 2-parameter family of graphs for which we have determined the radio numbers; these allow us to demonstrate that the gaps between achievable radio numbers have length less than n.

187. Structure Groups of Pseudo-Riemannian Algebraic Curvature Tensors

Joseph Anthony Palmer Truman State University
Advisor(s): Corey Dunn, California State University, San Bernardino

An algebraic curvature tensor R is the full Riemann curvature tensor of a manifold restricted to a single point, p, and a model space is the tangent space at p paired with the algebraic curvature tensor there. The structure group of such an object is the set of all linear transformation on the tangent space of the manifold at p which preserve R. We are able to greatly characterize the elements of the structure groups in question and produce general forms of their matrix representations. We also work with the direct sum decomposition of model spaces, and this plays a large role in describing the elements of the structure group. We prove the the kernel of R can always be decomposed apart from the rest of the model space under a model space direct sum and characterize what this does to the elements of the structure group. We also develop several results for the case when $kerR = \{0\}$ and a conjecture that would characterize the transformations further. It is also of note that this research is done in the arbitrary signature case, and we develop the motivation for this work and some conjectures and opportunities for further research.

188. Riparian Fungal Population Dynamics along Buffalo Bayou as influenced by soil element composition and pH

Tia Pilaroscia University of Houston - Downtown
Advisor(s): Lyons, University of Houston - Downtown

The influences on riparian fungal population of soil elemental composition, salinity and pH are being studied to establish whether a correlation exists between these critical environmental factors and the diversity and richness of the soil fungal community. The hypothesis is that significant changes in fungal community diversity will emerge as patterns that can be mathematically modeled. Statistical analysis such as one and two-way ANOVA supported the hypothesis; however, further analysis consisting of moving average and randomized block design will be conducted to better explain the relationships between the fungi community, mineral concentrations, and pH gradient.

189. A Point Process Model for Simulating Gang-on-Gang Violence

Mark Allenby Pepperdine University
Kym Louie Harvey Mudd College
Marina Masaki University of California, Irvine
Advisor(s): Timothy Lucas, Pepperdine University

Gang Violence is a prevalent problem in Hollenbeck, Los Angeles. To counteract this problem a point process method is presented for simulating gang-on-gang crimes. The Hawkes Process has historically been used to model earthquake and aftershock occurrences, but has clear application to criminology by the repeat and retaliatory nature of crimes.

The Hawkes Process, a self-exciting point process, is introduced as a temporal model for crimes between gangs. A variation of The Hawkes Process is then also applied as a marked point process to describe directional rivalry strength between pairs of gangs. This directional, rivalry-based Hawkes Process is then expanded upon to simulate crimes not only temporally but also spatially. Finally, we present a branched Hawkes Point Process to simulate crimes as a global system between all gangs in Hollenbeck. This model distributes crimes through space and time, and assigns the crime a pair of gangs and directionality within this pair. The parameters of all models were fit using spatially-penalized maximum log-likelihood estimation with 1400 gang-on-gang crimes in the city between 1999 and 2002. This data was provided by the LAPD and UCLA Department of Criminology.

190. Mathematical Models of Iron Metabolism in Breast Epithelial Cells

Ariel Kniss Bucknell University
Prapti Neupane Boston University
Benjamin Leung Rice University
Ivana Williams Winston-Salem State University
Advisor(s): Reinhard Laubenbacher, Virginia Bioinformatics Institute at Virginia Tech

Computational systems biology has brought many new insights to cancer biology through the quantitative analysis of molecular networks. Our goal is to apply a systems biology approach to the understanding of intracellular iron

metabolism in normal breast epithelium and the changes the network undergoes as cells transition to malignancy. This poster describes part of a complex cellular iron network that consists of multiple feedback loops. We also present a mathematical model intended to help shed light on key regulatory nodes of iron metabolism dynamics.

191. Results on the $3x + 1$ and $3x + d$ Conjectures

Dhiraj Holden California State University, Fresno
Advisor(s): Carmen Caprau, California State University, Fresno

We give results relating to the $3x + 1$ and $3x + d$ conjectures, proposed by Collatz and Lagarias respectively. We give a condition for which a primitive cycle will exist for a certain d, and list the first few primitive cycles found in this way. We also define formal grammars from the inverse $3x + 1$ and $3x + d$ maps, and restate the conjectures of Collatz and Lagarias in terms of these formal grammars.

192. Computer-Assisted Graph Theory

Anita Evelyn Thomas Illinois Institute of Technology
Advisor(s): Michael Pelsmajer, Illinois Institute of Technology

A k-tree is formed from a k-clique by iteratively adding vertices and incident edges to form new $k + 1$ cliques. Previously proved by Chappell and Pelsmajer is, for all k-trees, $k < 4$, there exists a vertex subset, S, that induces a subgraph where all vertices are of degree at most 1 and max $|S| =$ ceiling$[2n/(k + 2)]$, where n is the order of the k-tree. Expanding on Chappell and Pelsmajer's work, this research considers all k-trees, $k > 3$, with these same conditions. Our approach involves computer-assisted search and classification of k-trees and specific induced subgraphs that meet the conditions. After reviewing generated graphs, we looked for patterns and attempted to create a proof by cases followed by another proof to show that all k-trees with $k > 3$ fit at least one of these cases. Three cases have been identified and proved so far and the rest are a topic for future study. Possible approaches include proving the heuristic strategy explained in the technical paper associated with this research. Also, much analysis was done on 4-trees using one particular case. Focusing on k-trees with $k > 4$ using this case may lead to new findings.

193. Predator-Prey Network Optimization

Louis Boguchwal Hamilton College
Advisor(s): Andrew Dykstra, Hamilton College

This research introduces a network optimization methodology where edge lengths are governed by systems of ordinary differential equations. An algorithm for solving this problem in general is proposed. It extends the shortest-path work of Dijkstra. The methodology is demonstrated within the context of a predator-prey path pursuit problem. The optimization objective is to find the optimal path such that prey population is maximized at the terminal vertex, and has been extended to population minimization as well. Promising extensions of this work include improved navigation and map-guiding algorithms for networks possessing dynamic attributes.

194. Dengue Fever with Insecticides in Puerto Rico

Jesus Angel O'Neill Universidad Metropolitana (UMET)
Advisor(s): Juan Arratia, Universidad Metropolitana (UMET)

Dengue is one of the most important mosquito-borne viral diseases in the world. Insecticide is a way to control or eliminate mosquito population. We developed a mathematical model to study the effects of using insecticide in the mosquito (vector) population. The model uses a system of nonlinear differential equations to describe the change in mosquito and human population. Two cases were studied: one with insecticide and one without it. The basic reproductive number, R0, was compute to predict the diseases spread. Numerical simulations were run to study the effects of insecticide. The implications of model results to dengue dynamics and its control using insecticide are discussed in this research.

195. A Model for the Population of the Blue Crab in the Chesapeake Bay

Timothy Joseph Becker College of William and Mary
Advisor(s): Junping Shi, College of William and Mary

We model the population of the Blue Crab in the Chesapeake Bay by using differential equations. Blue crabs are inherently cannibalistic of juveniles, while also in competition with juvenile blue crabs for resources. These differential

equations describe the intraguild predation consistent in the blue crab food web, as well as the cannibalistic nature of the blue crab. We introduce an aging and birth rate to alter an intraguild predation model to fit the cannibalistic nature. Secondly, we introduce a resource equation into a simple model of cannibalism. Our future goal is to determine which model, or a combination of the two, is most accurate and come out with a functioning model of the blue crab population in the Chesapeake Bay.

196. Computing π Via New Polynomial Approximations to Arctangent

Colleen Michelle Bouey Loyola Marymount University
Erika Meza Loyola Marymount University
Advisor(s): Herbert A. Medina, Loyola Marymount University

Inverse trigonometric functions can be used to approximate π. Different rational functions can be used to produce, after integration, arctangent specifically, and therefore can be used to approximate π. Using the family of rational functions $\left\{t^{4m}\left(t-1/\sqrt{3}\right)^{6m}/\left(1+t^2\right)\right\}_{m\in\mathbb{N}}$ we produce efficient polynomial approximations to the arctangent function on the interval $[0, \frac{1}{\sqrt{3}}]$, and hence, provide approximations to π via the identity $\arctan\left(\frac{1}{\sqrt{3}}\right) = \frac{\pi}{6}$. Our polynomials produce approximations to π that require only the computation of a single square root ($\sqrt{3}$); furthermore, on the interval $[0, \frac{1}{\sqrt{3}}]$ they are orders of magnitude more accurate than Maclaurin polynomials and other polynomial approximations to arctangent recently studied. We analyze the efficiency and speed of our approximations as well as provide algebraic and analytic properties of our sequence of polynomials.

197. The Elusive Rank 9: Finding Curves of High Rank

Kelsy Danae Kinderknecht University of Kansas
Keatra Nesbitt University of Northern Colorado
Juan Cervantes Lewis & Clark College
Advisor(s): Edray Goins, Purdue University

The concept of ranks of elliptic curves is not well understood; in fact, we do not know how large the rank of any given elliptic curve over $\mathbb{Q}$ may be, so we try to find curves of high rank to better understand this concept. The elliptic curve $E : y^2 = (1-x^2)(1-k^2x^2)$ for some rational $k \neq -1, 0, 1$ has torsion subgroup $E(\mathbb{Q})_{tors} \simeq Z_2 \times Z_4$ when $\sqrt{1-k^2} \notin \mathbb{Q}$. The highest known rank for such a curve is 8; we search for a curve of rank 9 or higher. To do this, we develop an algorithm to first generate a list of rational k and then to analyze these k's to find the rank of the curve.

198. Preconcurrence for 2-qubit States

Edward Christopher Ulicny Lebanon Valley College
Advisor(s): David Lyons, Lebanon Valley College

Measurement and classification of entangled quantum states are important and difficult problems, motivated by potential applications in quantum computers. Even the simplest measures, such as concurrence for 2-qubit states defined by Wootters, are cumbersome to compute. In this work, we study a natural decomposition of 2-qubit states into smaller pieces called Bloch tensors, and derive closed form expressions from them for concurrence for certain classes of states. This technique suggests promising avenues for generalization.

199. Understanding Hailstone Sequences Using a New Coding Process

Richard Freedman Wake Forest University
Advisor(s): Stephen B. Robinson, Wake Forest University

Hailstone Sequences are orbits formed by the discrete dynamical system mentioned in the Collatz Conjecture (3x+1 Problem). Using a new coding process we call set positions, one may determine some behaviors of any Hailstone Sequence. This poster expands on the presentation given at MathFest 2010 by providing a deeper explanation of the derivation of set positions and their properties. This allows us to provide an equivalent statement of the Collatz Conjecture based on a discrete dynamical system involving set positions.

200. Isometries of Geometric Spaces

Marisa Catherine Zemsky College of the Holy Cross
Advisor(s): Thomas E. Cecil, College of the Holy Cross

With attempts to prove the parallel postulate in Euclidean geometry, ideas emerged about the existence of non-Euclidean geometries such as spherical geometry and hyperbolic geometry. This summer Professor Cecil and I began to build the foundation of our work by first studying Euclidean geometry and the transformations that can be obtained as a product of a finite number of reflections in lines: the identity transformation, reflections, translations, rotations, and glide reflections. We proved that in the Euclidean plane, every isometry, i.e., an onto mapping T from the Euclidean plane to itself that preserves distance, must be one of these types of transformations.

We continued our research by analyzing spherical geometry. Using our knowledge of the Euclidean plane we were able to study transformations on the sphere S^2 as well. Similar transformations to those in the Euclidean space are defined on the sphere. We proved our main theorem in spherical geometry: For every isometry T_0 of S^2 there is an orthogonal transformation T coinciding with T_0 on S^2. By proving this theorem we were also able to prove that every isometry of S^2 is one of the five transformations we studied, the identity transformation, a reflection, a translation, a rotation, or a glide reflection.

201. Unimodality and the Alexander Polynomial

Sean Kenneth Simmons The University of Texas at Austin
Advisor(s): Professor Cameron Gordon, University of Texas at Austin

A sequence $a_0, a_1, \cdots, a_n$ is said to be unimodal if $a_0 \leq a_1 \leq \cdots \leq a_m \geq a_{m+1} \geq \cdots \geq a_n$ for some m. Assume that K is an alternating link, $\Delta(t) = b_n x^n + \cdots b_0$ its Alexander polynomial. It has been conjectured by Fox that $|b_n|, \cdots, |b_0|$ is unimodal. It is our aim to use tools from combinatorics to study this conjecture. So far we have proven the conjecture for various families of links. More, we have also proven various other results about Alexander polynomials of alternating links that are already known, but using different tools.

202. Polynomial Approximations of a Heat Conduction Model

Kathryn Emily Christian University of Mary Washington
Advisor(s): Jangwoon Lee, University of Mary Washington

We describe and analyze two methods for a heat conduction model with nonhomogeneous Dirichlet boundary conditions. Here the aim of our project is to approximate the solution to the model using polynomials. First, we derive the exact solution to the model by Fourier series in two different ways and compute finite terms of the solutions using our own computer programs. Then we develop a numerical algorithm based on polynomial basis functions to approximate the solution of the model. We present an explicit form of the solution to the model in two different ways and include a comparison of the computational work required by each exact solution in Fourier series and numerical solution from polynomials to achieve a better accuracy.

203. On The Distribution of the Number of Automata For a Given Spanning Tree

Christopher Knaplund York College - CUNY
Advisor(s): Edoardo Carta-Gerardino, York College - CUNY

In the last few decades, several techniques to randomly generate a deterministic finite automaton have been developed. These techniques have implications in the enumeration of automata of size n as well. One of the ways to generate a finite automaton is to generate a random tree and to complete it to a deterministic finite automaton, assuming that the tree will be the automaton's breadth-first spanning tree. In this poster, I explore some ideas related to this question. I introduce the notions of tail characteristic and characteristic of a tree, and then use these ideas to define the weight of a tree. It turns out that the weight of a tree can be used to count the number of automata having a given tree as their spanning tree. I also present a recursive formula for this quantity in terms of the "derivative" of a tree. Finally, I analyze the implications of this formula in terms of the distribution of the number of automata with a given spanning tree with n nodes.

204. A stochastic game based on the gambler's ruin scenario for a cookie random walk

Brian Wu Bowdoin College
Advisor(s): Alexander Roitershtein, Iowa State University

We study a stochastic game between a "buyer" and a "seller," whose major component is a reinforced random walk performed by the "buyer" on the integer lattice. We assume a Gambler's Ruin scenario, where the walker (the "buyer) has the option of consuming a "cookie" which increases the probability of moving in the desired direction for one step. The cookies are supplied to the walker by the "seller." While our motivation stems from the popular model of excited random walks, the questions we investigate are inspired by their counterparts in stochastic control theory in which a random walk controlled by a reinforcing mechanism (the "seller) leads to termination of the walk, but is interested in keeping the walker in the "game" as long as possible. Thus, we study this problem within a game-theoretic framework, where optimal strategies of the reinforcing mechanism are determined through the interaction between "buyer" and "seller. We consider many extensions, in particular, a variant of the game involving a random walk on trees and a version which includes a third player, modeling either duopoly competition or state regulation. For several modifications of the game we have determined the players' optimal strategies.

205. Iterative Decomposition of Finite Element Approximations to the Inhomogeneous Burgers' Equation

Derek DeSantis California State University Channel Islands
Elliot Schrock Williams College
Nitin Krishnan University of North Carolina
Advisor(s): Victor Ginting, University of Wyoming

In this presentation, we consider approximate solutions to the inhomogeneous Burgers' equation, an important equation within fluid mechanics. We project the inhomogeneous Burgers' equation onto a finite space, and then split the operator into two iterative components. We subsequently describe an algorithm by which an approximate solution may be obtained, and show that this approximation does in fact approach the solution of the inhomogeneous Burgers' Equation.

206. Constructing moduli spaces of low dimensional A_∞-Algebras by extensions

Josh J Frinak University of Wisconsin-Eau Claire
Advisor(s): Michael Penkava, University of Wisconsin-Eau Claire

A_∞-algebras are generalizations of associative algebras, determined by a series of maps $d_k : T^k(V) \to V$, such that the sum $d = d_1 + \cdots$ is a codifferential in the tensor coalgebra of V. If d_k is the first nonzero term in d, then d_k determines a A_∞ algebra, and the construction of d from d_k is a deformation theory problem. Thus the first step in constructing the moduli space of A_∞ algebra structures on V is to determine the moduli spaces of degree k codifferentials, for all k. One method is to consider extensions of a degree k codifferential on a space W by a degree k codifferential on a space M, where $V = M \oplus W$. This idea of using extensions is very effective in constructing moduli spaces of associative algebras V from lower dimensional moduli spaces. We have carried out the construction of extensions of degree k codifferentials for some low dimensional spaces, and find that they are not as effective in constructing the moduli space of all degree k codifferentals. We found that there are a lot of algebras not given as extensions which have nontrivial deformations, so the theory of simple infinity algebras is not as nice as in the associative algebra case.

207. Bounds on the artificial phase transition for perfect simulation of repulsive point processes

Jason Xu University of Arizona
Advisor(s): Mark Huber, Claremont McKenna College

Repulsive point processes arise in models where competition forces entities to be more spread apart than if placed independently. Simulation of these types of processes can be accomplished using dominated coupling from the past with a running time that varies as the intensity of the number of points. These algorithms usually exhibit what is called an artificial phase transition, where below a critical intensity the algorithm runs in finite expected time, but above the critical intensity the expected number of steps is infinite. Here the artificial phase transition is examined. In particular, an earlier lower bound on this artificial phase transition is improved by including a new type of term in the analysis. In addition, the results of computer experiments to locate the transition are presented.

208. Vancomycin-Resistant Enterococci Colonization-Infection Model: Simulation, Analysis and Basic Reproduction Number

Jonathan Lowden California University of Pennsylvania
Sara Abdelmageed Ursinus College
Advisor(s): Mohammed Yahdi, Ursinus College

Vancomycin-Resistant Enterococci infections have been linked to increased mortality and ICU costs. We developed and analyzed a new model of a VRE infested intensive care unit based on transitions between five classes of patients: susceptible, colonized without special preventive care, colonized under special preventative care, infected undergoing VRE treatment and infected without VRE treatment. We investigated the dynamics of the corresponding system of non-linear differential equations, as well as the interplay and impacts of nineteen independent parameters involved in the transitions. We created computer simulations of VRE dynamics, and mathematically visualized and measured the impacts of the parameters on the spread of VRE infection. We conducted disease free analysis, and computed the basic reproduction number and its bifurcation diagrams. We pinpointed good strategies to efficiently adjust adequate parameters for controlling VRE infection and preventing outbreaks, without the risk involved in clinical testing, including the parameters with the largest impact and the values that minimize outbreak risks.

209. Second Twist Number of 2-Bridge Knots

Jessica Ceniceros Claremont McKenna College
Advisor(s): Rolland Trapp, California State University San Bernardino

In this poster we take a look at the Jones polynomial and the Tutte polynomial for alternating knots as well as the first and second twist number. We then examine the second twist number and extend it to 2-bridge knots and try to compute the second twist number in terms of things we can compute strictly from tangles that correspond to the given knot. The goal at the end is to be able to get a list of numbers (tangles) and be able to compute its second twist number. This research was made possible by NSF Grant DMS-0850959.

210. A Tale of Two Puzzles: How Graph Theory and Algorithms teach us to solve new puzzles of any dimension.

Leanne Elizabeth Merrill SUNY Potsdam
Tony Van University of Pennsylvania
Advisor(s): Paul Cull, Oregon State University

Towers of Hanoi and Spin-Out are two puzzles with different physical manifestations but similar graphical properties. In this research, we discuss a new puzzle formed by a combination of elements from both puzzles. Towers of Hanoi may be played in any odd dimension and Spin-Out in any 2^m dimension, and so their combination may be played in any finite dimension as any natural number may be expressed as the product of an odd number and a power of two. Algorithms exist to solve both puzzles separately; here, we introduce a counting algorithm for Spin-Out, and recursive, iterative, and counting algorithms for the combination puzzle. Instead of using Gray code properties of the corresponding complete iterated graphs, these algorithms rely only on simple binary counters. We do discuss the Gray code properties of the corresponding complete iterated graph and present a new result related to complete iterated graphs on three vertices.

211. Assortativity in Networks of Neurons

Matthew David Peppe College of William and Mary
Advisor(s): Gregory Smith, College of William and Mary

A group of connected neurons can be represented as a directed graph with each neuron represented as a node and every connection from the axon of one neuron to the dendrite of another as a directed edge from the former to the latter. Directed graphs may display various forms of assortativity such as node-degree correlation. This study uses numerical simulations to investigate the effects of such statistical properties of neuron networks on their dynamical function. An ODE model for the average firing rate of large populations of neurons with the same in and out degrees was derived from the standard integrate-and-fire model for a structured network with specified correlation coefficients. Parameter studies on this model have shown the node-degree correlation and the correlation between inputs to a presynaptic neuron and the out degree of a postsynaptic neuron affect the possibility for and range of connection-strength and

external-stimulation values that result in bistable behavior. These correlations also affect the sharpness of the onset of hysteresis as coupling strength is varied. Hysteresis in these sorts of networks is important for the phenomenon known as synaptic reverberation which may underlie short term memory.

212. Algebraic Curvature Tensors and Antisymmetric Two-forms

Forrest Blake Treadway University of Tennessee Knoxville
Advisor(s): Corey Dunn, California Statue University, San Bernardino

An algebraic curvature tensor gives information about the curvature at a given point on a manifold. The set of all algebraic curvature tensors is denoted as $\mathcal{A}(V)$. Algebraic curvature tensors can be constructed by symmetric or antisymmetric two-forms. Two analogous results from the research have been studied in the symmetric case. The purpose of this research is to draw similar conclusions about algebraic curvature tensors on antisymmetric forms. Surprisingly, one of the results differs.

213. Counting Arguments and Computer Proofs for Hypergeometric Identities

Alexander Christian Quenon Eastern Michigan University
Gary Ray Marple Colorado State University - Pueblo
Advisor(s): Akalu Tefera, Grand Valley State University

Alternate proofs are given for various hypergeometric identitites. In particular, the researchers make use of the algorithms of Gosper and Zeilberger and counting arguments in discovering these proofs. These computer algorithms provide a completely mechanical method by which to show the equivalence of two hypergeometric identities. In addition, these algorithms provide a hypergeometric 'certificate' that may be used to verify the given identities by hand. Where these computer-generated proofs are lacking in transparency, counting arguments are provided in order to prove that both sides of a given identity merely count the number of items in some given set in two different ways.

214. Matroids, Fixing Sets and Maker-Breaker Games

Jordan Rooklyn University of Montana
Advisor(s): Jenny McNulty, University of Montana

Maker-breaker games are two-person games in which the first person, Maker, tries to create a winning set while the second person, Breaker, tries to stop Maker. This game has been applied to matroids and graphs with various types of winning sets. We examine the game played on matroids in which Maker is trying to create a fixing set. A fixing set S of a matroid is a subset of the ground set so that the only automorphism of the matroid that fixes S pointwise is the identity. For example, fixing three noncollinear points of the Fano matroid, the matroid linked with $PG(2,2)$, fixes the entire system. In this poster, I present strategies and outcomes of such a game played on matroids associated with finite geometries.

215. Determining the Number of Loops of Regular n-gons

Kathleen Carroll Wheaton College
Advisor(s): Tommy Ratliff, Wheaton College

In his article Loops of Regular Polygons, K. Robin McLean completely characterized when a loop of non-overlapping regular n-gons of length s exists. In order to prove the existence of a loop for a given s and n, McLean showed how to construct one such loop. McLean did not, however, examine whether this is the only loop that exists for a given s and n combination. This poster presents a few results that have stemmed from my research regarding the question of how many distinct loops of s regular n-gons exist. In particular the Maple program I devised to calculate the number of loops of s regular n-gons for small values of s and n will be presented. Furthermore, an interesting result regarding the existence of overlapping loops of s regular n-gons that form non-overlapping loops when these n-gons are replaced by $k\,n$-gons for a sufficiently large value of k will be included.

216. Synchrony in a Two Patch Predator Prey Model

Matthew Harrington Becker College of William & Mary
Advisor(s): Junping Shi, College of William & Mary

A coupled two-patch Rosenzweig-MacArthur system of predator-prey interaction is investigated. Synchronization is the process in which oscillations attain the same frequency based on their coupling. The Moran Effect, the name for

the seemingly random changes seen in nature, has been attributed as a cause of synchrony, while scholars have studied other influences to ascertain causal relationships between any of them and a synchronous solution. We use a correlation function similar to Pearson's Correlation, one of the most well known correlation measures in statistical analysis, to measure the synchrony and consider what factors have greater influences upon a synchronous oscillatory solution.

217. Mathematical Analysis of The Hodgkin-Huxley Model for Cardiac Action Potential

Brandon Milonovich The College of Saint Rose
Advisor(s): Amina Eladdadi, The College of Saint Rose

The relationship between the spread of action potential across myocardial cells and the heart arrhythmia is presented using the Hodgkin-Huxley Model for Cardiac Action Potential. The Hodgkin-Huxley Model is a mathematical model which describes how action potentials in neurons are initiated and propagated. Cardiac arrhythmia is when the heart's normal rhythm is disrupted. Cardiac Arrythmia manifests through irregular formation of abnormal conduction of an action potential. Action potential is defined as a rapid change in the electrical potential across a myocardial cell from negative to positive and back. The prediction of the effects of cardiac arrhythmias presents a challenge. Due to the complexity of the intricate fibers of the heart, cardiac arrhythmias are difficult to predict. This poster explores how mathematical modeling can be used as a tool to examine the behavior of an action potential.

218. Fixed points and Gardens of Eden of the Sandpile model and its Generalizations

Vladimir Sotirov St. Olaf
Advisor(s): Kristina Garrett, St. Olaf College

The Sandpile model and its generalizations are discrete dynamical systems whose configuration space is the set of all partitions of positive integers, and whose transition rules send partitions of n to partitions of n. Determining closed forms for the generating functions of the Gardens of Eden (configuration states with no predecessor) and fixed points of these models is a recently posed question, which has been answered only for the case of the Sandpile model in as-of-yet unpublished work by Jaclyn Anderson. We generalize Anderson's work by introducing a new class of models for which her method of determining closed forms does extend. Further, we relate our new class of models to the standard generalizations of the Sandpile model known as Ice-pile models, and we use this relation to establish the generating function for the Ice-Pile model's fixed points. The relation between our new models and the Ice-Pile models does not allow us to determine the generating function for the Gardens of Eden, though it does suggest potentially fruitful avenues for future research.

219. Image Denoise Using M-band Wavelet Transforms

Yunhan Jing Affiliated HS of Jilin University
Haolong Yang Affiliated HS of Jilin University
Advisor(s): Qingjin Xu and Xiaodi Wang, Affiliated HS of Jilin University/WCSU

The removal of noise from audio and image signals is one of the most important aspects of signal processing. In this research we propose an M-band wavelet transform method for image denoising. Unlike existing block based wavelet thresholding methods, our work exploits simultaneously coefficients of the M-band wavelet transform of an image. The contributions of this project are two-fold. First, we conduct a statistical analysis of the wavelet decomposition of the contaminated image. We then determine relative thresholds and apply the efficient method we proposed to remove the noise from the image. Finally, we present the experiment results to support the proposed method.

220. Generic Formal Fibers of a Commutative Ring

Philip Van Vu Williams College
Advisor(s): Susan Loepp, Williams College

Let T be a commutative local ring, M its maximal ideal, and suppose T is complete under the M-adic metric. Let C a set of incomparable prime ideals of T. Let $A \subseteq T$ be a local domain with maximal ideal $M \cap A$ such that its completion, $\hat{A}$, is T. The generic formal fiber of A is the set $\mathrm{Spec}\,\hat{A} \otimes_A K$, where K is the quotient field of A. We study the conditions on T and C under which there exist a local domain A that completes to T and has a generic formal fiber with maximal elements precisely those in C. Necessary and sufficient conditions for when $|C| < \infty$ have already been obtained by Charters and Loepp (2004). We study the case when C is not finite.

221. Maker Breaker Games and Fixing Sets

Sharee Russell The University of Montana
Advisor(s): Jennifer McNulty, The University of Montana

A Maker-Breaker game is a game played by two players, Maker and Breaker, on a system (E, F), where E is a finite set and F is a collection of subsets of X. Players alternately choose elements of E. Maker tries to create an element of F while Breaker tries to prevent this. An example of such a game is the Shannon Switching game: X is the set of edges of a graph and F the set of paths between two distinguished vertices. Lehman generalized this game to matroids and solved the problem of who wins in 1964. In this poster, I will present results of a different type of Maker-Breaker game. The game is played on a matroid M in which E is the set of elements of M and F is the collection of fixing sets of M. A fixing set S of the matroid M is a subset of E such that the only automorphism of the matroid that fixes S element-wise is the identity. I will explore which types of matroids are always maker wins, breaker wins, or neutral (first player wins) and the strategies therein.

222. Who's Most Twitteriffic?

Joseph Lake Trask Davidson College
Advisor(s): Tim Chartier, Davidson College

The sheer amount of people who use online social networks regularly has turned them into important tools that can be used by advertisers and businesses. With these uses for online social networks on the rise, some important questions need to be considered. One can assume that the quickest way to spread information, i.e., news about a new product, would be to have someone of great "importance" on the network advocate it. How does one determine which users are "important" compared to others? This research attempts to address this question for Twitter. One way to look at Twitter is as a directed social graph, where an arrow points from user A to user B if user A follows user B. Web ranking methods such as Google's PageRank algorithm have been used to produce rankings of the social graph where the arrows are thought of as links. However, Twitter is not used in the same way as the web, and the "random surfer" model basis for PageRank may not be the best model for the issue. This poster will present recent work in adapting sports ranking methods to rank Twitter users by a measure of "importance." Numerical results will be presented for real Twitter networks as well as the inherent difference in computed ratings using PageRank versus the proposed sports ranking models.

223. Extinction Equilibria in Stage-Structured Populations

Georgia Waite Pfeiffer The College of William and Mary
Advisor(s): Sarah Day, The College of William and Mary

The interaction between invasive and native species can be modeled through a Lefkovitch model using stage structured populations. In this study, we analyzed the interaction of two species facing resource competition but not predation. Competition for resources is expressed through density dependent parameters. The stability of equilibrium population densities was investigated under varying parameter conditions for the two populations. We show that it is possible for both partial extinction equilibria (persistence of only one population) and the total extinction equilibrium (extinction of both populations) to be simultaneously stable under certain criteria. The goal of this research is to promote more effective conservation efforts through a better understanding of system dynamics.

224. Secretary Problem Revisited

Svetoslav Ivanov Semov Gettysburg College
Advisor(s): Bela Bajnok, Gettysburg College

I explore an extension of the Secretary Problem. In its original form the problem simulates a hiring decision, in which the decision maker is interviewing n applicants that are observed sequentially and in random order, each order being equally likely. The stopping rule consists of rejecting a certain number of applicants and then hiring the first one that is better than all of the rejected ones. The hiring decision is based solely on the relative ranks of the applicants—the natural numbers from 1 to n. The decision maker is satisfied only with the very best: the received payoff is 1 if the most valuable applicant is selected, and 0 otherwise. In the extension I analyze there is one significant modification to the problem. It is assumed that the payoff of the decision maker is the relative rank of the selected applicant—1 through n. This assumption enables me to look at a decision maker who is "less greedy". In other words, the value of the applicant chosen is not necessarily bigger than that of all of the applicants rejected under the optimal stopping

rule; it could be bigger than the value of the lth best applicant interviewed during the stopping rule phase. The case $l = 1$ was settled before; here I investigate $l \geq 2$.

225. A new classification of classical multiplier sequences

Benjamin Wright California State University, Fresno
James Edward Tipton California State University, Fresno
Advisor(s): Tamas Forgacs, California State University, Fresno

A sequence of real numbers $\{\gamma_k\}_{k=0}^{\infty}$ called a classical multiplier sequence if whenever $p(x) = \sum_{k=0}^{n} a_k x^k \in \mathbb{R}[x] \cap \mathcal{L} - \mathcal{P}$, we also have $\sum_{k=0}^{n} a_k \gamma_k x^k \in \mathbb{R}[x] \cap \mathcal{L} - \mathcal{P}$. It has long been known that in order to verify whether $\{\gamma_k\}_{k=0}^{\infty}$ is a classical multiplier sequence, it suffices to check its action on $(1 + x)^n$ (algebraic characterization) or on e^x (transcendental characterization). We show that one can characterize classical multiplier sequences by associating them to a simple set of polynomials Q, for which there exists an $\alpha > 1$ such that both $\{\alpha^k\}$ and $\{\frac{1}{\alpha}^k\}$ are Q-multiplier sequences.

226. Composing Two Non-Tricolorable Knots

Kelly Harlan Belmont University
Advisor(s): Rolland Trapp, CSU-San Bernardino

A knot diagram is made up of several arcs meeting at knot crossings. A coloring of a knot diagram is an assignment of colors to each of the arcs in such a way that at every crossing, the three arcs that meet at that crossing have either all the same color or all different colors. A knot is tricolorable if you can color its diagram with exactly three colors. In the early 2000s, Colin Adams asked whether the knot sum of two non-tricolorable knots is non-tricolorable. We prove that the answer is yes. Although this question had earlier been resolved, our methods are new: We use mod p coloring, coloring matrices, and their determinants in our solution.

227. The Magic Behind Franklin Magic Circles

Katie Watkins Sam Houston State University
Maxsimino Montes Sam Houston State University
Tatiana Kovyrshina Sam Houston State University
Advisor(s): Rebecca Garcia, Sam Houston State University

Benjamin Franklin is popularly known for his creation of the lightning rod, bifocals, and many discoveries regarding electricity. He also participated in the fundamental foundations of the United States of America including co-writing the Declaration of Independence. To avoid weariness in congressional debates, Franklin used his intellect to create both magic squares and magic circles. Franklin Magic Circles are whole numbers arranged in concentric circles such that when added in specific patterns the sum will be the same. In our presentation, we will discuss the recreation, enumeration, and symmetry operations of Franklin's original magic circle, as well as a new, unique Franklin Magic Circle. We will use techniques in algebraic combinatorics to unravel the mysteries of Franklin's creation while revealing the fascinating characteristics that define Franklin Magic Circles.

228. An Anti-Waring Conjecture

Michael Richard Laughlin Auburn University
Advisor(s): Peter D. Johnson, Auburn University

It is conjectured that for each pair of positive integers k and r, there exists a positive integer $N(k, r)$ such that every integer greater than or equal to $N(k, r)$ can be represented as the sum of r or more distinct kth powers of positive integers. It can be shown that this conjecture holds for all cases where $k = 1$: $N(1, r) = (r(r + 1))/2$; and it can also be shown that $N(2, 1) = N(2, 2) = N(2, 3) = 129$.

229. Analysis of Optimal Strategies in the Many-Option Iterated Prisoners' Dilemma

Rachel Sherman Adelphi University
Advisor(s): Lee Stemkoski, Adelphi University

The Prisoners' Dilemma is a classic model of game theory that highlights the conflict between altruistic and selfish choices. If the players interact repeatedly, and the time-value of points is taken into account (via a discount parameter,

for example), indirect communication is possible, resolving the dilemma. We generalize this model to more than two options and determine optimal strategies for maximizing points against a player with a known behavioral profile.

230. Langford-Type Difference Sets for Cycle Systems

Stephanie Zeppetello Illinois State University
Tina Helms Illinois State University
Maggie Murray Illinois State University
Advisor(s): Heather Jordon, Illinois State University

A Langford-type m-tuple difference set of size t and defect d is a set of t m-tuples $\{(d_{i,1}, d_{i,2}, \ldots, d_{i,m}) \mid i = 1, 2, \ldots, t\}$ such that $d_{i,1} + d_{i,2} + \cdots + d_{i,m} = 0$ for $1 \leq i \leq t$ and $\{|d_{i,j}| \mid 1 \leq i \leq t, 1 \leq j \leq m\} = \{d, d+1, \ldots, d+mt-1\}$. In this paper, Langford-type 5-tuple difference sets are given for d even and $t \equiv 0, 1 (\mathrm{mod}\, 4)$ with $d \leq \lfloor \frac{t}{2} \rfloor$, and d odd and $t \equiv 0, 3 (\mathrm{mod}\, 4)$ with $d \leq \lfloor \frac{t-5}{2} \rfloor$. As a corollary, we obtain cyclic 5-cycle systems of the circulant graph $\langle \{d, d+1, \ldots, d+5t-1\} \rangle_n$ for all $n \geq 2d + 10t - 1$ with d and t satisfying the above conditions.

231. Rubik Groups of Truncation Sequences of Dual Polyhedra

Corinna Venezia Adelphi University
Advisor(s): Lee Stemkoski, Adelphi University

Any convex polyhedron can be subdivided in such a way as to create a configuration puzzle in the style of Rubik's Cube. The set of permutations of the puzzle that can be attained by rotations of layers yields a group. When two polyhedra are dual to each other, there is a sequence of truncations that can be used to transform one polyhedron into the other. We determine the Rubik groups of polyhedra in these sequences, and show how geometric relationships between the polyhedra are illustrated by algebraic relationships between the corresponding groups.

232. Mean-Reversion Processes and Non-Competitive Markets: A Case Study of Oil Prices Since 1986

Andrew Snyder-Beattie University of Mary Washington
Advisor(s): Julius Esunge, University of Mary Washington

Although Geometric Brownian Motion (GBM) has been used to model behavior of the world's energy markets, some economists posit that markets for oil are not well-modeled by stochastic processes with stationary independent increments. Instead, oil markets might reflect trends determined by low levels of competition and price-making decisions. Using data since 1986, we examine the effectiveness of GBM as a stochastic model for oil prices, and compare it to mean-reverting stochastic processes. Using statistical evidence, we observe that GBM may be a problematic assumption for modeling the price of oil. Indeed, if OPEC were actually able to alter pricing, we might expect empirical data to reveal symptoms of this. By examining the evolution of oil prices, we evaluate models that may be capable of reconciling the volatile nature of the energy market with potentially oligopolistic structures.

233. On multiplier sequences of a special form for finite fields

Mario Banuelos California State University, Fresno
Michelle Hoshiko California State University, Fresno
Advisor(s): Tamas Forgacs, California State University, Fresno

In 1977 Craven and Csordas proposed the following question. If $\mathbf{F}$ is a finite field, $\{\gamma_k\}_{k=0}^{\infty}$ is a multiplier sequence of elements of $\mathbf{F}$ and $c \in \mathbf{F}$, under which conditions is the sequence $\{c\gamma_k + k\gamma_{k-1}\}_{k=0}^{\infty}$ also a multiplier sequence? We present some results toward the resolution of this question and discuss the methods used to obtain our results.

234. Modeling the Manduca sexta Midgut

Jennifer Lea Garbett Kenyon College
Advisor(s): Judy Holdener, Kenyon College

Metabolism is the process by which energy obtained through food is used and stored, and for reasons unknown, metabolism scales with body weight consistently across species. Manduca sexta, a type of caterpillar which grows to maturity in only 18 days and exhibits a 10,000-fold increase in weight, is an ideal organism for studying this scaling of metabolism. It has been suggested that the surface area of the caterpillar's midgut may play a crucial role in metabolic scaling. We present a model for midgut surface area which reflects the surface area contributions of

long, thin, finger-like projections called microvilli, larger projections called villi, and folding of the midgut. We also investigate and generalize an interesting discovery related to the contribution of microvilli to midgut surface area. Surprisingly, one of the components of our model that determines the amount of surface area contributed by microvilli remains constant regardless of the dimensions of the microvilli. Finally, we discuss the implications of our model in the study of metabolic scaling, and we discuss possible future research.

235. Minor Monotone Floor of Real-Valued Graph Parameters

Xander Heinz Rudelis University of Central Oklahoma
Advisor(s): Thomas Milligan, University of Central Oklahoma

The minor monotone floor of some graph invariant a(G) for some graph G is defined as $\lfloor a \rfloor(G) = \inf\{a(H)|G \preceq H\}$. Given a graph G and an invariant a, $\lfloor a \rfloor$ is the smallest value of $a(H)$ for any graph H with G as a minor. Similarly, the minor monotone ceiling is defined as $\lceil a \rceil(G) = \sup\{a(H)|H \preceq G\}$. Looking at graph invariants, many minor monotone ceilings and floors are trivial. We define some intrinsic properties of minor monotone invariants and look at their implications for the large-scale structures of graphs. Finally we give new bounds on $\lfloor Z \rfloor(G)$ and $\lceil \Delta \rceil(G)$, the minor monotone floor of the zero-forcing number and the minor monotone ceiling of the max degree of any graph G.

236. An Age-Dependent Epidemiological Model for Marburg Hemorrhagic Fever

Olivia J Brozek Marist College
Advisor(s): Matthew Glomski, Marist College

Marburg Hemorrhagic Fever (MHF) is a deadly viral disease first manifested forty years ago. In the most recent outbreak (Angola, 2005) case fatality rates exceeded ninety percent with seventy-five percent of deaths occurring in childrens under the age of five. In this poster, we expand the traditional Susceptible-Exposed-Infectious-Removed (SEIR) model to incorporate age-dependent incidence and mortality in MHF.

237. Forecasting Electricity Demand and Production Cost Considering CO2 Emission

Gilna Samuel Morgan State University
Advisor(s): Russ Calflisch, Institute for Pure and Applied Mathematics (IPAM)

Carbon emissions have become a serious issue as people begin to better understand the causes and effects of global warming on the Planet Earth. Lately, there has been a trend to reduce carbon emissions so as to reverse the associated adverse environmental impact. The electricity industry, through the use of coal, natural gas, and petroleum to power electricity plants around the United States, is a major source of carbon emissions, as well as other pollutants. For this reason we undertook a study of the electricity production market in order to develop a framework that would allows us to understand the effects of carbon reduction policies on future and current electricity production and the associated shifts in carbon emissions. We accomplished our goal through the use of three key mathematical tools: a linear regression model to predict future electricity demand, stochastic models to simulate the key economic variables used in our regression model, and an optimization model to predict future production levels for various production technologies. Taking the final result of the optimization model, we can calculate total emissions from electricity production to study the effects of imposing penalties for emitting carbon

238. Math Anxiety and Math Education Curricula

Moira Devlin St. Joseph's University
Advisor(s): Agnes Rash, St. Joseph's University

My poster discusses math content knowledge and math anxiety. One focus is the content of college-level math courses and the other is on both preexisting and new math anxiety of students. Math anxiety is mainly defined as feelings of tension that interfere with using numbers and solving math problems both inside and outside the classroom. Math anxiety originates in a student from a lack of math achievement in youth and if not dealt with correctly, results in a permanent block. In the 2010 undergraduate curriculum, all students take a math theory course. We have put together the course booklet and will use the pedagogy of "hands-on" learning and learner-centered discovery to teach math content. We wanted to determine how effective the course is at preparing pre-service elementary school teachers. We implemented a pretest-posttest design on math content knowledge and math anxiety to determine if there is an attitudinal change and if there is an increase in knowledge resulting from this course. We created a math card game,

Divisors and Multiples, for elementary education majors to use with their students. Our goal is to help elementary education majors receive the knowledge and support to gain confidence in order to become great teachers and to help put an end to math anxiety.

239. Contractibility and homotopy type of the Hom Complex.

Mychael Sanchez New Mexico State University
Advisor(s): Daniel Ramras, New Mexico State University

The Hom Complex, Hom (G, H) is a cell complex built from the graph multi-homomorphisms from G to H. The Hom Complex was constructed in order to prove the famous Kneser conjecture in combinatorics, and the proof involved using topological properties of Hom (G, H) to create obstructions to certain graph colorings. In this research, we use techniques from representation theory to compute lower bounds on the ranks of the homology groups of Hom (G, H). Further, we use techniques from algebraic topology to determine conditions under which Hom (G, H) is not contractible. Finally, the case where G and H are both cycles has proven to be a difficult problem. We use new methods from combinatorics to calculate the homotopy type of Hom (G, H) when both G and H are cycles.

240. On the Distribution of Orders of Bases of $\mathbb{Z}_n$

Raquel Barata CSU Channel Islands
Samantha Fuller Pennsylvania State University
Advisor(s): Maribel Bueno Cachadina, University California Santa Barbara

Let $S \subseteq \mathbb{Z}_n$. For $k \in \mathbb{N}$ we denote by kS the set $kS := \{a_1 + \cdots + a_k \mid a_i \in S\}$. S is said to be a basis for $\mathbb{Z}_n$ if there exists a $k \in \mathbb{Z}_n$ such that $kS = \mathbb{Z}_n$. The smallest such k is said to be the order of S denoted by $order(S)$. In our project we study the set $E_n = \{\text{order}(S) \mid S \subseteq \mathbb{Z}_n\} \subset \mathbb{Z}_n \setminus \{0\}$, whose elements are not well known.

We call the jth box, B_j, of $\mathbb{Z}_n$ the set of integers in the interval

$$[\left\lfloor \frac{n}{j} \right\rfloor - 1, \left\lfloor \frac{n}{j} \right\rfloor + j - 2]$$

and we conjecture that if $S \subseteq \mathbb{Z}_n$ is a basis, then $\text{order}(S) \in [1, \lceil \sqrt{n} \rceil] \cup \bigcup_{j=1}^{\lceil \sqrt{n} \rceil} B_j$. We have proven that all integers in $[1, \lceil \sqrt{n} \rceil]$ are attained by bases of $\mathbb{Z}_n$. In addition, we determined the distribution of the orders in B_j for $j \in \{1, 2\}$.

241. Generalized Polynomial Chaos and Dispersive Dielectric Media

Erin Bela Chapman University
Advisor(s): Nathan Gibson, Oregon State University

We investigate wave propagation in dispersive media. When the polarization mechanism cannot be described by a single relaxation the material is said to be anomalously dispersive. Heuristic models such as the Cole-Cole have been used to for polarization, but such models require the computation of fractional order derivatives, the simulation of which is nontrivial. We propose an alternative approach. Building upon the framework of Gibson et al. we develop a method for using a continuous distribution of relaxation times. We accomplish this using Generalized Polynomial Chaos, which is a method for expressing stochastic solutions to differential equations using a basis of orthogonal polynomials. By projecting into finite-dimensional random space we replace a single stochastic ODE with a system of deterministic ODEs, which can then be simulated numerically. Our primary contribution was determining the conditions for stability of the method and showing that the method displays exponential convergence. This research has applications in medical imaging.

242. A Statistical Look at the Gauss-Kuzmin Distribution

Steven Elliott Duff Bucknell University
Advisor(s): Nathan Ryan, Bucknell University

The Gauss-Kuzmin distribution predicts the distribution of terms in the continued fraction expansion of almost all real numbers. Unfortunately, it provides no characterization of the set of full measure for which the distribution holds. Finding elements contained in this set would tell us more about this set and about continued fractions in general. We develop a framework for experiments to determine if a number is contained in the set of full measure. An important

part of describing this framework is developing and implementing algorithms that generate random continued fraction expansions.

243. Encrypting with Elliptic Curve Cryptography

Anna Tracy University of the South
Advisor(s): Edray Goins, Purdue University

Today many people communicate via text messaging and "microblog" sites such as Twitter making security an issue of vital importance. We discuss how to use elliptic curves for encoding and encrypting these messages to communicate securely. In the process, we will use Unicode to encode text as a number, as well as the Koblitz method to encode text as a point on an elliptic curve over a finite field. We focus on the Diffie-Hellman and Massey-Omura methods of encrypting messages so that they may be transmitted securely via a key exchange. This research was conducted during the 2010 Mathematical Sciences Research Institute Undergraduate Program under the guidance of Edray Goins.

244. Continuity on a given set

Sleiman Jradi Christopher Newport University
Advisor(s): Mihaela Dobrescu, Christopher Newport University

The Dirichlet type functions are important example in analysis. The Dirichlet function is an example of a function that is discontinuous at any point. The modified Dirichlet function, also known as the Thomae's function, is continuous at all irrationals and discontinuous at all rational. It is known that there does not exist a function that is continuous at rationals and discontinuous everywhere else. However, we show that there exist functions that are continuous precisely on a given set S, assuming the set S has certain properties, through a constructive method. We also investigate the existence of monotonic functions that are continuous precisely on a given set S.

245. The $N + k$ Queens Problem

Mackenzie Martin Washington & Jefferson College
Eric Stultz Washington & Jefferson College
Advisor(s): Ryan Higginbottom, Washington & Jefferson College

Chessboard problems pose the challenge of placing standard chess pieces (usually queens) in certain arrangements. The intention of one such chessboard problem, the $N + k$ Queens Problem, is to place $N + k$ queens and k pawns on an $N \times N$ chessboard so that no two queens may attack each other. We examine the existence and symmetry of solutions, connections with alternating sign matrices, and extensions to the cylindrical chessboard. We also introduce a new problem: given an $N \times N$ cylindrical chessboard, what is the minimum number of pawns needed to place N mutually non-attacking queens?

246. Visualization of the family of expander graphs, $SL2(q)$ with various generating sets

Stephanie Oh Northwestern University
Advisor(s): Darren Long, University of California- Santa Barbara

A family of expanders is a family of networks with a bound on the size of the connections, which is increasing in size and difficult to disconnect. The study of such graphs are useful for understanding networks that require high connectivity but have limited resources.

A construction of one family of expanders uses 2-by-2 matrices over finite fields with determinant 1 and cleverly chosen sets of generators. This construction will give us a non-constructive proof that both the diameter and the girth grow with the logarithm of the size of the graph.

Ultimately, we explore better visualizations of expander graphs, other than through algebraic constructions, bounds on various properties of the graphs, and standard planar representations. In order to gain an intuitive understanding of general families of expanders, we examine the Cayley graph of $SL_2(q)$ with various generators. We search for different ways to partition the graph, as well as ways to characterize the graph only using graph theoretical interpretations.

247. Chemical Pollutant Diffusion Model: Analysis and Approximations

Teresa Yao University of Mary Washington
Erin Strange University of Mary Washington
Advisor(s): Leo Lee, University of Mary Washington

We derive and analyze two methods for the time-dependent chemical pollutant diffusion model with nonhomogeneous Dirichlet boundary conditions. First we use the idea of Fourier series to derive the exact solution to the model in two different ways. We write computer code to approximate values to the two solutions and then compare them. The code also produces animation of the diffusion over time. Then we derive three numerical models using difference equations to approximate the solution of the model. For our numerical models, we develop code that is based on a new numerical algorithm that involves matrices and vectors that represent matrices of matrices. Finally, we compare the exact solution to the numerical solutions from the different numerical schemes to determine which of the numerical methods gives us the best accuracy.

248. Cyclic Codes, Cyclic Frames, and Erasures

Lauren Hope Tomlinson Coastal Carolina University
Advisor(s): James Solazzo, Coastal Carolina University

In this poster presentation, we use cyclic codes to motivate and introduce cyclic frames. In $\mathbb{C}^k$ (or $\mathbb{R}^k$), a **frame** is any subset F of $\mathbb{C}^k$ which spans $\mathbb{C}^k$. A frame F in $\mathbb{C}^k$ is called a **cyclic** frame provided that the range of the associated frame operator is shift invariant. We present examples of cyclic frames as well as describe which cyclic frames are optimal for one and two erasures in $\mathbb{C}^k$ for $k = 2, 3$.

249. Maker-Breaker Games and Bicircular Matroids

Hannah Stanton University of Montana
Advisor(s): Jenny McNulty, University of Montana

"Maker-Breaker" games are two player games and are typically played on graphs. The object of Maker-Breaker games is for Maker to create a basis on the graph while Breaker tries to prevent this from happening. A game with a winning strategy is one which, independent of playing order, Maker always wins; a neutral game occurs when Maker must go first to win; and in a losing strategy, Maker always loses. Following this background, we examined the Shannon Switching Game. This game varies a bit from the original Maker-Breaker game; here Maker wins by creating a *cycle*. We then decided to analyze games creating bicycles. We looked at what generalities of the Shannon Switching game extend to Maker-Breaker games on bicircular graphs and matroids.

250. Continuation Analysis for the Diblock Copolymer Equation in One Dimension

Ian Johnson George Mason University
Advisor(s): Thomas Wanner, George Mason University

Diblock copolymers are a class of materials formed by the reaction of two linear polymers. The different structures taken on by these polymers grant them special properties, which can prove useful in applications such as development of new adhesives and asphalt additives. The diblock copolymer equation governs the formation of these polymers. Using the software package AUTO, continuation analysis of the equilibria of the diblock copolymer equation in one dimension was performed. Using the equilibrium structure implied by continuation analysis, time-varying simulations were performed.

251. The Effects of Timed Stem-cell Gene Therapy and Adaptive Regulatory T-cell Modulation on the Viral Evolution of HIV

Renata Rawlings University of Michigan
Michael Simonov University of Michigan
Advisor(s): Patrick Nelson, University of Michigan

Stem-cell gene therapy is an emerging therapy against HIV during which haematopoietic stem cells are purified from patient's blood and treated with a plasmid containing a viral RNA mimic. The new stem cell population is then reintroduced to the patient and will differentiate into CD4 T-cells, monocytes, etc. Treated cells have shown an increased resistance to the proliferating virus and have arrested viral progression on a slower time scale than traditional HAART

therapies. We model the timing of stem-cell gene therapy in conjunction with HAART to minimize the emergence of drug resistant HIV strains. In addition, we examine the effects of regulatory T-cells (Tregs), which suppress the activation of CD4 T-cells. It is hypothesized that the role of Tregs may change over the course of infection with the proliferation of an adaptive Treg population, which specifically targets HIV-specific responses. To study the role of Tregs in HIV infection, we build a model examining the possibility of two distinct Treg populations, normal and adaptive, and their respective effects in limiting viral load. Through the conjunction of stem-cell therapy and potential Treg suppression/activation therapy, we can construct optimal treatments for patients and elucidate viral mechanisms of infection.

252. Driving Down the Road Looking for Optimal Results

Jessica T Nguyen Lamar University
Advisor(s): Kumer Pial Das, Lamar University

The Bonus Malus System (BMS) is a merit rating system used by insurance companies (particularly in European, Latin American and Asian countries) to reward good drivers by reducing their premium (bonus) and to penalize bad drivers by increasing their premium (malus). In this study, we investigate the optimal BMS under which the premium is set by taking into account both the severity of the claims and the frequency of the claim of each policyholder. In which, the number of claim is assumed to follow Poisson distribution with given parameter lambda, where lambda denotes the differing underlining risk of each policyholder having an accident. If we assume that lambda is distributed accurately to exponential distribution then we'll show that the unconditional distribution of the number of claims follows a geometrical distribution. We follow the same approach and use an exponential distribution to model the size of the claims and we use an Inverse Gamma distribution to model the parameter of exponential distribution. With the given information and further computations we find that the unconditional distribution of the claim size is a Pareto distribution.

253. Quantum Information: Classification of Symmetric States Under Local Unitary Action

Curt David Cenci Lebanon Valley College
Advisor(s): David W. Lyons, Lebanon Valley College

Quantum algorithms rely on an algebraic property of composite quantum systems called entanglement. Currently, there is no complete classification of quantum states by their entanglement types. By exploiting local unitary stabilizer subgroups and properties of Lie algebras, we obtain results classifying the set of quantum states which are invariant under particle interchange, called symmetric states. These states are of particular interest in experimental quantum information due to their relative computational simplicity. For symmetric states whose local unitary stabilizers have a positive number of continuous degrees of freedom, the classification is exhaustive. This poster will focus on these states, as well as give some interesting examples of symmetric states with discrete stabilizers.

254. Optimizing Software Architecture for Efficient Modeling

Chris Harvey University of Portland
Advisor(s): Meike Niederhausen, University of Portland

Advanced forecasting methods are used in operations research to optimize product inventory levels. This study focuses on improving probability models replenishing inventory of items with intermittent and seasonal demand. Our models were programmed using R, but because the initial code implemented was not engineered for speed or efficient memory use, it limited our ability to quickly test different models. To address this problem the simulations were re-engineered in a manner that compartmentalized the code into distinct pieces that were unaware of the overarching data structure. This resulted in simulations with significantly decreased run times. The modular nature of the main simulation code then allowed for implementation of various updating methods. One such method involved updating model parameters with exponential smoothing. These updated parameters were then used to compare the results of different inventory reordering policies to see which performed the best for intermittent seasonal demand. Due to long run times, this would have been unthinkable with the original software architecture.

255. New Patterns with a Paradigm Shift in Data Clustering

Colin Thomson Davidson College
Advisor(s): Tim Chartier, Davidson College

There are hundreds of clustering algorithms, each with its own strengths and weaknesses and each with an appropriate application. One approach is aggregate clustering, which combines multiple clustering methods to give a single, more conservative clustering. However, some of the most important patters in a data set are not found within clusters, but within which data points were difficult to cluster. By taking advantage of the fact that different algorithms place different items in different clusters, the aggregate approach can reveal those items that are difficult to cluster.

This summer I designed an applet in MATLAB to view these "fringe" items, complete with a tool to identify which specific items had been placed in different clusters by a certain number of algorithms. As an example, I investigated handwriting samples, as it it illustrates the potential of the approach very well. The potential for biological data sets is also presented.

256. Conditioning the Capital Asset Pricing Model to Incorporate Macro-Economic Based Variables

Maria Casandra Rusti Whittier College
Advisor(s): Marcel Blais, Worcester Polytechnic Institute

Time variations in expected returns are related to the business cycle. Evidence shows that expected returns are higher in economic recessions, since investors are less willing to hold risky assets, and lower in economic booms. This suggests that time variations in equity premiums should be accounted for by variables related to the business cycle. We develop a conditioning variable that captures time variations in risk premium across business cycles and we test its predictive power for future market returns. We look at the following macro variables: dividend yield, term spread, default spread, and short-term interest rate. Our analysis uses Johansen's cointegration to look at a stationary time series of the four macro variables as a new factor. We test our model's predictive power compared to widely used models in order to conclude whether it is a viable alternative or improvement over current practices. Our study indicates that the model outperforms the original CAPM and performs equally to the Fama and French factor model. Our factor is not adding much value to the models currently being used, although it is accounting for different influencers. Further study can look at combinations of the Fama and French factors with our cointegrated term or adding a momentum factor as well.

257. The modular representation of kS_n for $n < 6$.

Bethany Michelle Tasaka California State University, San Bernardino
Advisor(s): Giovanna Llosent, California State University, San Bernardino

We study the modular representation of kS_n for $n < 6$, where k is an algebraically closed field of characteristic different from 0 and S_n is the symmetric group in n letters. We illustrate what semisimplicity is obtained in each case by means of the radical of kS_n. We also illustrate some other ideas such as the radical series and the socle of these group algebras. Finally, for kS_4 where k is an algebraically closed field of characteristic 2, we illustrate these ideas via the associated path algebra.

258. Planarized Pascal's Triangle Graphs mod p

Michael Samuel Donders McDaniel College
Advisor(s): Anant, Godbole

We have generalized results of Teguia and Godbole on planarized Pascal's triangle fractal graphs mod 2 to the case of graphs similarly constructed with Pascal's triangle mod a general prime p. We attempt to detail the properties of these graphs, which are highly related to Seripiński's Triangle, for all primes p, and for all fractal iterations n. This poster will focus on the path oriented properties, including Hamiltonicity, pancyclicity, diameter and radius.

259. Braid Groups and the Oriented Jones Polynomial

Ana-Cristina Jimenez California State University, Fresno
Advisor(s): Carmen Caprau, California State University, Fresno

A braid is a set of strings, all of which are attached to a horizontal bar at the top and bottom. Each string intersects any horizontal plane between the two bars exactly once. We can always pull the bottom bar around and "glue" it to the top bar, so that the resulting strings form a knot or link, called the closure of the braid. One of the primary goals in knot

theory is to distinguish between different representations of the same knot or link. This may be done using various knot invariants, in particular the Jones polynomial. Since a closed braid represents a knot, one can study braids to gain information about knots.

Braids form a group under the operation of concatenation, and in this project we focus on the study of the braid groups and their representations.

We consider the oriented version of the Jones polynomial of a link, and define the Temperley-Lieb algebra in terms of generators and relations. We define a representation of braid groups into the Temperley-Lieb algebra, and show that this representation can be used to recover the oriented Jones polynomial.

260. Polluting the Air One Day at a Time

Nick Duplan Lamar University
Advisor(s): Kumer Das, Lamar University

In this study we will be using data from the Environmental Protection Agency on air samples in states around the Gulf of Mexico. Due to the recent oil spill, traces of toxic chemicals can be found in the air. These chemicals can be very harmful to the people living in these areas. For example, some chemicals we will look at are PM10, PM2.5, VOC, and H2S. The data can be grouped by substance, location, and date. We will use appropriate statistical techniques to try to find a trend or pattern in the data and see how that impacts air quality.

261. Nim on Trees and Complete Graphs

Sarah Leggett Georgia Institute of Technology
Advisor(s): Neil Calkin, Clemson University

The game of Nim is generalized to trees and complete graphs by removing any number of edges from a particular vertex of a given graph. The game is lost when a player is forced to remove the last edge. Graphs are determined to be winning or losing by analyzing the game in which each player makes the best possible move. We discuss computational methods in determining winning graphs and analyze the distribution of losing graphs.

262. Rational Distance Sets on Conic Sections

Megan Danielle Ly Loyola Marymount University
Shawn Tsosie Massachusetts Institute of Technology
Advisor(s): Luis Lomeli, Purdue University

Leonhard Euler noted that there exists an infinite set of rational points on the unit circle such that the pairwise distance of any two is also rational; the same statement is nearly always true for lines and other circles. In 2004, Garikai Campbell considered the question of a rational distance set consisting of four points on a parabola. We introduce new ideas to discuss a rational distance set of four points on a hyperbola. We will also discuss the issues with generalizing to a rational distance set of five points on an arbitrary conic section.

263. HIV's Interaction With the Adaptive Immune System and Treatments

Jason Dungca University of Southern California
Advisor(s): Fred Adler, University of Utah

While linear ordinary differential equations might be easier to solve, real life systems often require using nonlinear differential equations to account for positive and negative feedback loops. I have created a mathematical model based on nonlinear ODEs to simulate the interaction between HIV and the adaptive immune system's components, such as B Cells, T Cells, and macrophages. The nonlinear ODE system is created through the addition and subtraction of growth and death factors. The results of my model have helped answer questions about the severity of the virus and effectiveness of the choice of treatment. Using Matlab, I have concluded that the severity and state of the virus can affect a person's lifespan and changing the severity of treatment can affect the outcome of the model, which shows either a long, normal life or a short life span. By understanding the interaction between the adaptive system, the form of treatment (such as prescription drugs), and HIV itself, scientists can figure out better treatments for HIV and eventually, a cure for the virus itself.

264. The Sperner Property for Integer Partition Posets

Kerry Elizabeth Gannon Nazareth College of Rochester
Katie Martha Jones University of Kentucky
Advisor(s): Neil Calkin, Clemson University

We examine the integer partition poset, $\mathcal{P}_n$, ordered by a covering relation to determine whether or not it has the Sperner property. To show that $\mathcal{P}_n$ is Sperner we must prove it satisfies unimodality and the bipartite matching property. It was previously shown by Canfield that the bipartite matching property holds for $n \leq 45$. We prove that the bipartite matching property holds between each pair of consecutive level sets from level $k = \left\lceil \frac{n}{2} \right\rceil$ to $k = n$. It has been shown computationally by Canfield for $n \leq 2000$ and asymptotically by Szekeres for n sufficiently large that $\mathcal{P}_n$ is unimodal. To find an explicit value for this sufficiently large n, we hope to show $\mathcal{P}_n$ is log-concave, which would imply unimodality. Thus, we studied the log-concavity of the number of partitions of n, $p(n)$, and use the relationship between $p(n,k)$ and $p(n)$ to determine the behavior of the second half of the sequence $p(n,k)$.

265. Simple proofs of error estimates for common numerical integration techniques

Matthew Wiersma University of the Fraser Valley
Advisor(s): Erik, Talvila

The trapezoidal, midpoint, and Simpson's rules are common techniques of numerical integration taught in first-year calculus courses. Students in these courses are usually shown error bounds for these techniques but are not shown why these bounds must hold. Elementary proofs of error bounds for these will be presented, including an elementary proof of the third order error estimate of Simpson's rule, which was an open problem (L.A. Talman, *Simpson's rule is exact for quintics*, American Mathematical Monthly **113** (2006), 144–155). The methods used in these proofs can be readily adapted to find new techniques of numerical integration. Approaches to and results from doing this will also be presented.

266. An Upper Bound on the Number of Tridiagonal Factors of Banded Permutations

Charles Augustus Albert William & Mary
Advisor(s): Gexin Yu, William & Mary

A permutation is said to b-banded if, given its matrix representation σ, there is no nonzero element $\sigma_{i,j}$ for which $|i - j| > b$. The permutation may be factored into tridiagonal (i.e., 1-banded) permutation matrices. This project determines that the maximum number of factors needed for any b-banded permutation is $2b - 1$. Two algorithms are presented which achieve this bound.

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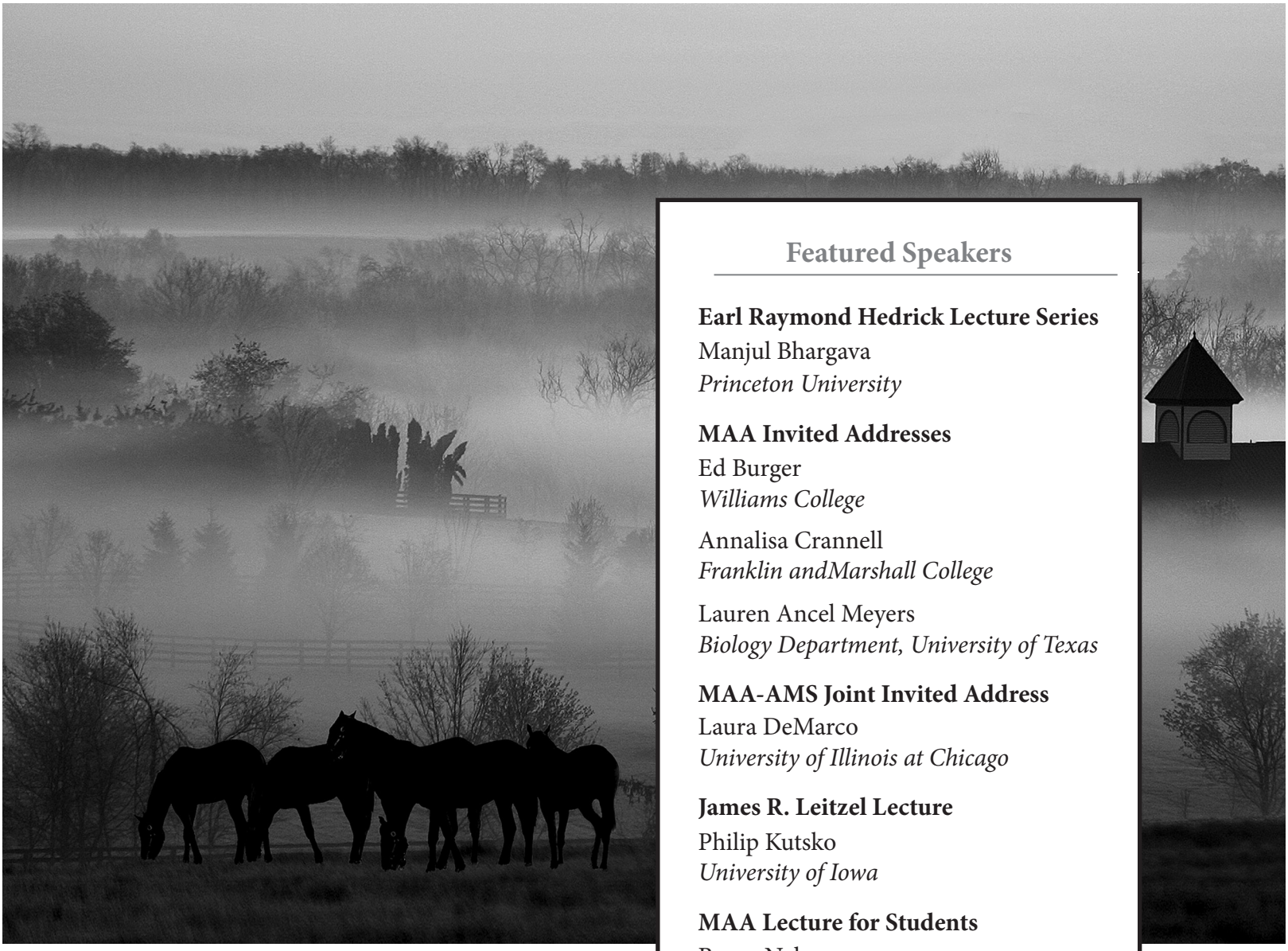

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