Abstracts for the MAA Undergraduate Poster Session

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Organized by

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Montclair State University

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and

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Introduction

Dear Students, Advisors, Judges and Colleagues,

This is a momentous year for me as I watch my first student poster prize winner receive his doctorate. I have brought a student to the Joint Meetings since 1998 and can remember just about every detail surrounding each student's poster session experience. In Steve's case, I remember hoping that everyone who stops by his poster will see in him within the time frame of a few hours what I have had the opportunity to observe over a year. The feedback Steve received from judges and the general audience was very encouraging. Steve couldn't get over an email sent to us by a well known number theorist who happened to browse by his poster and became interested in his work. The poster session experience definitely had an impact on his choice to pursue a doctorate.

It has been 10 years since my first student presented a poster at the session and the energy, enthusiasm and support for this event has grown tremendously. I would like to thank all the advisors and students at this event for their continued efforts and participation at this event. It is our chance to get a peek in a few hours at the magic that has been developing over the past year and we thank you for that opportunity. As the number of students has grown, the number of professional mathematicians who volunteer their time and energy to judge posters also grew. One of the best aspects of the poster competition is that you have 3 mathematicians who provide you with feedback on your research. All of our students benefit greatly from this personal attention and we thank the judges for once again volunteering for the session.

Our financial and administrative support has also grown. The poster session is supported financially by the Educational Advancement Foundation, SIAM, AMS, MAA, AWM, and Pi Mu Epsilon. In addition, our online submission system and technical support is key to managing a large number of poster entries. We thank Dan Connor and Stephen Desanto at the MAA for their efforts on collecting poster and judge registration submissions. The booklet itself has grown in size and its professional look is due to Beverly Ruedi, MAA Electronic Production Manager. There are many details of the poster session that begin with putting out the advertisement in FOCUS in February, ensuring students have travel money and organizing tables in the room we are in today that are attributed to Jim Tattersall (MAA Associate Secretary), Michael Pearson (MAA Director of Programs and Services), Robert Vallin (MAA Associate Director for Student Programs) and Donna Salter (AMS). In addition, I receive assistance from Michael O'Leary (Towson State University) who coordinate judges to posters, Suzanne Lenhart (University of Tennessee, Knoxville) who collects the prize money and runs the judge registration table and Thomas Hagedorn (The College of New Jersey) who runs the student registration table. Today itself we will see a set of volunteers entering scores quickly so we can announce prize winners. The technological upgrade to a network entry of scores was developed by Michael O'Leary and every year Mario Martelli (Claremont Graduate University) helps to enter in scores. To all of you I wish to express my deepest appreciation for your continued efforts on making this session a success!

Finally, I wish to thank my home institution, Montclair State University, their faculty and chairperson Helen Roberts for their consistent assistance and support of the poster session! A special thank you to my students Christina Gratale and Andrew Huth who made plans to do "anything that is needed" at the session.

I hope you have a wonderful experience at this year's poster session!

Diana Thomas
Montclair State University

Judges and Judge Affiliations

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50. Yousuf George, *Nazareth College*
51. Jose Giraldo, *Texas A&M University-Corpus Christi*
52. Darren Glass, *Gettysburg College*
53. Anant Godbole, *East Tennessee State University and Johns Hopkins University*
54. Kris Green, *St. John Fisher College*
55. Zdenka Guadarrama, *Rockhurst university*
56. Jill Guerra, *University of Arkansas - Fort Smith*
57. Aliakbar Haghighi, *Prairie View A&M University*
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63. James Hartman, *The College of Wooster*
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65. Geir Helleloid, *University of Texas at Austin*
66. Randall Helmstutler, *University of Mary Washington*
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Titles, Authors, Advisors and Abstracts

1. When One Becomes Two: Splitting Zero-Divisor Graphs of Rings Into Shiny, New Subgraphs

Abigail Bishop Appalachian State University
Oliver Pechenik Oberlin College
Advisor(s): Michael Axtell, University of St. Thomas

Zero-divisor graphs are ways to organize and investigate the structure of zero-divisors in rings. We introduce two new subgraphs called nilradical and non-nilradical graphs, and show that they have interesting properties. Most surprisingly, we find that the set of non-nilpotent zero-divisors of a commutative ring is a highly structured object. We also give a complete classification of modular rings according to the structures of these new graphs.

2. Properties of Ideal-Divisors

John M. Holmes Wabash College
Adam Shull Valparaiso University
Advisor(s): Dr. Axtell, Dr. Stikles, St. Thomas University, Millikin University

We seek to generalize the concept of zero-divisors of a ring to ideal-divisors. We classify when ideal-divisors form a ideal infinite commutative rings with or without identity. We also provide significant results concerning the relationship between the ideal-divisors and zero-divisors of its associated factor ring.

3. Options in a Retail Environment with Dynamic Inventory Pricing

Bryant Angelos Brigham Young University
McKay Heasley Brigham Young University
Advisor(s): Jeffrey Humpherys, Brigham Young University

We explore the use of option contracts as a means of managing and controlling inventories in a retail market. Specifically merchants can buy option contracts on unsold inventories of retail goods as a means of managing and transferring risk. We propose a new kind of put option on an inventory where the holder of the option is allowed to freely discount the original sale price of the underlying goods during the period of the option contract. We show somewhat paradoxically that this added freedom actually reduces the cost of the option since price reductions always benefit the option writer. We investigate methods to compute the closed-form price of the option based on specific price-demand dynamics, and then discuss further generalizations. We then discuss how inventory management problems can be reformulated as portfolio optimization problems through the use of option contracts.

4. Mitochondrial Resistance to Hydrogen Peroxide Across Strains

Dana K. Kell Central Michigan University
Advisor(s): Dr. John Daniels, Dr Steve Gorsich, Central Michigan University

Successful fertilization in mammals requires the production of functional gamete cells. The events that give rise to gametes incorporate mass amounts of energy produced by mitochondria. Recent research suggests that high proportions of inviable embryos may be related to errors in the number, function, and distribution of mitochondria [1]. Budding Yeast (Saccharomyces cervisisiae), used in this research, produce spores(comparable to gametes) by a similar process called sporogenesis. Studying this process in yeast can ultimately lead to a better understanding of embryo development in mammals.For this research I focused on analyzing spore count and mitochondrial DNA data obtained from another undergraduate researcher (Tricia Brown), under the direction of Dr. Steven Gorsich of the Central Michigan University genetics department. This data was analyzed via linear regression theory by means of SAS (Statistical Analytical Software). Ultimately it was verified that the wild type mitochondrial DNA and the fission mutant mitochondrial DNA produce differing levels of spore viability as oxidative stress is increased. Furthermore, as oxidative stress increases, the numbers of DNA wild type morphologies and mutant morphologies change.

5. A Math Classic: The Tale of Three Links

Samuel Jacob Behrend Denison University
Advisor(s): Dr. Lew Ludwig, Denison University

Recently there has been considerable work done on the linking properties of spatial graphs, spurred by Conway, Gordon and Sach's seminal result regarding K_6. Specifically, they were able to prove that K_6 was intrinsically linked every embedding of K_6 contains at least one two-component link. Flapan, et. al. proved that the minimal number of vertices needed for a triple link (links with *three* components) is 10. In the same article they provided a non-straight-edge embedding of K_9 without a triple link. In this work we consider triple links in the more restrictive geometric setting of straight-edge embeddings. Straight-edge embeddings are relevant to molecular chemists who synthesize knotted molecules atoms and their bonds resemble straight-edge graphs. We establish results that determine when certain linear subgraphs of K_10 are triple linked as well as certain linear embeddings of K_9. Using new techniques, we give an alternative proof to Flapan's result restricted to straight-edge embeddings.

6. The Structure of Unitary Cayley Graphs

Isidora Jimenez SUMSRI/Mills College
Advisor(s): Reza Akhtar, SUMSRI/Miami University

The unitary Cayley graph of a ring R is the graph whose vertices correspond to elements of R and whose edges are pairs u, v such that u-v is a unit in R. In this paper we investigate various structural properties of unitary Cayley graphs (primarily when R is the ring of integers modulo n), in particular clique and chromatic number, vertex and edge connectivity, planarity, and crossing number.

7. Sequence Design in Wireless Communication

Corneliu Alexandru Bodea University of Richmond
Matthew F. Der University of Richmond
Calina Anamaria Copos University of Richmond
David O'Neal University of Richmond
Advisor(s): James Davis, University of Richmond

We provide new theorems that describe when two sequences have the same Non-Periodic Autocorrelation Function (NPAF). Knowledge of the NPAF can be used to determine the Peak-to-mean envelope power ratio (PMEPR), a key measure of the suitability of the sequence for use in the wireless transmission scheme known as Orthogonal Frequency Division Multiplexing (OFDM). This poster provides background on OFDM, a brief summary of recent work by Fiedler and Jedwab demonstrating the importance of knowledge of "Shared Autocorrelation Property," and an overview of our new results. We also include preliminary results of our search for new near-Golay sequences and other low power sequences.

8. Predicting Viscoelastic Properties of the Arterial Wall

Kasey Crompton University of South Carolina - Columbia
Andrew Davis Clarkson University
Satoru Ito North Carolina State University
Gregory Morton Morehouse College
Amanda Olsen LaGrange College
Advisor(s): Dr. Mette Olufsen, Daniela Valdez-Jasso, Associate Professor of Mathematics of North Carolina State University, Biomathematics Doctoral Student of North Carolina State University

The design of stents and grafts require knowledge of the mechanical properties of the arterial wall, which can be hard to determine experimentally. Difficulties arise, since mechanics differ in-vivo and in-vitro, and because the vessel wall displays viscoelastic behavior. This study utilizes a 2-parameter elastic model and a 4-parameter Kelvin viscoelastic model to predict elastic and viscoelastic properties of the arterial wall using in-vivo measurements of vessel area and blood pressure. Data were measured in the proximal ascending aorta in seven sheep at a number of different frequencies. Mechanical properties were predicted by estimating model parameters and by solving the inverse problem minimizing the least squares error between computed and measured values of vessel area. Results showed that we were able to estimate model parameters using only a portion of the data, and that parameter estimates did not differ significantly even without prior data filtering. While the vessel radius was not significantly impacted by changes in frequency, differences were observed in both elastic and viscoelastic parameters. Results of sensitivity analyses showed that all parameters were sensitive, and since all model parameters are independent, we conclude that it is possible to estimate all parameters. Moreover, results showed that the Kelvin viscoelastic model was able to capture the pressure-area hysteresis, which the elastic model could not predict. Finally, we showed that the hysteresis is significantly smaller in-vivo than in-vitro, a phenomenon, which may be a result of smooth muscle cell regulation and support of adventitia.

9. A mathematical model of the immune system's role in obesity-related chronic inflammation

Justin Krueger Miami University
Toby Shearman Virginia Tech
Advisor(s): Reinhard Laubenbacher, Virginia Tech

Obesity is quickly becoming a pandemic. The low-grade chronic inflammation associated with obesity leads to health risks such as cancer, heart disease, and type 2 diabetes mellitus. To better understand the progression of obesity-related inflammation, Dr. Bassaganya-Riera's Lab fed mice either high- or low-fat diets over 140 days. At days 0, 35, 70, and 140, the percentages of macrophage subsets, CD4+ T cells and regulatory T cells infiltrating the intra-abdominal white adipose tissue (WAT) were examined. Monocyte chemoattractant protein-1 (MCP-1) mRNA expression in WAT was also quantified. Additionally, glucose-normalizing ability was examined by administering a peritoneal glucose tolerance test. A system of ordinary differential equations models this system. The model consists of 8 differential equations, has 25 parameters, and has 1 forcing function. Tools used to characterize the model include parameter estimation, sensitivity analysis, and stability analysis. Based on the data provided, the system describes the growth of adipocyte size and chronic inflammation over 105 days beginning at day 35, which is approximately when the adipose cells become hypertrophic. The model shows that without intervention, chronic inflammation escalates and the related health problems persist.

10. Solving Motivic Integration of Monomial Ideals in $K[x, y]$

Zhexiu Tu Bard College
Advisor(s): Jason Howald, The State University of New York - Potsdam

We define the motivic integral as:

$$\int_{J_\infty(X)} \mathbb{L}^{-ord_Y} d\mu_X = \sum_{s=0}^{\infty} \mu(ord_Y^{-1}(s)) \cdot \mathbb{L}^{-s}$$

where $ord_Y(j)$ is a function that measures the order of tangency of a jet in $J_\infty(X)$ to the subscheme Y; $\mathbb{L}$ represents the class of the affine line in the motivic ring. We give out a formula to compute the motivic integral of an arbitrary monomial ideal Y in the polynomial ring $K[x, y]$. Besides, we describe our path to this formula by studying the induced cases on the change of the number of blow-ups and we present proof of this formula briefly by listing all the lemmas we've used along the way.

11. Bubbles, Steiner Points, and Metacalibration

Rebecca Dorff Brigham Young University
Advisor(s): Dr. Gary Lawlor, Brigham Young University

We investigated a problem dealing with minimizing areas and distances on geometric shapes. Using metacalibration, we combined the Steiner Problem, finding the shortest distance between a set of points, and the Isoperimetric Problem, minimizing the perimeter for a given area. We will present the method of metacalibration, and then show how we used it to prove the minimizer for 4 equidistant points enclosing a given area on the plane.

12. The Rate of Convergence of Polya's Urn to the Beta Distribution

John E. Drinane Winona State University
Advisor(s): Dr. Joyati Debnath and Dr. Yevgeniy Kovchegov, Winona State University and Oregon State University

This project was motivated from the work of Kovchegov concerning the behavior of edge reinforced random walks. The particles move along the line, and the probability of the particles movement converges to the Beta Distribution. The model developed to understand a base case of these particle movements used Pólya's Urn. The distribution of the urn can be thought of the probabilities of reaching a certain proportion of red balls in the urn. We can calculate

the distribution by creating a tree of different possibilities. In this presentation the convergence of the Urn to the Beta distribution will be shown. Different methods will be used to arrive at specific rates. Numerical evidence of the analytical result will be included in the presentation. Direction for further research on this problem exists and will also be discussed. Mathematica 6 code will be included for generating the distribution of the urn so the audience can visualize the convergence.

13. On Possible and Probable Triangles in a 2-Edge-Colored Complete Graph

Rebecca Ruth Payne Pomona College
Advisor(s): Ami Radunskaya, Pomona College

Goodman (1959) provided both a formula for the number of forced monochromatic triangles in any 2-edge coloring of a complete graph and a construction for exactly the minimum number of triangles when the number of vertices n is even. Elaborating on this method, an explicit construction has been provided for any number of triangles between the minimum and an n^2 term above the expected value for the case when n is even and the probability p of a red edge is $\frac{1}{2}$. Furthermore, it will be shown that when n is large the distribution of triangles in a graph randomly 2-colored with equal probability of red and blue edges is closely approximated by a binomial distribution, to show that a two-coloring exists with high probability for any number of triangles below some bound close to the maximum.

14. On Metric Trees and n-Widths

Kyle E. Kinneberg Claremont McKenna College
Advisor(s): Asuman Aksoy, Claremont McKenna College

Given a subset A of a normed linear space V, the Kolmogorov n-width of A is a non-negative number that intrinsically measures how close the subset is to an n-dimensional subspace of V. It is easy to extend this idea to measure how close a set A is to an element of a specified collection of subsets in V. For example, the compact width of A is a non-negative number that measures how close A is to a compact set in V. Some types of widths, including the compact width, can be defined analogously for subsets of metric spaces. The definition of the Kolmogorov n-width, however, relies on the linear structure of V, namely, the existence of n-dimensional subspaces. We introduce a notion of n-width defined on a certain class of metric spaces, often called metric trees. We also present properties of these new n-widths that are similar to properties of traditional Kolmogorov n-widths. Our primary results concern the limit of the n-widths of a given subset A in a metric tree. In particular, we find equality among this limit, the compact width of A, and the Hausdorff (or ball) measure of non-compactness of A.

15. Unimodality in the differences of Gaussian polynomials

Jeremy A. Muench Bates College
Advisor(s): Pallavi Jayawant; Jennifer Quinn, Bates College; University of Washington, Tacoma

We investigate the unimodality of the coefficients of the polynomial in q resulting from the differences of Gaussian polynomials of the form

$$\begin{bmatrix} an+b \\ b \end{bmatrix}_q - \begin{bmatrix} a+bn \\ a \end{bmatrix}_q$$

Where a and b are non-negative integers, and $a < b$. From the data collected with the help of Maple procedures to look at the coefficients, we conjecture that the coefficients are unimodal. Because these polynomials count partitions, we attempt to transform partitions counted by the second polynomial into a subset of those counted by the first. We also use ideas from Kathleen O'Hara's proof of unimodality in Gaussian polynomials to try to find a bijection. Using her formula, we find a bijection between two specific subsets of these partitions.

16. Coding and Cryptography with Hyperovals

Katie Hunsberger University of Mary Washington
Catherine Castleberry University of Mary Washington
Advisor(s): Keith E. Mellinger, University of Mary Washington

Finite projective planes are defined as a collection of points and lines that satisfy a series of axioms. Within a finite projective plane, there are objects called conics. Conics are like circles in the Euclidean plane in that each point has a unique tangent line that passes through it. In certain planes, conics contain a unique nucleus which is the point where

all the tangent lines from the conic meet, and the combination of a conic with its nucleus is called a regular hyperoval. The nucleus can be determined by two tangent lines or by five points, and this proves to be a useful property for our investigations into cryptography and coding theory based on hyperovals. For the first part of our project, we create several secret sharing schemes using properties of hyperovals. In such a scheme, a secret is divided into several pieces of information which are then distributed to several people. The only way the secret can be recovered is if several people collaborate and put their pieces of information together. In addition, we generate error-correcting codes using the incidence matrix determined by certain lines and points. Using properties of the geometry of hyperovals we are able to prove several things about the secret sharing schemes and the linear codes we create.

17. Graphs That Are Minor-minimal with Respect to Intrinsically Linked with an Unused Vertex

Kayla Murray University of Arkansas Fort Smith
Advisor(s): Kathy Pinzon, University of Arkansas Fort Smith

It has been shown that there are three known operations that transform an intrinsically linked graph to an intrinsically linked with an unused vertex (ILUV) graph. We can use these operations to generate minor-minimal ILUV graphs from the Peterson graphs. We hope to generate a complete list of minor minimal ILUV graphs by performing triangle-y exchanges on graphs that we know are minor-minimal ILUV.

18. The Connection Between Two Distinct Families of Polynomials Related to the Fibonacci Number Sequence

Luke David Edholm University of St. Thomas
Advisor(s): Dr. Yongzhi Yang, University of St. Thomas

We consider two different families of polynomials generated by the Fibonacci number sequence. The first family is well known and are usually called traditional Fibonacci polynomials. The second family is the Fibonacci coefficient polynomials. Using the Riordan Group to assist our study, we develop a connection between these two families. We then use this connection to derive new identities involving Fibonacci numbers, sums of Fibonacci, Catalan numbers, and binomial coefficients.

19. A Simple Approximation Formula for a Complex Probability Event

Florince Payen Queensborough Community College of the City University of New York
Advisor(s): Haishen Yao, Queensborough community College of the City University of New York

In a masked dancing party, suppose n couples (male and female) come. Since we cannot tell the difference among the same sex in a masked dancing party, we ask if the couples break up and look for their original partner, what is the probability that exactly k ladies find their original partner? This problem is not hard. However, what about a more complex problem: suppose the dancing parties are given many times, say m times, m is a positive integer. Each time that the number of ladies that have found their original partner is k_i, where $1 \leq i \leq m$. What is the probability for $\sum_{i=1}^{m} k_i = s$ (or $P(\sum_{i=1}^{m} k_i \leq s)$),where s is a non-negative integer. We will give the formula and also the way to approximate the numerical result. Our problem will connect the combinatorics, probability and asymptotics.

20. Universal Cycles of Labeled Graphs

Emma E. Snively Rose-Hulman Institute of Technology
Advisor(s): Dr. Anant Godbole, Eastern Tenessee State University

A universal cycle is a compact listing of a class of combinatorial objects. We explore the properties of universal cycles of graphs on n vertices, and prove the existence of several classes of labeled graphs, including simple graphs, trees, graphs with m edges, multigraphs with up to m repeated edges, directed graphs, hypergraphs,and k-uniform hypergraphs.

21. The Busemann-Petty Problem

Emily Klungtvedt University of Wisconsin- Eau Claire
Advisor(s): Simei Tong, University of Wisconsin- Eau Claire

Posed in 1956 the Busemann-Petty problem asks if the relative volumes of two convex bodies can be determined from their $n-1$-dimensional sections. The ultimate solution was that for $n = 2, 3$ and 4 yes but not for 5 and above. A

natural generalization is to ask about the their m-dimensional sections rather than their $n-1$-dimensional sections. This has already been found to be false for $m \geq 4$, but is still open for $m = 2, 3$. This poster reviews the analytic approach in solving the Busemann-Petty problem and displays open related questions.

22. Investigation of the Benefits of Active Learning in Mathematics

Madiha Aslam Rockhurst University
Advisor(s): Dr. Mairead Greene, Rockhurst University

The purpose of this project was to investigate if inquiry-based learning helps students to gain a better understanding of mathematics and a greater awareness of how they learn. By using content analysis on the students' weekly journals, we were able to use their emotional responses as an indicator of their attitude toward the learning style. A strong overall positive response to the learning style was found. Analyses of the journals found that students felt they comprehended the material well, improved their critical thinking skills, and gained confidence in their ability to problem solve. This preliminary data suggests that an inquiry-based learning approach can be used as a tool to further enhance the educational experience of all students and assist in the development of beneficial learning characteristics that will help students in all of their classes. We hope this work will help lead to further research in this area.

23. A new construction of Golay sequences of length 2^m

Amy Wiebe Simon Fraser University
Advisor(s): Jonathan Jedwab, Simon Fraser University

Golay complementary sequence pairs have been studied for over 50 years, both for their mathematical structure and for their digital information processing applications such as multislit spectrometry, optical time domain reflectometry, and power control for multicarrier wireless transmission.In 2008, Fiedler, Jedwab and Parker unified and extended previous constructions, enumerating all known 2^h-phase Golay sequences of length 2^m from just two sources of Golay seed pairs. These sources are the trivial Golay pair of length 1 and the 512 "cross-over" 4-phase Golay pairs of length 8, which give rise to "standard" and "non-standard" Golay sequences, respectively. But our exhaustive computer search revealed there are exactly 98496 6-phase Golay sequences of length 16, of which only the 93312 standard sequences were previously known. How do the 5184 additional non-standard Golay sequences arise, and what can be constructed from them? The 5184 sequences were classified into 18 sets, each represented by one Golay pair. The 18 pairs were then organized into two sets of nine pairs, each set fitting the same "template". The internal additive structure expressed in this template led to the unexpected discovery that all 5184 sequences can be simply constructed from a single length 5 complex-valued Golay sequence pair. The newly-discovered sequence pairs are only the second known non-trivial source of seed pairs for constructing Golay sequences, and give rise to new infinite families of 6-phase and 12-phase non-standard Golay sequences.A joint paper describing this research has been submitted to *Journal of Combinatorial Theory (Series A).*

24. Modeling Deeply Knotted Proteins

Matthew E. Brady College of the Holy Cross, Worcester, MA
Advisor(s): David Damiano, College of the Holy Cross, Worcester, MA

Using different methods, protein biologists have been able to identify the crystalline structure of proteins. This consists of the sequence of amino acids (primary structure), sheets and helices formed by the chain of amino acids (secondary structure), the folding of the chains and sheets (tertiary structure), and the arrangement of the folded chains (quarternary structure). Of interest to mathematicians, knots sometimes appear in the tertiary and quarternary structures of proteins. In this project, we used the mathematical modeling program KnotPlot to identify knotting in proteins. For a large collection of proteins, we extracted the three-dimensional coordinates of the alpha-carbon backbone from the Protein Data Bank, translated the coordinates into a form readable by KnotPlot, and used KnotPlot to produce a stick model of the backbone. By a judicious use of KnotPlot's smoothing feature, we were able to identify dynamically and in real time deep (and shallow) knots in the carbon backbone. This replicates results obtained by different methods by Yan-Long Lai, et. al.

25. Triangles of equal area related to the hyperbola

Adam Romasko Rowan University
Advisor(s): Thomas Osler, Rowan University

Consider a hyperbola with center at the origin of the xy-plane. We examine triangles with one vertex at the origin and the other two on the hyperbola itself. We seek natural conditions under which a family of triangles, all having the same area can be obtained. This work is an extension of a paper that appeared recently in the Mathematical Spectrum which featured similar results for triangles inside an ellipse. The notion of "oblique angled diameters", discussed by Euler is used.

26. Integer Solutions to Descartes Polynomials Associated with Finite Graphs

Theodore W. Swang University of Oklahoma
Advisor(s): Dr. Andrew Miller, University of Oklahoma

Let X be a graph with n vertices $x_1, \ldots, x_n$. The Descartes equation of X is the quadratic equation in $x_1, \ldots, x_n$ obtained by setting the sum of the squares of the variables minus twice the sum of the cross terms of adjacent variables equal to zero. I am interested in finding integer solutions to these equations. For each k there is an operation σ_k that takes one integer solution to another by replacing x_k with twice the sum of adjacent variables minus x_k. By applying sequences of these swapping operations, an equivalence class of solutions is generated. In examples that I have investigated so far, each equivalence class has a unique representative in which each of the σ_k operations causes an increase in $x_1 + \cdots + x_n$. I will examine several example graphs and solutions to their Descartes equation. When X is the graph with 3 vertices and 2 edges integer solutions to the Descartes equation correspond to Pythagorean Triples, and there are only two equivalence classes. The complete graph X on 4 vertices has infinitely many equivalence classes, and these correspond to Apollonian circle packings with integral curvatures. I also plan to examine the star graph on n vertices.

27. Optimizing the Evacuation of Hospitals

Kaitlyn R. Hellenbrand University of Wisconsin-Eau Claire
Advisor(s): Simei Tong, University of Wisconsin-Eau Claire

During an emergency, evacuation must take place quickly. One of the more complicated emergency situations arises in the setting of a hospital. This poster displays a mathematical model for the optimal evacuation of a hospital. Using data from Luther Midelfort Hospital/Clinic in Eau Claire, Wisconsin and the Eau Claire Emergency Management office, a transportation model was created to find the most efficient way to evacuate the hospital. AutoCAD was used to measure distances in the hospital, and Excel was utilized to solve the transportation model using the Simplex Method. The optimal solution was tested by the researchers, and then presented to hospital administrators, who applied it to their emergency plan. This model can be modified to apply to numerous situations.

28. Lower Bounds for Cyclic Van der Waerden Numbers

Jeffrey Burkert Harvey Mudd College
Advisor(s): Peter Johnson Jr., Auburn University

Van der Waerden Numbers are a Ramsey type number that give information about monochromatic arithmetic progressions when the numbers in a larger arithmetic progression are colored. In this paper we discuss a variant of the Van der Waerden Numbers,which we will call the cyclic Van der Waerden numbers, or $W_c(k, r)$,where r is the number of partitions and k is the length of the arithmetic progressions. We present a construction that gives lower bounds for these numbers, and hence also the actual Van der Waerden numbers.

29. Statistical comparison of false reject rates for biometric identification systems

Amanda B. Pendergrass St. Lawrence University
Advisor(s): Michael Schuckers, St. Lawrence University

Evaluation of the matching performance of biometric identification systems is an important undertaking that has significant ramifications for how these devices are perceived and utilized. False accept and false reject rates are currently the most common measures of how well such systems perform. In this poster we focus on false reject rates, or false non-match rates as they are commonly known in the biometric identification literature. We develop statistical significance

tests for determining whether or not there are significant differences between two or more false reject rates. Incorporating the correlated structure resulting from the data collection process, new methods are presented for both paired and independent data. We then demonstrate the appropriateness of these tests through simulations and applications to real data.

30. Finding the Conductor

Megan Knauss Gettysburg College

Advisor(s): Bela Bajnok, Gettysburg College

The conductor of a finite set S, denoted $C(S)$, is the smallest integer, C, such that every $n \geq C$ is a non-negative integer combination of S. It is well known that $C(S)$ exists whenever $\gcd(S) = 1$. If $|S| = 2$, say $S = \{a, b\}$, then $C(S) = (a-1)(b-1)$; this was first proved by J.J. Sylvester in 1884. A similar direct formula for $|S| = 3$ is only known in very special cases. Here we examine the case when $|S| = 3$, in particular the case when S is of the form $S = \{a, a+d, ma+kd\}$.

31. Service Learning in Math classrooms — A Statistical and Qualitative Analysis of Recent Findings

Eric Larson, Britta Gocht, Diy Cardenas, Stefan Fritz, Patrick Rholl, Carl Edgren, Jonathan Nehring, Sarah Johnson
North Park University

Advisor(s): Dr. Rachelle Ankney, North Park University

Last spring, several undergraduates, along with Senior Seminar adviser Dr. Rachelle Ankney, performed a pedagogical experiment. Utilizing the lower-level classes taught by Dr. A, we revised the syllabus to incorporate units pertaining to basic finances and money-management, added assignments to create work sheets explaining financial concepts, and created incentives for attending ESL classes, where the exemplar work sheets would be taught. We also looked extensively at previous efforts to create service learning opportunities and analyzed their findings, from both a statistical and qualitative perspective. We especially emphasize the pedagogical analysis of the effectiveness of our experimental lesson plan as well as those created by others. Many of us in the seminar are either considering or planning to teach math, and our findings reflect that personal connection to our topic. Our poster will give preliminary results of our analysis and several explanations of how we intend to use this type of pedagogical innovation in our own future classrooms.

32. The Rubik Series of Polyhedra

Jaclyn Bogensberger Adelphi University

Advisor(s): Lee Stemkoski, Adelphi University

A Rubik-style puzzle for a given polyhedron is a particular division of the polyhedron into a set of pieces that are permuted in subsets (those pieces that share a common face). The set of all configurations that can be generated by rotating pieces within these subsets is a subgroup (the "Rubik group") of the group of all possible permutations of the pieces. We will explain the group structure for Rubik puzzles constructed on various polyhedra (platonic solids and prisms), which enables us to determine the size of each Rubik group and develop algorithms for restoring the puzzle to its original configuration.

33. Permutation codes

Eteri M. Svanidze SUNY Fredonia

Advisor(s): Meral Arnavut, SUNY Fredonia

Data storage is one of the most concerning issues nowadays with an increasing dependence on real-time data accessibility and availability. It is necessary to minimize occupied volume. Data compression is used to reduce size of documents, data and images so that the amount of time and cost necessary for transmitting the data is smaller.A possible way to compress given data is to use permutation codes. In this work, some characteristics and properties of permutation codes are investigated. In particular, we study perfect permutation codes since they may yield relatively good data compression when permutation codes are used.

34. Landen Transformations with $\cot(3\theta)$

Gerard Diant Koffi UMass Boston
Loraine C Torres University of Puerto Rico
Advisor(s): Prof. Victor Moll, Tulane University

Landen transformations are transformations on the parameters of an integral that leave the integral invariant. Landen transformations were first discovered by John Landen [1775], an English mathematician, when studying elliptic functions and elliptic integrals. It was Gauss [1799], in his attempt to compute elliptic integrals of the type

$$\int_0^{\pi/2} \frac{d\theta}{\sqrt{a^2\cos^2\theta + b^2\sin^2\theta}}$$

that developed the theory of Landen transformations. Gauss observed that by changing the parameters a and b in the integral above by $\frac{1}{2}(a+b)$ and $\sqrt{ab}$, respectively, the numerical value of the integral did not change. Landen transformations are important tools in computational analysis. They provide a new method of computing the value of certain integrals by taking the limit of their iteration. I will present a study of the dynamics of new Landen transformations of the parameters of the integral

$$\int_{-\infty}^{+\infty} \frac{cx^4 + dx^2 + e}{x^6 + ax^4 + bx^2 + 1} dx.$$

These transformations arise from the change of variable $y = \frac{x^3-1}{3x^2-1}$ which was derived from expressing $\cot(3\theta)$ as a function of $\cot(\theta)$.

35. An Investigation of a Strictly Positive Definite Function With Sinc-Like Properties.

Eugene R. Lamie Illinois Institute of Technology
Advisor(s): Gregory Fasshauer, Illinois Institute of Technology

The positive definite function in question is of the form

$$\Psi_D : x \mapsto \frac{\sin(\pi x)}{D\pi \sinh(\frac{x}{D})}$$

found in the book *Approximate Approximations* by V. Maz'ya and G. Schmidt (AMS, 2007). We begin by introducing the function and describe its similarities to the function sinc: $x \mapsto \frac{\sin(\pi x)}{\pi x}$. It is then noted however, that Ψ_D has a shape parameter that can be adjusted in order to achieve different approximation behavior, whereas the sinc is fixed and corresponds to the limit of Ψ_D where D is taken to infinity. From here, numerical results are then presented in order to demonstrate the effect the shape parameter D has on approximations. Since it is known that every positive definite function can be associated with a reproducing kernel Hilbert space which in turn provides a framework for optimal recovery, we conclude by discussing a possible approach to discover Ψ_D's associated reproducing kernel Hilbert space.

36. Multilievel and Multidimensional Hadamard Matrices

Bryce Lee Olin College
Caity Greeley Olin College
Matthew Crawford Olin College
Advisor(s): Dr. Sarah Spence Adams, Olin College

Hadamard matrices are square $\{\pm 1\}$ matrices with mutually orthogonal columns, and they have a variety of applications in modern communications systems. We examined generalizations of Hadamard matrices, such as *multilevel* and *3-dimensional (3D)* Hadamard matrices. Multilevel Hadamard matrices allow entries to be any integer. A 3D Hadamard matrix of size $n \times n \times n$ can be viewed as a stack of n 2D Hadamard matrices of size $n \times n$ in which certain substructures must be mutually orthogonal. We looked to combine these ideas into 3D Multilevel Hadamard Matrices (3D MHMs), which we believe to be a new development.Few constructions for multilevel Hadamard matrices were previously known, none of which could guarantee the desirable property that the constructed matrix contains n distinct integer entries, each appearing exactly once per column. We discovered a construction technique for $n \times n$ multilevel Hadamard matrices which guarantees this property for all n. We also proved the existence of $n \times n \times n$ 3D MHMs by discovering a method to construct 3D MHMs from 2D multilevel Hadamard matrices. We expect that these orthogonal matrices may prove useful in communications systems, as their 2D analogs already have.

37. Group Theoretic Algorithms for Fast Matrix Multiplication

Richard Strong Bowen Harvey Mudd College
Bob Chen Harvey Mudd College
Hendrik Nikolas Orem Harvey Mudd College
Martijn FransPeter van Schaardenburg Harvey Mudd College
Advisor(s): Michael Orrison, Nicholas Pippenger, Harvey Mudd College

Classical matrix multiplication algorithms have shown that the product of two $n \times n$ matrices can be computed in $O(n^2.38)$. Algorithms for matrix multiplication via group algebra embeddings have tied this best known bound, but previously have been limited to embeddings that satisfy a strict algebraic relation. We present an approach that generalizes the existing group-theoretic algorithm using results about partial matrix multiplication to loosen this constraint. In a specific case, we show that our modified embedding improves the computational complexity of the algorithm.

38. Wireless Message Transmission and Interference in Mobile Ad Hoc Networks (MANETs)

Olga Hizkiyahu Devry University, North Brunswick
Maurizio Zanni Devry University, North Brunswick
Advisor(s): Dov Chelst, ICMA

We model MANETs as geometric graphs. Geometric (planar) graphs have vertices with fixed coordinates whose edges connect vertices that lie within a prescribed distance. We vary these graphs by modifying their size, shape and positioning rules. Graphs contain from 20 to over 1000 vertices. These vertices lie within a simple square or a shape designed to model an idealized airport. Vertices are placed at random with uniform probability or using a fractal model. To represent wireless communication networks with these graphs, we create a system of messages and examine their transmission through the graph. We calculate an overall throughput rate for each network. To more mimic wireless communication, we include rules to account for radio interference between messages. We observe that this naturally reduces the throughput rate. In addition, we show how the overall boundary shape of the network affected its throughput rate.This project uses Matlab and the MatlabBGL toolbox and is based upon models designed by D. Chelst and I. Mitchell. The research recreates and extends the works of W. Krause, M. Greiner et al. in *Impact of network structure on the capacity of wireless multihop ad hoc communication* (2004).

39. On A Fruitful Identity in the Theory of Numbers

Robert Peter Schneider University of Kentucky
Advisor(s): David Leep, University of Kentucky

We prove the identity

$$\sum_{k=1}^{n} f(k) \sum_{d|k} g(d) \;=\; \sum_{d=1}^{n} g(d) \sum_{j=1}^{[\frac{n}{d}]} f(dj) \;,$$

which we have noticed is implicit in many proofs in the theory of numbers. Several known results involving number theoretic functions such as the Möbius function and the Riemann zeta function follow immediately from this identity, depending on the choices of f and g. In addition, a number of results may be obtained which are infrequently encountered, if not novel.

40. The Modified Korteweg-de Vries Equation and its Exact Solutions

Antonio Lopez University of Texas at Arlington
Advisor(s): Dr. Tuncay Aktosun, University of Texas at Arlington

The modified Korteweg-de Vries equation is considered, and a formula is obtained for its N-soliton solutions in terms of three constant matrices and using matrix exponentials. The solution formula is verified analytically, and a Mathematica computer program is prepared to produce such solutions and their animations.

41. Knot Counting

Kelsie L. McCartney Marietta College
Advisor(s): Dr. John Tynan, Marietta College

Any knot of any size can be represented in matrix form using the concept of p-colorability. Using these matrices together with the properties of knots we have developed rules for narrowing down the number of square, knot producing, matrices of a given size. In this way, we are working toward eliminating matrices that do not produce knots as well as those that duplicate knots which have already been counted. We are on our way to developing an algorithm to determine an upper bound on the number of unique knots with any number of crossings.

42. Computer Optimization of Electron Beam Devices

William J. Tallis North Carolina State University
Advisor(s): Hien T. Tran, North Carolina State University

Electron beams can be used as power sources for high-frequency, high-energy radio and microwave sources for a variety of applications including radar, communications, electronic countermeasures, and many defense and homeland security systems. Existing cylindrical beam designs cannot achieve the required beam power for some of these applications. Sheet beam guns can deliver much more power; however, at higher power levels the magnetic field containing the beam interacts with the electric field of the electrons to generate a force that curls the beam at the edges. Counteracting this curling requires adding components to alter the magnetic field at the edges of the beam. The shape of the beam is very sensitive to the location of these magnetic components, and the interactions of the components prevents optimizing them independently. Consequently, the performance of the beam depends on too many parameters to be effectively optimized manually. Computer optimization can dramatically reduce the costs and time to develop new electron beam devices. Our research focuses on an automated process for optimizing the focusing of electron beams, using a sheet beam gun as a real-world problem. Two optimization algorithms are being studied, including parallel implementations of both algorithms, as well as a variety of methods to characterize the performance of the device.

43. Exploring a Rational Landen Transformation of Degree Eight

Marcos A. Ortiz University at Buffalo
Ricela Feliciano University of Puerto Rico
Jason Rosenberg Tulane University
Kevin Wingfield Morehouse College
Advisor(s): Dr. Victor H. Moll, Tulane University

Landen transformations are functions on the coefficients of an integrand that leave their positive indefinite integral invariant. These transforms have been shown to give an alternative method for evaluating previously intractable integrals. In the case of rational integrands considered here, the iteration of these transforms on the coefficients of the denominator of the integrand results in orbits that generate a dynamical system. We explore aspects of the dynamical system arising from a degree eight Landen transformation.

44. A Stability Study of Three Numerical Schemes for a Skew-dominated Discretized System

McCarthy Anum-Addo The George Washington University
Matthew R. Darst The George Washington University
Advisor(s): Dr. Katharine Gurski, Howard University

We consider nonlinear systems of differential equations that may be discretized as $\mathbf{B}^{n+1} = (\mathbf{I} - \tau\mathbf{G}^n)\,\mathbf{B}^n$. The real matrix $\mathbf{G}^n$ can be decomposed into symmetric, $\mathbf{P}$, and skew-symmetric, $\mathbf{S}$, components. If the skew component becomes dominant, then the CFL stability condition requires the step size τ to approach zero. As a first step we introduce the scheme $\mathbf{G}'(\theta) = \mathbf{I} - \tau(1-\theta)\mathbf{P} - \tau\theta\mathbf{S}$ where $0 \leq \theta \leq 1$. We consider the stability of $\mathbf{G}'(\theta)$ and alternative schemes $\mathbf{M}'(\theta) = \mathbf{I} - (1-\theta)\tau\mathbf{P} - \tau\theta S + \tau^2\theta^2 S^2$ and $\mathbf{C}'(\theta) = \mathbf{I} - (1-\theta)\tau\mathbf{P} - \tau\theta\mathbf{S} + (1-\theta)^2\tau^2\mathbf{P}^2$, to investigate whether a stable scheme with nonzero step size exists. We concentrate on 2×2 matrices and find general analytic solutions to the step-size problem using the diagonal dominance condition of P-matrices. We include numerical examples that highlight these analytical results.

45. Homomorphic and Color-Critical Graphs: Easing the Search through Computer Programming

Chelsy A. Croson Simpson College

Advisor(s): Patrick Bahls, Murphy Waggoner, Debra Czarneski, Paul Craven, University of North Carolina at Asheville, Simpson College

The necessary properties for a graph to be color-critical are addressed, while specific examples are examined. A program that systematically searches all simple graphs with j vertices and compares these graphs to an original graph will be described. This program eases the process of finding all j-vertex graphs that are homomorphic to a given graph, which inevitably means a faster route to finding color-critical graphs. This project begins to answer questions raised by Nesetril and Nigussie.

46. Examining Violations of the CHSH Bound for State Spaces Composed of Regular Polygons

Casey Oliver Susquehanna University

Dan Mease Susquehanna University

Advisor(s): Lisa Orloff Clark, Jeffrey Graham, Alex Wilce, Susquehanna University

While quantum probability allows for greater correlations between two observables than those seen in classical probability, it still restricts the magnitude of the correlation obtainable within a bipartite state. A measurement of the strength of these correlations is the upper bound of a CHSH-type inequality. The classical upper bound is 2, and Tsirel'son showed that the upper bound of a bipartite quantum state is $2\sqrt{2}$. Popescu and Rohrlich had previously demonstrated that in the specific case of a state space composed of two squares, the bound was maximally violated up to the a priori bound of 4. Here, we investigate the bounds on state spaces generated by the tensor of two regular polygons. We show that for a regular n-gon where n is even, the maximal violation is always greater than or equal to $2\sqrt{2}$. When n is a multiple of 8, we find that the maximal violation is exactly equal to the Tsirel'son bound. For odd values of n, the state space generated by tensoring two regular n-gons oscillates about the Tsirel'son bound in a predictable way. Finally, as n approaches infinity, the violation approaches the Tsirel'son bound for all composite states, as one would expect due to the geometry of the Bloch sphere.

47. The Geometry of SIC POVMs

Maegen V. Demko Susquehanna University

Mark C. Layer Susquehanna University

Advisor(s): Lisa Orloff Clark, Chris Fuchs, Jeffery Graham, Alexander Wilce, Susquehanna University, Perimeter Institute, Susquehanna University, Susquehanna University

The existence of SIC POVMs has been the subject of much research in the field of Quantum Information Theory. If SICs exist in dimension n, then the corresponding states of an n-dimensional quantum system can be geometrically represented by a subset of the intersection of a probability simplex and a sphere. We have found the approximate volume of this intersection by using Monte Carlo methods. Information gained from a geometric approach could provide some guidance to those seeking to solve this existence problem algebraically.

48. Finite Difference method for Boundary value Poisson Problem

Lan Truong Nguyen University of California, Berkeley

Advisor(s): Dr. En-Bing Lin, Central Michigan University

Poisson equation is a partial differential equation with many application in electrostatics, mechanical engineering and theoretical physics. Although analytical solutions for the equation on some special domains can be derived using Green functions method, it is generally hard to find these Green functions. Accordingly, one would prefer to approximate the solution using numerical methods. In this article, we use the method of finite difference to solve the boundary value Poisson equation for rectangular domains. We examine how effective the approximation is in different examples. At the end of the article, we use the method to solve some other similar boundary value problems.

49. Wilf Equivalence in the Generalized Factor Order

Daniel G. Glasscock Rice University
Min Xu University of California, Berkeley
Advisor(s): Dr. Brian Miceli, Trinity University

Let $\mathbb{P}$ be the positive integers and consider the free monoid $\mathbb{P}^*$ of all words over $\mathbb{P}$. A word $w = w_1 w_2 \dots w_n$ has length $|w| = n$, norm $\Sigma(w) = \sum_i w_i$, and weight $wt(w) = (|w|, \Sigma(w))$. We say that w embeds u if there are words $w', v, w'' \in \mathbb{P}^*$ such that $w = w'vw''$, $|v| = |u|$, and $v_i \geq u_i$ for all $1 \leq i \leq |u|$. The generalized factor order is the order obtained by letting $u \leq w$ if and only if w embeds u. Let $\mathcal{E}(u)$ be the set of all words from $\mathbb{P}^*$ that embed u. Two words u, v are Wilf equivalent ($u \sim_w v$) if there exists a weight preserving bijection between $\mathcal{E}(u)$ and $\mathcal{E}(v)$. We prove a nice sufficient condition for Wilf equivalence based on pebble diagrams, namely words with equivalent pebble diagrams are Wilf equivalent. Wilf equivalence necessitates a highly structured bijection between $\mathcal{E}(u)$ and $\mathcal{E}(v)$, and this structure is explored.

50. Numerical Solutions for Intermediate Angles of the Laplace-Young Capillary Equations

Genevieve Noel Dupuis University of Notre Dame
Advisor(s): Chad Westphal, Wabash College

Capillarity is the phenomena of fluid rise against a solid vertical wall. For our research, we consider bounded cases of intermediate corner angles ($\pi/2 < \alpha < \pi/2 + 2\gamma$), where γ is the angle of contact and 2α is the wedge angle. The Laplace-Young Capillary equations are used to determine the rise of the fluid, especially at the corners of the domain. While there exist asymptotic expansions for the height rise occurring at the corner of an intermediate angle, not all coefficients are known analytically. Therefore, numerical solutions are necessary, even though only a few numerical methods have been published. We explain our least-squares finite element method used in determining solutions to the Laplace-Young Capillary equations, and then give our results.

51. Modeling Blood Flow in Time Dependence

Bryant M. Watkins University of Maryland Baltimore County (UMBC)
Bo Xu Columbia University
Dezhi Xu Wabash College
Advisor(s): Chad Westphal, Wabash College

We present the progress to date of the partial differential equation (PDE) model for time dependent blood flow which includes shear thinning and viscoelastic behavior. For shear thinning we used the Carreau-Yasuda model, which indicates a nonlinear relationship between shear rate and viscosity. Complex fluids such as blood not only display viscous properties (fluid-like), but also show elastic properties (solid-like) as well. The viscoelastic model that we used was the Oldroyd-B model, which is a generalization of Navier Stokes equations. We will detail the numerical method to solve this nonlinear PDE using Newton's method along with the method for solving the time dependent model using Euler's method.

54. An Investigation of the Structure Underlying Irreducible Divisors

Hilary Smallwood Wabash Summer Institute of Mathematics (WSIM) / Fort Lewis College
Drew Swartz Wabash Summer Institute of Mathematics (WSIM) / Indiana University - Purdue University Fort Wayne
Advisor(s): Mike Axtell; Joe Stickles, Wabash Summer Institute of Mathematics (WSIM)

In previous literature Coykendall/Maney, as well as Axtell/Stickles have discussed the idea of irreducible divisor graphs of elements in domains and rings with zero-divisors respectively, under two different definitions. Here we seek to look at the irreducible divisor graphs of ring elements under a hybrid definition of the two previous ones; in hopes that this graph will reveal structure concerning irreducible divisors when considering rings with zero-divisors. We also compare the three graphs and examine in what respects they are related. The diameter and girth, as well as other graph-theoretic properties of this graph will also be discussed.

55. Zero-divisor Graphs of Localizations and Modular Rings

Thomas Cuchta Marshall University
Kathryn A. Lokken University of Wisconsin
Advisor(s): Mike Axtell, University of St. Thomas

We examine the zero-divisor graphs of localizations of a modular ring $\mathbb{Z}_n$ around a prime ideal, and we also provide a complete classification of modular rings based on their zero-divisor graphs.

56. Stability of Viscous Shocks in Isentropic Gas Dynamics

Blake Barker Brigham Young University
Advisor(s): Jeffrey Humpherys, Brigham Young University

We examine the stability of viscous shock solutions of the isentropic compressible Navier-Stokes equations, or p-system with real viscosity. We find a bound on the region where unstable eigenvalues may occur. Then we numerically compute the Evans function to show there are no unstable spectra in the entire right half plane for Mach number up to $M = 3000$ and $1 \leq \gamma \leq 3$. We conclude by showing finite difference simulations of perturbed shocks converge to a translate of the original wave solution. Extending our finite difference study to the p-system with capillarity, we show perturbed shocks also converge to a translate of the original shock.

57. Optimal Control and Monetary Policy

Ian Fillmore Brigham Young University
Advisor(s): Jeffrey Humpherys, Brigham Young University

In the United States, banks are required to hold a minimum percentage of deposits in reserve at an account with the U.S. Federal Reserve or Fed. If, during regular business operations, a bank finds itself below the requirement, it will borrow reserves overnight from another bank with extra reserves. The rate at which banks borrow and lend funds to each other is called the Fed Funds Rate. This is the highly publicized interest rate that the Federal Reserve Board sets during its regular meetings. It is important because it serves as a baseline for all other interest rates in the country and affects economic activity in every sector.However, the Federal Reserve Board does not actually set the Fed Funds Rate by decree. Rather, it is determined by the supply and demand for reserves in the banking system. In reality, the Fed sets a target rate, and, through buying or selling government securities, known as Open Market Operations (OMO's), the Fed can increase or decrease the supply of reserves and indirectly control the Fed Funds Rate. Of course, consistently keeping the interest rate at its target level requires conducting OMO's on a daily basis. In this work, we use a dynamic macroeconomic model to describe the relationship between interest rates and the economy. Then, through optimal control methods, we explore the OMO policies needed to achieve the Fed's target rate given its goals of low inflation, high employment, and stable economic output.

58. On factorization properties of $\mathfrak{B}(\mathbb{Z}, S)$.

Yiwei She Northwestern University
Ryan Rodriguez Texas A&M
Advisor(s): Scott Chapman, Trinity University

Consider the set (called $\mathfrak{B}(\mathbb{Z})$) of multisets of integers the sum of whose elements is 0. This set (together with the empty set as the identity) is a monoid under the operation of set union called the block monoid over $\mathbb{Z}$. For any fixed $S \subset \mathbb{Z}$, we define the restricted block monoid $\mathfrak{B}(\mathbb{Z}, S) = \{B_s | B_s \in \mathfrak{B}(\mathbb{Z}), \forall x \in B_s x \in S\}$. A block B is irreducible if it has no proper subset which sums to 0. $\mathfrak{B}(\mathbb{Z})$ has non-unique factorization and moreover the lengths of irreducible factorizations of an element may be different. We define the length set $\mathcal{L}(B)$ to be the set of integers which are the length of some irreducible factorization of B. If $\mathcal{L}(B) = \{x_1 \langle x_2 \langle \ldots \langle x_n\}$, then define the delta set $\Delta(B) = \{x_i - x_{i-1} | 1 \langle i \leq n\}$ and $\Delta(\mathfrak{B}(\mathbb{Z}, S)) = \bigcup_{B \in \mathfrak{B}(\mathbb{Z},S)} \Delta(B)$. By a result of F. Kainrath, every finite $S \subset \mathbb{N}_{\geq 2}$ is realized as the length set of some block in $\mathfrak{B}(\mathbb{Z})$. If $\mathfrak{B}(\mathbb{Z}, S)$ also has this property, then we call $\mathfrak{B}(\mathbb{Z}, S)$ length complete. The purpose of our project was to find necessary and sufficient conditions on S so that $\mathfrak{B}(\mathbb{Z}, S)$ is length complete. To this end, we have found an alternative and constructive proof that $\mathfrak{B}(\mathbb{Z})$ is length complete. We have also proved the intermediate result that $\Delta(\mathfrak{B}(\mathbb{Z}, S))$ is unbounded iff both $S^+ = \{x \in S | x \geq 0\}$ and $S^- = \{x \in S | x \leq 0\}$ are unbounded.

59. Zero-Divisor Graph Associated to a Semigroup

Jonathan Peiyu Wang Harvard University
Advisor(s): Lisa DeMeyer, Central Michigan University

The zero-divisor graph of a commutative semigroup with zero is the graph whose vertices are the nonzero zero-divisors of the semigroup, with two distinct vertices adjacent if the product of the corresponding elements is zero. New criteria to identify zero-divisor graphs are derived using both graph theoretic and algebraic methods. We find the lowest bound on the number of edges necessary to guarantee a graph is a zero-divisor graph. In addition, the removal or addition of vertices to a zero-divisor graph is investigated by using equivalence relations and quotient sets. We also prove necessary and sufficient conditions for determining when regular graphs and complete graphs with more than two triangles attached are zero-divisor graphs. Lastly, we classify several graph structures that satisfy all known necessary conditions but are not zero-divisor graphs.

60. Voice-Printing Individual Great Horned Owls Using Wavelet Analysis

Nicole Kingsley State University of New York at Geneseo
Katherine McCaffrey University of St. Thomas
Heather Thomas Mesa State College
Advisor(s): Chris Hallstrom, Stephanie Salomone, University of Portland

In an attempt to track individual Great Horned Owls without the obstacles involved in tagging, voice recognition may be an effective alternative. By recording owl hoots and studying their waveforms, mathematical methods can be used to determine unique characteristics. Traditionally, signal processing has employed Fourier techniques which localize the signal in the frequency domain. In recent decades, however, wavelet analysis has become an effective method of examining a signal in both the frequency and time domains. We use wavelet packet decomposition to identify characteristics in hoots that are unique to each individual owl.

61. Obstacle Numbers of Graphs

Hannah Alpert University of Chicago
Christina Koch St. Olaf College
Advisor(s): Joshua D. Laison, Willamette University

An obstacle representation of a graph G is a drawing of G in the plane together with a set of polygons called obstacles, where an edge exists in G if and only if it does not intersect an obstacle. The smallest number of obstacles required to represent G in the plane is the obstacle number of G. Previous research did not determine whether any graph had obstacle number greater than 1; we present graphs with arbitrarily large obstacle number. As a variation, we may restrict all obstacles to be convex, and find that the convex obstacle number of a graph can be much bigger than the obstacle number. Specifically, for every k, there is a graph with obstacle number 1 and convex obstacle number k. Also, surprisingly, the graphs with convex obstacle number 1 can be classified in terms of previously-studied intersection graphs: a graph has an obstacle representation with a single convex k-gon if and only if it is a non-double-covering circular arc graph with clique covering number at most k, and for $k = 2$, these are the complements of interval bigraphs.

62. Minimizing the expected length of the minimal spanning tree of graphs

Krista Foltz Linfield College
Advisor(s): Colin Starr, Peter Otto, Willamette University

Given a graph with random edge weights, different configurations of the edges can lead to different expected lengths of the minimal spanning tree. In this project, we investigate the question: which configuration of edges will minimize the expected length?

63. Tutte polynomials and the expected length of the minimal spanning tree (MST) of some families of graphs

Ryan Ladislao Valles CSU Pomona
Advisor(s): Colin Starr, Peter Otto, Willamette University

For a given graph, Steele's formula provides an explicit formula to calculate the expected length of the MST of a graph with randomly weighted edges using the Tutte polynomial of the graph. We use this formula to compute the expected length of the MST for some families of graphs, including the flower graph.

64. Integrand in Steele's formula

Jared George Nishikawa Willamette University
Advisor(s): Colin Starr, Peter Otto, Willamette University

Steele's formula is an integral formula for the expected length of the minimal spanning tree of a graph with random edge weights. We prove that for certain graphs, the integrand of this formula can be expressed as a polynomial with coefficients equal to the number of cycles of the graph.

66. The United States, Mexico, and Classical Trade Theory

Karl Bruce Gregory Central Michigan University
Advisor(s): John Daniels, Central Michigan University

This research assesses the applicability of classical trade theory to the present situation between the United States and Mexico—the doubtfulness of which has arisen from an apparent misalignment between theoretical predictions and recent empirical claims. By modeling changes in labor productivity over time with linear regression, a case is built for Mexican industry's having grown more capital— rather than labor—oriented since the adoption of the North American Free Trade Agreement in 1994. This violates the capital immobility assumption of the Heckscher-Ohlin and Stolper-Samuelson theorems. This research thus points out the need for either a revised model, or a new framework which accounts for the mobility of production factors. *Project funded by National Science Foundation Long-Term Undergraduate Research grant # 06-36528. Thanks to faculty supervisor Dr. John Daniels of Central Michigan University.*

67. Using Real Figures to Invest in Real Estate: A Multivariate Statistical Analysis of the US Housing Market

Takisha Harrison Alabama A & M
Holly Sontag Butler University
Advisor(s): Vasant Waikar, SUMSRI, Miami University

For many Americans, investing in property is a quick and easy way to make money. The real estate game has become a very popular phenomenon, even for those without a millionaire's wallet. However, due to recent struggles in the economy, for some, investing has become more of a burden than a success story. Using multivariate statistical analysis techniques such as Principal Component Analysis, Factor Analysis, and Discriminant Analysis, we determine the factors having the most effect on housing markets. We also discover which of the 50 US states' housing markets are likely to provide a stable or risky investment for those wishing to dabble in real estate."A seemingly minor dislocation originating in the housing sector, such as a higher rate of foreclosures, might cascade through the rest of the economy in un-foreseen ways, for example, in a collapse in bank earnings or a hiccup in the huge market for securities that back residential mortgages." Jeffrey Knight, Chief Investment Officer of Global Asset Allocation at Putnam Investments, *Business Week,* October 30, 2006

68. 4-Covering Maps on Elliptic Curves with Torsion Subgroup $Z_2 \times Z_8$

Brett Jefferson SUMSRI/Morgan State University
Advisor(s): Dr. Edray Goins, SUMSRI/Purdue University

In this exposition we consider elliptic curves over $\mathbb{Q}$ with the torsion subgroup $Z_2 \times Z_8$. In particular, we discuss how to determine the rank of the curve $E : y^2 = (1-x^2)(1-k^2x^2)$, where $k = (t^4 - 6t^2 + 1)/(t^2+1)^2$ and $t = 9/296$. We use a 4-covering map $\widehat{C}'_{d_2} \to \widehat{C}_{d_2} \to E$ in terms of homogeneous spaces for $d_2 \in \{-1, 6477590, 2, 7, 37\}$. We

provide a method to show that the Mordell-Weil group is $E(\mathbb{Q}) \simeq Z_2 \times Z_8 \times \mathbb{Z}^3$, which would settle a conjecture of Flores-Jones-Rollick-Weigandt and Rathbun.

69. The Soap Bubble Problem on the Sphere

Edward S. Newkirk Williams College
Advisor(s): Frank Morgan, Williams College

What is the least-perimeter way to partition the surface of a sphere into n prescribed areas? For n=2, the solution is known. The problem has also been solved for n=3 (Masters, 1994) and for n=12 in the case of equal areas (Hales, 2002). We show simulations of equal-area partitions for n¿3 and discuss progress on a general solution for n=4.

70. On a Theorem of Intersecting Conics

Darren C. Ong Texas Christian University
Advisor(s): Scott Nollet, Texas Christian University

Given two conics on the plane that intersect at a point P, draw a line through P with slope m. Generally, this line will touch both conics once more each, at points Q and R. As m varies, what does the locus of $\frac{Q+R}{2}$ look like? When is the locus itself a conic?

71. First Order Compatibility of the Cubic Schroedinger Equation

Jackson Richard Fliss University of Central Arkansas
David Allen Ekrut University of Central Arkansas
Advisor(s): Dr. Danny Arrigo, University of Central Arkansas

We examine a system of equations generated from the compatibility between the cubic Schroedinger and a system of quasi-linear partial differential equations (PDEs). This can be seen as an extension to the non-classical method of symmetry reduction for PDEs. Here we derive twenty determining equations that must be satisfied. Through the introduction of a transformation that leaves our original system invariant, we solve the determining equations. We find two classes of compatible equations. The first is the one derived by the usual classical Lie symmetry method. The second is an entirely new class of compatible equations. We solve these in conjunction with the cubic Schroedinger equations reducing the original to a second order ordinary differential equation.

73. Minimal Triangulations of Contractible Spaces and Random Collapsing of n-simplices

Bena M. Tshishiku Washington and Lee University
Advisor(s): Katherine Crowley, Washington and Lee University

Collapsing is a combinatorial analog of contractibility for smooth spaces. Many problems in topology and combinatorics reduce to analyzing a simplicial complex, and in particular whether the complex collapses to a point. In practice, checking for collapsibility can be computationally intensive if the order in which one collapses affects the outcome. While it is straightforward to find a way to collapse any n-simplex to a point, it is less obvious whether one can perform collapses in a different order and get “stuck”, with no more available collapses, before arriving at a single point. Previously, Crowley and Ebin showed that if $n \geq 7$, then it is possible to collapse an n-simplex to the dunce hat or Bing’s house with two rooms, neither of which can be collapsed further. We will answer the question for $n \leq 6$.

74. The Brain and Mathematical Modeling: Influence of Neuronal Geometry on its Repetitive Firing

Harold L. Gomes Queens College-CUNY
Advisor(s): Dr. Joshua C. Brumberg (Advisor & PI), Department of Psychology, Queens College, & The Graduate Center, CUNY; Dr. Nicholas T. Carnevale (Collaborating Advisor), Department of Neurobiology, Yale School of Medicine, Yale University

The brain is a complex system, where voltage, electricity, cell geometry play important roles in complex computations and information processing. Neurons are the basic building blocks of our nervous system, and action potentials (voltage-impulses) are at the core of the information encoding-decoding process. Six morphological groups of neurons were identified in a different study. Here, we have investigated the role of cell geometry on repetitive firing of action

potentials i.e., voltage-frequency. Using NEURON, a modeling software, we have simulated 146 actual neurons with Hodgkin-Huxley dynamics

$$\sum I_m = C_m(dV_m/dt) + g_{Na}(V_m - E_{Na}) + g_k(V_m - E_k) + g_L(V_m - E_L)$$

under six different computational models. Geometric variables were the only parameters that varied in each cell (i.e., actual cell morphology). All other experimental variables were held constant in any specific model. Our results indicate that there were indeed differences and similarities in electrophysiology across the groups. Since all six models had similar results, the degree of validity of modeling technique is high. Thus, we believe that neuronal geometry can strongly influence action potential dynamics, and these biophysical differences may lead to a better understanding of the information processing in our complex nervous system.

75. Application of a Coupled Oscillator Model to Sea Lamprey Locomotion

Natalie Elizabeth Sheils Seattle University/ Penn State Erie
Advisor(s): Joseph Previte, Penn State Erie

We consider the problem of a chain of n oscillators coupled with "nearest-neighbor coupling" described by a phase oscillator θ_i forced by another phase oscillator θ_f at some point along the chain. The chain of oscillators is said to be entrained with the forcing oscillator provided that (after some transient behavior) the chain of oscillators all oscillate at the frequency of the forcing oscillator, ω_f. We investigate what values of the forcing frequency cause the chain of oscillators to entrain to the forcing frequency. Further, we determine how the entrainment range depends on the position of the forcing oscillator along the chain. This chain of oscillators can be used to model a sea lamprey as it swims. The lamprey has a simple nervous system allowing us to remove the spinal cord and mechanically force the spinal cord at different locations. Our theoretical results are compared with actual experimental entrainment ranges where the frequency of forcing is increased until the lamprey spinal cord is no longer able to entrain with the forcing oscillator.

77. Algebraic Methods for Phylogenetic Inference

Andrew Howard Sam Houston State University
Alexander Diaz Sam Houston State University
Advisor(s): Luis Garcia, Frank Sottile, Sam Houston State Univerity, Texas A&M University

Statistical models based on phylogenies, or evolutionary trees, are used to study and quantify differences between species. A phylogenetic invariant for a model of biological sequence evolution along a phylogenetic tree is a polynomial that vanishes on the expected frequencies of base patterns at the terminal taxa. In this talk we will describe the phylogenetic invariants based on the GM+I model. This model is an extension of the General Markov model that considers the probability that a nucleotide site cannot change between species. This work extends the database of small phylogenetic trees by implementing efficient algorithms to compute the phylogenetic invariants for the GM+I model and including the results on the small phylogenetic trees website.

78. Calculating the parameters $\mu(D)$ and $k(D)$ in Distance Graphs

Rosemary Nyambura Waithaka California State University San Bernardino
Jimmy Uziel Urrutia California State University
Advisor(s): Min-Lin Lo, California State University San Bernardino

Let D be a set of positive integers. The distance graph $G(\mathbb{Z}, D)$ with distance set D is the graph with vertex set $\mathbb{Z}$, and two vertices x and y are adjacent if $|x - y| \in D$. The chromatic number, fractional chromatic number, and circular chromatic number of distance graphs have been studied greatly over the past two decades. Closely related to these parameters is the density of a distance set D, $\mu(D)$, and the parameter $\kappa(D)$ involved in the Lonely Runner Conjecture. It is known that $\mu(D) \geq \kappa(D)$ for all distance sets D, and it has been shown that $\mu(D) = \kappa(D)$ when $|D| \leq 2$. So far, all the known examples for $|D| = 3$ have $\mu(D) = \kappa(D)$, whether or not this is true for all 3-element sets D remains an open problem. In our research we proved that $\mu(D) = \kappa(D)$, in additional to the known results, for several types of distance sets D with $|D| = 3$: Punched sets, union of two intervals, $D = \{n, n+d, n+2d\}$ with $gcd(n,d) = 1$, and $D = \{i, j, k\}$ where $i < j < k$, i, j, k are not all of the same parity, and $\frac{i}{gcd(i,j)} \equiv_2 \frac{j}{gcd(i,j)}$.

79. The Riemann Zeta Function in Statistical Mechanics

Anthony David Varey Winona State University
Advisor(s): Dr. Joyati Debnath, Winona State University

The applicability of Zeta function to many facets of the world of science and mathematics makes it interesting and becomes fundamental for our advancement of statistical mechanics. In mathematics, this function plays a definitive role in the realm of the prime numbers. In physics, the same function has a different role in connection to the physical world and is frequently used in Quantum Statistics and Thermal Physics in dealing with fermions and bosons, and their probabilities of associated energy states.This presentation will lead up to the Gaussian in physics, and carry the Gaussian function over to the integrand:

$$\int_1^\infty \frac{x^n}{e^x - 1}\,dx$$

It will also focus on showing the connection of the energy states of the fermions and bosons with the Zeta function and the evaluations of Zeta function for certain values that often arise.

80. Solution Matching for a Second Order Three Points Boundary Value Problem on Time Scales

Shernita Lynnae Lee Alabama State University
Advisor(s): Dr. Ana M. Tameru, Alabama State University

We will show the existence and uniqueness of solution for a boundary value problem

$$y^{\Delta\Delta}(t) = f(t, y(t), y^{\Delta}(t)), \quad t \in [x_1, x_3]_{\mathbb{T}}$$
$$y(x_1) = A, \quad y(x_3) - y(x_2) = B,$$

by matching the solution of the three-point boundary problem on $[x_1, x_2]_{\mathbb{T}}$ with the solution of the three-point boundary value problem on $[x_2, x_3]_{\mathbb{T}}$.

81. Schroeder's Functional Equation for Linear Fractional Maps on the Ball

Elizabeth Sweeney Indiana University Purdue University Indianapolis
Yeonjoo Yoo Indiana University Purdue University Indianapolis
Advisor(s): Carl C. Cowen; William M. Higdon, Indiana University Purdue University; University of Indianapolis

A linear fractional map phi on $\mathbb{R}^n$ is a map of the form $\varphi(z) = (Az + B)(<z, C> + D)^{-1}$ where A is an $N \times N$ matrix, B and C are column vectors in $\mathbb{R}^n$, D is a real number and $<\cdot, \cdot>$ is the usual inner product on $\mathbb{R}^N$. A linear fractional functionon R^n is a function of the form

$$f(z) = (<z, E> + F)(<z, G> + H)^{-1}$$

where E and G are column vectors in $\mathbb{R}^n$and F and H are real numbers. Linear fractional maps take $\mathbb{R}^n$ to $\mathbb{R}^n$, and linear fractional functions take $\mathbb{R}^n$ to $Rn1 = \mathbb{R}$. For a linear fractional map φ, Schroeder's Equation is $f \circ \varphi = \lambda f$, where λ is a number and f is a real valued function defined on $\mathbb{R}^n$. For our project, we limited our attention to the case $N = 2$. Given linear fractional maps ϕ that take the unit ball in $\mathbb{R}^2$ into itself, we found all solutions f of Schroeder's Equation that are linear fractional functions. To do so, we employed the matrix analogue of Schroeder's Equation: $M_f M_\varphi = \alpha M_{\lambda f}$ where

$$M_f = \begin{pmatrix} E* & F \\ G* & H \end{pmatrix}$$

and

$$M_\varphi = \begin{pmatrix} A & B \\ C* & D \end{pmatrix}$$

and α is a non-zero constant. Not all linear fractional maps give non-trivial solutions of Schroeder's Equation that are linear fractional functions. Because exponentials of solutions of Abel's Equation, $f \circ \varphi = f + 1$, give solutions of Schroeder's Equation, we also found linear fractional functions that are solutions of Abel's Equation to find, indirectly, solutions of Schroeder's Equation.

82. Arithmetic Derivation of the Ring of Integers

Aaron Thomas Sewell California State University at Chico
Advisor(s): Dr. Benjamin Levitt, Professor, Advisor, REUT research leader

Research in the relatively new concept of the Arithmetic Derivation and Anti-derivation of the Ring of Integers will be presented including several theorems and conjectures new to the publications research is built upon. Mainly set forth by Victor Ufnarovski and Bo Ahlander's publication "How to Differentiate a Number", theorems for the generation of anti-derivatives of a given 'length', lower bound for an integer to have an anti-derivative of a given 'length', as well as continued research using PARI/GP programming environment to prove several personally stated conjectures and further findings upon graph analysis.

83. Environmental Evolutionary Graph Theory

Gregory J. Puleo Rochester Institute of Technology
Advisor(s): Robert Muncaster, University of Illinois at Urbana-Champaign

We consider a simple spatial model of competition between two species. The environment is represented by a graph with red and blue vertices, which offer different levels of reproductive fitness to the two species. In general, the process appears to be difficult to analyze. However, in the case where the coloring of the vertices is a "proper" two-coloring, we show that these graphs are fair: neither species has an overall advantage.

84. The Development of Mathematica Software Tools for the Analysis of Differential Equation Systems

Amy D. Schmidt University of Minnesota, Duluth
Advisor(s): Harlan W. Stech, University of Minnesota, Duluth

The release of Wolfram's Mathematica includes several new and powerful features, such as the Manipulate command. In this project, we explore the development of software tools for the analysis of parameter-dependent first order and autonomous second order differential equations. Using common population models often studied in undergraduate and graduate courses as a case study, we construct generic notebooks for such systems. The approach taken is intentionally designed so that it can quickly be altered to allow the study of any system with any number of parameters. This work demonstrates the power of new development in symbolic software for both instructional purposes and for the analysis of differential systems.

85. Random Multigraph Generation with Geographical Attachment

Colleen A. McCarthy Elon University & University of North Carolina Asheville
Advisor(s): Patrick Bahls, Samuel Kaplan, David Peifer, University of North Carolina, Asheville

We introduce a new algorithm, developed by Besty Katz of the University of Georgia, for randomly generating multigraphs using geographical attachment preferences. This new model looks at how vertices are connected in order to govern the growth of the graph. We looked at various statistical measures of the graph. These measures included the expected number of edges between vertices for the paths P_3 and P_4 and bounds for the expected time to completion for $K_n - e$, where e is any edge. Our future work on this project will include searching for expected values for other classes of initial graphs.

86. Prime Walks in Cyclotomic Fields

Jacob Bond Macalester College
Advisor(s): David Bressoud, Macalester College

This project focused on investigating the existence of prime walks to infinity in cyclotomic fields. In particular, we looked at the possibility of such walks in the Gaussian, $\mathbb{Z}[i]$, and Eisenstein, $\mathbb{Z}[\omega]$, integers, the ring of integers in the second and third cyclotomic fields, respectively. Po Ruh-Loh shows that any prime walk in the Gaussian integers must sweep out some angular sector of positive measure. Further, he is able to demonstrate that the union of angular sectors on which no prime walk can occur is arbitrarily close to 2π. These results were extended from $\mathbb{Z}[i]$ to $\mathbb{Z}[\omega]$. On the other hand, Jan Kristian Haugland argued that based on the density of the primes and the symmetry of the gcd function in the Eisenstein integers, such a walk must cross an arbitrarily large region composed of only composite numbers. Thus, a prime walk does not exist in $\mathbb{Z}[i]$. This argument is extended from the Eisenstein integers to the Gaussian

integers. Although they give no definitive answer, these results seem to provide additional evidence that no such walk exists on either the Gaussian or Eisenstein integers.

87. Small space entropy approximation can be fast, too

Justin Ross Thaler Yale University
Advisor(s): Graham Cormode, AT&T Labs – Research

Data streaming algorithms have recently garnered strong interest, driven by the ability to generate massive amounts of information and the need for sophisticated real-time analysis of that data. Computation on data streams presents unique challenges: Memory access is often a bottleneck, and as a result polylogarithmic space is mandatory.We study streaming algorithms to compute the empirical entropy. Chakrabarti et al. [1] give a one-pass algorithm that (ϵ, δ)-approximates the entropy of a stream of length m using space $O(\epsilon^{-2} \log \delta^{-1} \log m)$, which is proven to be near-optimal. However, the algorithm as given in [1] requires time $O(\epsilon^{-2} \log \delta^{-1} \log m)$ per update.Our poster will present an implementation of this algorithm that requires only $O(\log \epsilon + \log \log \delta + \log \log m)$ time per item. This implementation allowed us to achieve throughputs hundreds of thousands of times better than those of the original. We also present empirical results showing the algorithm is much more accurate in practice than the theoretical bounds of [1] indicate.[1] A. Chakrabarti, G. Cormode, and A. McGregor. A near-optimal algorithm for computing the entropy of a stream. ACM-SIAM Symposium on Discrete Algorithms, 2007.

88. Solutions to a Diophantine Equation Derived from Polynomials over the Integers

Emel Demirel Montclair State University
Advisor(s): Aihua Li, Montclair State University

In this paper, we investigate on a particular Diophantine equation, $9X^2 + Y^3 = 2368Z^3$, and solution triples (X, Y, Z) to the equation, which are derived from some polynomials in $Z[x, y]$. We focus on three polynomials $f(x, y)$, $g(x, y)$ and $h(x, y)$ that satisfy the equation, which are relatively prime as polynomials in $Q[x, y]$. However, the integer values for a fixed pair x, y may not be necessarily relatively prime in Z. We investigate the greatest common divisors between these three polynomials for specific integer values x and y and the types of solutions they derive. We characterize the greatest common divisors of the integer values of the three polynomials for $y = 1$ and $y = 2$. We then give a complete classification on the distribution of the GCDs. In the last section we talk about relatively prime solutions to other Diophantine equations derived from the integer values of the polynomials where the GCD is not 1.

89. The Behavior of DS-Divisors of Positive Integers

Elizabeth Arango Montclair State University
Advisor(s): Dr. Aihua Li, Montclair State University

We study the behavior of DS-divisors of positive integers. Here "*DS*" stands for "*divisor-squared*". For an integer n, a positive divisor q of n is called a DS-divisor of n if $q^2 \mid n - q$. Such a pair (n, q) is called a DS-pair. Using a table generated for DS-pairs, we examine the existence and the numbers of positive DS-divisors of prime powers, products of two prime powers, and other cases represented by prime factorization. We also investigate patterns and structures of DS-divisors derived from our observations of the table. In addition, we study relationships between the number of DS-divisors and the values of Euler functions.

91. Application of Mathematical Methods to Analyze Electroencephalographic Recordings for Source Localization of Brain Signals

Shubham Debnath University of Minnesota-Twin Cities
Advisor(s): Dr. Joyati Debnath, Winona State University

Electroencephalography (EEG) is a noninvasive method to measure electrophysiological signals due to spontaneous cortical brain cell activity. In a standard head model, potentials can be calculated using results provided by the EEG signals. These potentials can be matched by distribution methods to correspond the statistics as ideally as possible to pinpoint the location of the source; this is known as source localization. Spatio-temporal brain activity and modulation are imaged from scalp EEG recordings. The recordings are then off-line analyzed using algorithmic methods. This process of inverse calculation from electrode and sensor information to the identification of location and orientation of source in the brain can be done with reasonable accuracy and precision. This poster will describe the mathematical

methods necessary in producing images to identify the location of sources of electrical signals in the brain. It will summarize results of experimental research and report levels of accuracy. Future of the outcomes, as well as the next step in experiments, will also be explained.

92. Controlling the Motion of Charged Particles in a Vacuum Electromagnetic Field from Boundary

Luis R Suazo University of Central Arkansas
Advisor(s): Weijiu Liu, University of Central Arkansas

We consider the problem of driving two non-relativistic charged particles in a bounded vacuum electromagnetic field to a same location by applying electromagnetic forces through the boundary of the domain. The dynamics of the particles is modeled by Maxwell's equations coupled with the Lorentz force law and the problem is reduced to a boundary feedback control problem. Using the perturbed energy method, we design feedback controllers and prove that the particles under the designed control move to the origin exponentially. Our result may have potential applications in particle acceleration and nuclear fusion.

93. The Geometry and Motion of Nematode Sperm Cells

Kaitlyn Elizabeth Murphy Montclair State University
Advisor(s): Diana Verzi, San Diego State University

The movement of Ascaris suum sperm cells is caused by protrusive, adhesive and contractile forces that act inside the cell. A discrete, 2-D geometric model of the forward motion and turning of the cell is modeled in this paper. The general assumption used is that the internal pH level of the lamellipod is responsible for motility. The main focus of this model is the protrusion of the front boundary of the cell, although contractile and adhesive forces are present in the model. This model only considers MSP bundles because they appear to be responsible for protrusion, and they make up the framework for the shape of the lamellipod.

94. A Stochastic Model of a Tuberculosis Epidemic

Andrew J. Basinski University of Wisconsin-Stevens Point
John Holodnak Ohio Northern University
Advisor(s): Yuliya Gorb, Jay Walton, Texas A&M University

Our poster will present research done at the 2008 TAMU Research Experience for Undergraduates. The topic studied was the spread of tuberculosis through a population. John and I developed a stochastic model run by computer simulation that is based on a system of differential equations developed by Raimundo, S. Our model differs from Raimundo's in that it is able to take spatial effects into account. The model is run on a square grid consisting of cells representing distinct parts of a city. We studied ways in which to decrease the severity of an epidemic using treatment, vaccination, and quarantine. The effect of different levels of movement (individuals moving from one cell to another) was also investigated. Results of averaged simulations and conclusions of the model will be presented.

95. A Finite Difference Model of Flute Dynamics

Stefanie Elaine Meyer Sam Houston State University
Advisor(s): Dr. John Alford, Sam Houston State University

We explore the oscillatory behavior of the acoustics of musical instruments, namely the clarinet and flute. We will discuss existing nonlinear feedback-loop (dynamical)models. It has previously been shown that the fluctuating air pressure inside the mouthpiece of a clarinet may be expressed as a nonlinear difference equation. Similarly, we derive a nonlinear difference equation with delay to model the air jet oscillation into and out of the embouchure hole of a flute. We analyze the model's dependency on parameters in order to determine the onset of oscillatory behavior.

97. Conjuring calculus in the realm of transformations as it casts its spell on non-singular matrices

Javier Joya New York City College Of Technology
Advisor(s): Prof. Satyanand Singh, New York City College Of Technology

In this investigation we will focus on the vector space of real valued functions that are differentiable and has continuous derivatives. Some useful properties of matrix transformations will be established which will lead to the finding of

derivatives and antiderivatives of various functions by way of matrix multiplication. The key to this technique is the clever choice of the appropriate basis and its invertibility relative to the choice of basis.

98. Geometric Methods in Voting and Agreement

Michael Abrahams Vassar College
Meg Lippincott Vassar College
Advisor(s): Thierry Zell, Vassar College

Our study focused on a mathematical representation of approval voting, a voting system in which an individual's vote consists of the outcomes they would consider acceptable. In our research, we focused on the case in which the political spectrum is Euclidean space in d dimensions, and each vote is a d-dimensional box, that is, a parallelepiped with sides parallel to the coordinate axes. Two or more votes are said to agree if there is a platform (a point in the spectrum) that is shared by all of them. We call a society (2,3)-agreeable if, given any three voters, at least two of them agree on a common platform. Our goal was to study the agreement proportion of such societies, or the maximum percentage of a society that could be satisfied by a single platform. In dimension 1, the agreement proportion is 50%, and this bound is sharp. We know that the agreement proportion in dimension 2 is no more than 3/8, or .375. Our main result is that a (2,3)-agreeable society in any dimension must have a positive agreement proportion – in particular, in dimension 2 the agreement proportion must be at least 0.2324.

99. Nonlinear Dynamics of a Simple Microvascular Network

David Gardner Olin College
Yiyang Li Olin College
Benjamin Small Olin College
Advisor(s): John Geddes, Olin College

Blood flow through microvascular networks has been shown to change, oscillate, and even reverse direction without biological control. In order to study this phenomenon, we investigate a model of blood flow through small vessels. Blood flowing through small vessels exhibits rheological properties such as the Fåhræus-Lindqvist effect, which describes the viscosity of blood, and plasma skimming, which governs the separation of red blood cells at diverging nodes. We define a node to be the intersection of exactly three blood vessels, and a network to be the union of two or more nodes. To help understand large complex networks consisting of hundreds of vessels, we begin by studying a simple three node network. Using a variety of analytical and computational tools, we develop methods to find the equilibrium solutions that a given configuration of the three node network can support and the stability of each of these solutions. Our results will be used to design *in vitro* experiments.

100. The Effects of Maternal Age on the Prevalence of Autism

Melissa Ann Bilbao California State Polytechnic University, Pomona
Advisor(s):

Autism's cause is unknown, but suggested causes are often attributed to genetic or environmental factors. This research examines whether advancing maternal age contributes to the increasing prevalence of autism. To test our hypothesis, we create a deterministic model. Values are generated representing the proportion of offspring expected to be diagnosed with autism, provided their mother belongs to a specific age class. The results show that women of the age class consisting of ages 40–44 are more susceptible, by nearly 20 percent, to having a child who will be diagnosed with autism. Using our model, projections are made about the prevalence of autism in future populations, specifically, for the United States and California. These projections predict a continued increase in the prevalence of autism. A linear regression model is also used to statistically confirm that maternal age is affecting the increase in the prevalence of autism.

101. The Algebraic Compatibility of Riemannian Operators' Voice-Leading Properties

Maxx H. Cho Swarthmore College
Advisor(s): Samuel R. Kaplan, University of North Carolina at Asheville

Mathematical music theory, using heavily algebraic techniques, have been dubbed "Neo-Riemannian" music theory in recent years after the music theorist Hugo Riemann, who first noticed a dualism between major and minor triads.

In the early formulations of this theory, the Riemannian operators were defined at least in part by their voice-leading properties. However, some have suggested a root-intervallic approach to the operators. This has the advantage of crystallizing the operators' algebraic properties, but has the disadvantage of abandoning their voice-leading properties. In this paper, we show that there exist classes of pc-set classes for which it is possible to define unique automorphisms on the Riemannian group that preserve their voice-leading properties. In proving the existence of this automorphism, we also observe that there is an interesting connection to Galois theory, in that the automorphisms permute common-tone retention operators.

102. Differential Equation Model of Axon with Action Potential

Noah Weiss University of Nebraska-Lincoln

Susan Koons Texas A&M University

Advisor(s): Bo Deng, University of Nebraska-Lincoln

The neuron has been modeled mathematically with electrical circuits and differential equations for more than fifty years. We propose a model for the electrical behavior of the nodes of Ranvier and extend it to model the axon. We report on the action potentials that propagate across the myelinated axon and consider the effect of capacitance on the propagation of a signal down the axon.

103. Intrinsically triple-linked graphs in $\mathbb{R}P^3$

Emily R. Stark Pomona College

Kristin McNamara James Madison University

Advisor(s): Joel Foisy, SUNY Potsdam

Using a strict definition of the unlink, it has been shown that the complete set of minor-minimally intrinsically linked graphs in arbitrary 3-manifolds is characterized by the seven Petersen-family graphs. We explore a weaker definition of unlinks in projective space, which leads to two distinct two-component unlinks. In particular, six of the seven Petersen-family graphs can be embedded linklessly in $\mathbb{R}P^3$. Flapan, Naimi, and Pommersheim showed that every spatial embedding of K_{10} contains a non-split three-component link (K_{10} is intrinsically triple linked). We show K_{10} is intrinsically linked in $\mathbb{R}P^3$ as well.

104. Modification and Investigation of the Akaike Information Criterion for Models in the Natural Log of Y

Thomas Jeffrey Wolfe University of Mary Washington

Advisor(s): Debra Hydorn, University of Mary Washington

In model selection, researchers must reach a balance between the information gained and the complexity of the model. This balance is why many researchers have begun to use the Akaike Information Criterion (AIC) to analyze which model fits best. The AIC analyzes the residuals coupled with a penalty term for increased number of parameters, to reach a balance between information and complexity. When fitting models on different y-value scales, the AIC will almost always favor the model on the smaller scale. Two of these scales are y and ln y and the AIC will almost always favor the model in terms of ln y. As such, a penalty term was derived for the AIC for models in terms of the ln y (AIClny) to put it on the same scale as the AIC for models in terms of y. This research generated random x-values and calculated y-values based on a selected model (linear, exponential, power, and logarithmic). This data was then adjusted by a normal random error term that was a percentage of the range of y-values. Then linear, exponential, power, and logarithmic models were fit to the data and analyzed based on the AICln y, the AIC, and the R2 values. These results were then compared with the original model to determine what percent of the different methods were "right". The results show that the AICln y is a competitive criterion for determining the correct model as compared to the other two. This means that the AICln y can be used to select a best fit model. Further research would include more complex models and possibly other derivations of the AIC.

105. Free Splittings of Free Groups and X-digraphs

Yakov Berchenko-Kogan California Institute of Technology
Advisor(s): Kim Whittlesey and Ilya Kapovich, University of Illinois at Urbana-Champaign

This poster presents the results of research at an REU at the University of Illinois, wherein techniques of geometric group theory were applied to explore a complex developed by I. Kapovich containing free splittings and conjugacy classes of finitely generated free groups. Specifically, the decidability of computing distances in the complex was addressed. An algorithm for deciding whether or not the distance between two given vertices equals two was constructed using Whitehead automorphisms and Stallings subgroup X-digraphs. In addition, some progress was made towards demonstrating the decidability of this problem for larger distances.

106. Variational symmetries and local conservation laws in general relativity

Olabode M. Sule University of Central Arkansas
Advisor(s): Balraj Menon, University of Central Arkansas

The variational symmetries and local conservation laws admitted by stationary, axisymmetric space times are investigated. The vacuum Einstein equations for stationary, axisymmetric space times are derived from a variational principle by adopting the projection formalism devised by Robert Geroch in his investigation of such space times. The variational symmetries (symmetries of the action functional) are obtained by applying Lie's symmetry group methods and the local conservation laws associated with these variational symmetries are derived by invoking Noether's theorems that relate variational symmetries to local conservation laws. The physical significance of these local conservation laws are discussed via applications to well-known solutions of Einstein's equations like the Kerr metric and the exterior metric of a cylindrically symmetric gravitating string.

107. Improving Estimates of Position Using Bias Corrected Eigenvalues of Sample Covariance Matrices

Jonathan Wesley Stallings University of Mary Washington
Advisor(s): Dr. Debra Hydorn, University of Mary Washington

Global Positioning System (GPS) receivers are used by people all over the world to find their location on Earth. GPS satellites send out information to these receivers, which calculate the position in terms of longitude and latitude. The number of satellites the receiver is connected to and the relative position of these satellites to the receiver affect the accuracy of the longitude and latitude. Hence, associated with each consumer GPS receiver is a certain level of error, typically 3 to 15 meters from the true position.

Treating longitude (X) and latitude (Y) as data having a bivariate normal distribution, we can create a $100(1-\alpha)\%$ confidence ellipse for the true location using the sample covariance matrix and mean vector. The shape of this ellipse is directly related to the eigenvalues of the sample covariance matrix. These eigenvalues, however, are biased estimates of the true eigenvalues, that is, the larger eigenvalue overestimates and the smaller eigenvalue underestimates. Using known methods of bias-correction, we can create improved eigenvalue estimates. A new covariance matrix is reconstructed from these eigenvalues, which is then used to create improved confidence ellipses. We also use a result from a previous undergraduate research project advised by Dr. Debra Hydorn to create a lower bound and upper bound confidence ellipse, or confidence ring, in which we are $100(1-\alpha)\%$ confident the ring contains the true confidence ellipse.

Ultimately, we hope this will help geographers with Geographic Information Systems, particularly with creating maps. Our approach, however, can be applied to any data having a bivariate normal distribution.

108. A Beckman-Quarles type theorem for Laguerre transformations in the dual plane.

Landon Kavlie J Kavlie Calvin College
Advisor(s): Michael Bolt, Associate professor at Calvin College

In 1953, Beckman and Quarles proved a well-known result in Euclidean Geometry that any transformation preserving a distance ρ must be a rigid motion. In 1991, June Lester published an analogous result for circle-preserving transformations in the complex plane. In our paper, we introduce to notion of dual numbers and the geometry of the dual plane. We focus on the set of vertical parabolas and non-vertical lines $\mathcal{P}$ with a distance d between pairs of parabolas defined to be the difference of slopes at their point(s) of intersection. We then prove that any bijective transformation from $\mathcal{P}$ to itself which preserves the distance 1 induces a fractional linear or Laguerre transformation of the dual plane.

109. A Linear Algebraic Proof of Demailly and Skoda's Theorem

Yisha Peng Zhejiang University
Advisor(s): Qifan Yang, Zhejiang University

Demailly and Skoda's theorem is very famous and important in algebraic geometry area. However, the traditional proof of this theorem requires highly advanced mathematical skills such as Fourier analysis. Also, some prior knowledge of Nakano Positive, Griffths Positive and vector bundle are required. In our paper, we translate this complicated algebraic geometry theorem into simple matrix language. We also transform the proof of this theorem into the proof of a hermitian matrix's positiveness. In the end, we give an elementary proof of this transformed one. In this way, even a freshman in college can understand this complicated theorem and the beautiful proof of it.

110. A Sinkhorn-Knopp Fixed Point Problem: Fundamental Theory and Results

Ashley M. Burt Pepperdine University
Kristen Anderson Pepperdine University
Advisor(s): David Strong, Pepperdine University

We consider the fixed point problem $\vec{x} = (N*(N*\vec{x})^{(-1)})^{(-1)}$, where $^{(-1)}$ is the entry-wise inverse of each vector. This problem arises when using the Sinkhorn-Knopp Algorithm for transforming a square matrix into a doubly stochastic matrix. We will present some of the basic results we have found and theory we have developed. These include: the existence and the number of solutions, depending on such factors as size, the sign of entries and number of zeroes; solutions to the problem for particular types of matrices, including circulant and block matrices; and the relation of our work to the corresponding Sinkhorn-Knopp doubly stochastic matrix problem.

111. The Classification of n-hedral Groups

Jami N Kessler Nevada State College
Advisor(s): Aaron Wong, Nevada State College

We define an n-hedral group as a group of the form $\mathbf{Z}_m \rtimes_\theta \mathbf{Z}_n$, where $\rtimes_\theta$ is the semi-direct product and $\theta : \mathbf{Z}_n \to \mathrm{Aut}(\mathbf{Z}_m)$ is a non-trivial map. The classic examples of n-hedral groups are the dihedral groups, $\mathbf{Z}_m \rtimes_\theta \mathbf{Z}_2$, where $\theta : \mathbf{Z}_2 \to \mathrm{Aut}(\mathbf{Z}_m)$ is given by $1 \mapsto \phi_{m-1}$ and ϕ_{m-1} is the automorphism with $1 \mapsto (m-1)$. We will seek patterns among the other n-hedral groups in an attempt to classify all n-hedral groups.

112. A Sinkhorn-Knopp Fixed Point Problem: Some Cases and Results Involving Structured and Patterned Matrices

Brent Hancock Pepperdine University
Advisor(s): David Strong, Pepperdine University

We consider the fixed point problem $\vec{x} = (N * (N * \vec{x})^{(-1)})^{(-1)}$, where $^{(-1)}$ is the entry-wise inverse of each vector. This problem arises when using the Sinkhorn-Knopp Algorithm for transforming a square matrix into a doubly stochastic matrix. I investigate the existence and classification of solutions to this problem in various cases involving matrices with specific structures. Beginning with some simple cases, including low dimensions and simple patterns, e.g. circulant matrices, we make some conjectures about solutions in higher-dimensional and more complex or generalized cases. I will also explore relationships between solutions and eigenvectors of N, and prove a few simple theorems in the case that N is circulant.

113. Exploring Male Dimorphism in the Dung Beetle using a Discrete-time Stochastic Population Model

Phillip Andreae Emory University
Adam Falk Grand Valley State University
Advisor(s): Anthony Tongen, D. Brian Walton, James Madison University

Certain dung beetle species that belong to the genus Onthophagus display an interesting behavioral and physical male dimorphism, with populations split between horned and hornless males with implications for reproductive behavior. We have developed several variations of a discrete time stochastic population model to study this male dimorphism and determine if there exists an optimal strategy for dividing a population between horned and hornless males. By comparing two subpopulations, each of which is characterized by a strategy, we can determine the probability that an individual in the next generation would belong to a particular subpopulation and inherit the corresponding particular

strategy. We will present our results that show that we can find an optimal strategy using adaptive dynamics for varying encounter rates, sperm potency, and body size.

114. Extracting Topics from Product Reviews

Bethany A. Herwaldt University of Notre Dame
Advisor(s): Dr. Carl Meyer, North Carolina State University

For many products, there are more reviews online than anyone has time to read, but people are interested in the general opinions given. Our goal was to find a technique that will allow us to identify the topics discussed in a group of documents so that they can later be rated as positive or negative opinions. We used techniques from linear algebra to create a list of keywords. This list was refined by comparing the ratios of the frequencies of words in the documents to the frequencies of those words in general English. We then grouped these words into topics by applying graph theory and linear algebra to data about word relationships, both in their meaning and in their average distance from each other in the documents.

115. Non-Negativity of the γ-vector for 3-dimensional Polytopes

Rob Zima Houghton College
Advisor(s): Kristin Camenga, Houghton College

The γ-vector, a linear combination of the measures of solid angles, is conjectured to be non-negative for polytopes in any dimension. Since entries of the γ-vector are found by adding and subtracting the measure of angles in different dimensions, this is non-trivial. This presentation will show the results of the investigation of the γ-vector for pyramids and prisms in 3-dimensional space.

It was previously known that the γ-vector is non-negative for all 3-simplices and 4-simplices, where a simplex is defined as a d-dimensional object with $d + 1$ vertices. It was also known that the γ-vector is non-negative for all 2-dimensional polytopes. Since we already knew this to be true, we looked at connections between γ-vectors of prisms and pyramids and to the γ-vectors of their 2-dimensional base. By subdividing pyramids and prisms into simplices, known results were applied to make deductions for pyramids and prisms.

We proved that all 3-dimensional pyramids have non-negative γ-vectors. We also showed that $\gamma_1(P)+\gamma_2(P) = \frac{n-1}{2}$ for a pyramid over an n-gon. For prisms, we were able to demonstrate the relationship between the angle sums of a prism and the angle sums of the simplices in the subdivision of the prism. Furthermore, $\gamma_1(P) + \gamma_2(P) = \frac{n}{2}$ for a prism over an n-gon.

116. Tiling $4 \times n$ Rectangles with Tetrominoes

Mindy M. Swancott Houghton College
April Bowers Houghton College
Advisor(s): Kristin Camenga, Houghton College

Recently a solution to find the number of different ways to tile a 3 by n rectangle with tetrominoes was discovered. The solution technique employed does not generalize readily to the problem of tiling 4 by n rectangles with tetrominoes. In this poster presentation, we will reveal how we developed an approach to the tetrominoe problem. Employing this technique we will show four problems in which we find the number of different ways to tile a $4\times n$ rectangle, including the combinations T and L, T and Z, L and Z, and T, L, and Z tetrominoes.

117. Symmetric Magic Squares: A Linear Algebra Approach

Charles Edward Fisher Fitchburg State College
Mark W. Maggio Fitchburg State College
Advisor(s): Peter Staab, Fitchburg State College

For over two and a half millennia, magic squares have been a popular form of recreational mathematics. From Albrecht Durer to Benjamin Franklin, both scholars and non-scholars alike have been fascinated and intrigued by the development of such squares. Furthermore, in the last hundred years mathematicians have investigated magic square properties such as determinants, eigenvalues, and eigenvectors. Quite recently, it has been shown by R. Bruce Mattingly that a class of even-order magic squares have determinant zero. Upon further inspection of Mattingly's work, we have found a generalization of this class of magic squares that also have determinant zero.

118. A Graphical Aid for Evaluating Initial Values for Numerical Optimization

Noella Grady PennState/Whitman
Advisor(s): Dr. Michael Rutter, Penn State

In optimization problems we often encounter problems for which many parameters must be estimated. However, different initial values can lead to different parameter estimates. In this poster we present a graphical method for helping to asses the effects of initial values on parameter estimates. The method has other applications such as determining the effectiveness of modifications to the objective or likelihood function and the effect of including bounds on the parameter values during estimation. The fitting of a surplus production model for Pacific halibut populations will be used an example.

119. Traditional and Digraph Iterated Function Systems for Variations of Peano's Space-filling Curve

Jessica Davis Stewart Elon University
Advisor(s): Dr. Jeff Clark, Elon University

Despite appearing very complex with their non-integer dimension, many fractals can easily be described using an iterated function system (IFS). IFS's can also be used to describe the approximations of many space-filling curves. The path of these space-filling curves may as well be explained using a digraph IFS. The technique of finding the traditional and digraph IFS's for a space-filling curve is generalized for all space-filling curves, regardless of their dimension, from the example of Hilbert's two-dimensional space-filling curve. This generalized technique for finding the traditional and digraph IFS is applied to two-dimensional switchback and meandering Peano curves, two variations of the three-dimensional Hilbert curve, and a three-dimensional Peano switchback curve.

120. Analysis of Hydrogen Delamination Growth

Marek Fikejz Gainesville State College
Advisor(s): Alla Baloueva, Professor

Transport of hydrocarbons is under a constant threat from hydrogen delaminations which lead to the embrittlement of the metal pipeline. Hydrogen being accumulated inside the delamination cavity creates pressure which eventually leads to the damage of the pipeline. The focus of this study is the modeling of how the radius of delamination grows with respect to time. The volume of the delamination cavity is first defined in terms of its radius and the hydrogen pressure. The second step is to define the mass of the gas present in the delamination cavity at any time. The equation of state for the ideal gas is first used; however, such is only accurate for low pressures. This study applies the van der Waals equation which is valid for high pressures as well. By substituting the known expressions of volume and gas mass into this equation, an integral equation for the delamination radius is derived. Next the integral equation is reduced to the differential equation by taking the derivative of both sides and applying the Fundamental Theorem of Calculus. The separation of variables is then used to solve the differential equation. The analytical solution for the dependence of the radius of growing delamination on time is derived. Since the obtained solution is in an implicit form, the equation is first solved using the Mathlab Software for specific points of time, making it possible to generate the final graph of the delamination radius versus time.

121. Trigonometric and Hyperbolic Identities for Matrices

Will Alexander Eagan Hamilton College, Class of 2011
Advisor(s): Prof. Larry E. Knop, Ph.D., Hamilton College

Trigonometric and hyperbolic functions for square matrices can be defined by generalizing the infinite series formulations of the corresponding functions of scalars. Given trigonometric and hyperbolic functions of matrices, the natural question is: Do the standard trigonometric and hyperbolic identities hold when scalars (angles) are replaced by matrices? The short answer is *Yes.* Examples, explanations of the short answer, and some preliminary attempts at an interpretation of meaning will be presented.

122. Steiner Inellipses in the Unit Circle

Elizabeth A. Skubak Bucknell University
Advisor(s): Pamela Gorkin, Bucknell University

Given any triangle with its three vertices z_1, z_2, z_3 on the unit circle, we know there exists a unique inscribed ellipse that is tangent to the triangle at the midpoints of its sides; this ellipse is called the Steiner inellipse. Also from Steiner, we know that the foci of this ellipse are the critical points of the monic polynomial with z_1, z_2, z_3 as roots. Note that, interestingly, these Steiner inellipses are also Poncelet ellipses.Consider this problem in reverse; given two points a and b in the open unit disk, can we find a Steiner inellipse with a and b as foci so that the circumscribing triangle has its vertices on the unit circle? Not always: we have shown that we must choose a and b so that $2|ab| = |a + b|$, which severely limits our choice of pairs of points. We have also completely described
1) the case in which both a and b lie on a diameter of the unit circle and
2) the case in which a and b are symmetric about a diameter of the unit circle.These two cases produce a unique Steiner inellipse with an isosceles circumscribing triangle.

123. Recursive Sequences and Polynomial Congruences

Christopher L. Triola University of Mary Washington
Advisor(s): Dr. Randall D. Helmstutler, University of Mary Washington

During a research project performed under the direction of Dr. J. Larry Lehman at the University of Mary Washington we considered recursive sequences defined by linear homogeneous recurrence relations of arbitrary order when they are reduced modulo a positive integer m. We showed that the period of such a sequence with characteristic polynomial f can be expressed in terms of the order of$\omega = x + \langle f \rangle$ as a unit in the quotient ring $\mathbb{Z}_m[\omega] = \mathbb{Z}_m[x]/\langle f \rangle$. When m is a prime number p, this order can be described in terms of the factorization of f in the polynomial ring $\mathbb{Z}_p[x]$. We use this connection to develop efficient algorithms for determining the factorization types of monic polynomials of degree$k \leq 5$ in $\mathbb{Z}_p[x]$.

124. Variations on the Schelling Segregation Model

Nicole S. Alves Adelphi University
Advisor(s): Lee Stemkoski, Adelphi University

The Schelling Segregation model studies aggregate behaviors of populations due to individual preferences. This model, first published in 1971, is one of the first constructive models of a self-organizing system and qualitatively reflects observed residential divisions. We will explore a number of variations on the basic model, including increased agent sophistication, local and global topology, movement sequencing, and initial configuration.

125. Properties and Topologies Created by Applying Linear Lebesgue Measure to Plane Sets with Concentric Circles

Charles A. McEachern St Olaf College
Advisor(s): Paul Humke and Wladislaw Wilczynski, St Olaf College and Lodz University, Poland

Density points on a plane set are typically determined by use of two-dimensional Lebesgue measure. We create an alternative by considering the linear density of complete and almost-complete concentric circles around a point in the plane. We explore several properties of our operators and can in several cases make strict comparisons to ordinary and strong Lebesgue density on the plane. Our primary investigation is into the properties of topologies than can be created using our concentric density operators. In considering the separation axioms we find that several of our topologies are normal.

126. BCH codes with small generator sets

Jacob Farinholt University of Mary Washington
Advisor(s): Keith E. Mellinger, University of Mary Washington

Cyclic codes are a class of linear error-correcting codes that are constructed algebraically using the polynomial rings and ideals. The construction involves a very elegant relationship between codewords and polynomials, and this connection allows one to investigate properties of the codes by examining their algebraic counterparts. One subclass of the cyclic codes is the BCH codes. These codes are constructed with a prescribed minimum distance which means that the

codes can be designed to correct as many errors as are required for the intended application. Our goal is to construct classes of BCH codes in as simple a fashion as possible. When we desire our codes to correct as many as 2 errors, we look at the corresponding polynomial ring and its ideals in order to determine algebraic conditions that would lead to the desired properties. This leads us to number theoretic arguments involving powers of elements in certain finite fields. The results involve the construction of BCH codes with small sets of generators.

127. Julia Sets of Non-Analytic Functions

Jeffrey M. Winter US Air Force Academy
Advisor(s): Beth Schaubroeck, US Air Force Academy

There are many interesting topics when dealing with Julia sets of analytic, complex valued functions. We have investigated an area that most mathematicians have stayed away from when discussing Julia Sets, the Julia sets of $f(z) = z^n + c$, where n is a rational number instead of an integer. These functions have surprising Julia Sets. We discuss concepts such as attracting basins, fixed points, and p-cycles; we also examine how the branch cut of the complex plane is now present in the visual representation of the Julia and Mandelbrot-like sets that are formed. We also demonstrate how small changes in the c-values have large impacts on the Julia Set.

128. Chaotic Day at the Beach

Lianne Loizou Loizou James Madison University
Juan Carlos Ortega James Madison University
Michael Dankwa James Madison University
Jan Herburt-Hewell James Madison University
Advisor(s): Dr. Anthony Tongen and Dr. Roger Thelwell, James Madison University

The chaotic waterwheel, a physical model of the Lorenz system, is a well studied and fairly well understood problem in dynamical systems. Last summer, NREUP participants at James Madison University designed, developed, constructed and analyzed a sandwheel, in which sand replaced water. Linear stability theory was used to explore stability. Numerical experiments indicated that the center of mass could be used to classify the system's behavior; including constant, rolling, periodic or chaotic states. Ongoing research compares physical observations to the mathematical observations and working to find consistency between the two. The talk will outline our work on the 'not-so-chaotic' sandwheel.

129. Values of the gamma and beta functions conjectured from a historic table of Wallis

Lee N. Collins Rowan University
Advisor(s): Thomas Osler, Rowan University

We examine an interesting table from "The Arithmetic of Infinity" written by John Wallis in 1665. It was the study of this table that lead Wallis to conjecture his famous infinite product for pi using rational numbers as factors. We show that the same table conceals additional information. We use it to conjecture the values of the gamma function at an integer plus , and also to express the beta integral in terms of the gamma function. Mathematical derivations of these results are nontrivial, and these conjectures provide another insight into the nature of these functions.

130. On the Dynamics of Genralized Quadratic Maps

Ziying Pan Michigan State University
Advisor(s): Aklilu Zeleke, Michigan State University

The dynamical behavior of generalized quadratic maps given by the form $G(x) = ax^2 + bx + c$, where a, b, c are parameters, is explored. By specifying certain relationships among the three parameters, we classify orbit diagrams, fixed points and cycle points. Moreover we present experimental and graphical results for chaotic behaviors of G. We also generate Mandelbrot sets and compare these to the classical Mandlebrot set of the quadratic map $x^2 + c$.

131. The Competitive Facility Problem: A Winning Strategy for Player Two

Ryan David Ewing University of Arkansas Fort Smith
Advisor(s): Kathy Pinzon, University of Arkansas Fort Smith

We consider a variation of the competitive facility problem with two players. In a tournament (simple complete digraph), players label vertices until no more can be labeled: the winner labels the last vertex. We present a winning

strategy for the second player in a specific graph with $\{2n+3|n \in \mathbb{N}\}$ or $\{4n+2|n \in \mathbb{N}\}$ vertices. We hope to find all tournaments in which player two has a winning strategy.

132. On the Dynamics of Non-Linear Tent-Maps.

Oumarou Njoya Michigan State University
Advisor(s): Aklilu Zeleke, Michigan State University

Consider a family of non-linear tent maps defined by $F(x) = cx^b$, if $0 \leq x < 1/2$ and $F(x) = a(1-x^b)$ if $1/2 \leq x < 1$. Here a, b, c are real parameters. By finding conditions on these parameters we explore dynamic properties of F that arise under continuous iteration. We present results about the existence and nature of fixed points and cycle points. We will also investigate chaotic behaviors of F using graphical means (such as bifurcation diagrams and density graphs) and numerical studies (using Lyapunov exponents). Connections between the dynamics of F and fractal sets will be discussed.

133. Simultaneous class number divisibility in quadratic function fields

Natee Pitiwan Williams College
Advisor(s): Allison Pacelli, Williams College

Number fields and function fields are finite algebraic extensions of the field of rational numbers and the quotient field of polynomials over finite fields, respectively. To each number field and function field we associate the class number, which contains information on how close the ring of integers of the field is to being a unique factorization domain. It is known that infinitely many number fields and function fields have class number divisible by a given integer.Komatsu proved that for any given nonzero integer m, there are infinitely many pairs of quadratic fields $\mathbb{Q}(\sqrt{D})$ and $\mathbb{Q}(\sqrt{mD})$ whose class numbers are both divisible by 3. The main tools that he used in the proof are class field theory and a theorem proven by Llorente and Nart, which tells us the criteria for a cubic polynomial to yield an unramified cubic extension. Here we discuss the analogue of Komatsu's result for function fields, using analogues of class field theory as well as Llorente and Nart's theorem for function fields.

134. Pricing Derivative Securities Based on Three Independent Assets

Raul Escobar-Rodas California State University Dominguez Hills
Advisor(s): Robert Aguirre, Carnegie Mellon University

The Binomial Asset Price Model is very well understood in Mathematical Finance. However, one of its weaknesses is that only one asset is used to describe the model. In this research, a model is built with more than one independent asset using methods from *Stochastic Calculus for Finance II* by Shreve for the Black-Scholes asset model. Methods from the special case of one independent asset were used to outline the methods that are used to conduct this research. There are two parts to this research: (1) to find risk-neutral measures that will make our discounted portfolios martingales and (2) to use the Stochastic Integral (Martingale Transform) to price any derivative security. These methods were used to develop *No Arbitrage* conditions as well as develop a complete market. The research is conducted specifically for the case of a three independent stock model. Methods in linear algebra and stochastic processes, such as random walks, were used to attempt to find a *No Arbitrage* condition. The results indicate that given a model one can show whether the model is arbitrage free or not. Financial math is mostly interested in the replication of derivative securities so that whatever happens to the stock, one will not necessarily lose money. The research conducted implies that in the discrete time binomial model one can replicate derivative securities that do not just depend on one stock but on multiple stocks as well.

135. Extensions and Deformations of Associative Algebras

Mitch Phillipson University of Wisconsin- Eau Claire
Advisor(s): Michael Penkava, University of Wisconsin- Eau Claire

Associative algebras play a role in both mathematics and mathematical physics.We study low dimensional examples of these algebras, and use extensions to classify the non-isomorphic structures. Deformation theory is concerned with how one structure smoothly changes into another structure, and the object of studying the deformations is to understand how the space of all such structures is glued together. In physics, deformations arise because the algebra of quantum mechanics is a deformation of the algebra of the phase space of classical physics. In mathematics, one is interested in the structure of the space of algebras, which is called a moduli space. We present some examples of low-dimensional moduli spaces of algebras, and show how the deformations give apicture of these moduli spaces. The moduli space is constructed using algebraic extensions.

136. Pricing Call Options Under the Binomial Model

Konrad Dirk Aguilar Cornell University's Summer Mathematics Institute 2008
Advisor(s): Mark Kozek, Whittier College

A call option gives you the option to buy the stock for a fixed price at a given future date. We want to find a mathematical model so that we can calculate the value of the call option at any time step from now to the maturity. A Cumulative Distribution Function or CDF gives us more information about the call option, so we find a sequence of CDF's based on the time steps and use characteristic equations and Levy's Continuity Theorem to find that these CDF's converge to a CDF after some rescaling. Finally, we use this to derive an equation for the price of the call option today as the number of time steps converges to infinity.

137. Modeling Gene Drive Systems

James Sylvester Wratten Jr. Rochester Institute of Technology
Advisor(s): Darren Narayan, Rochester Institute of Technology

A great deal of attention has recently been given to the possibility of genetically modifying mosquitoes to prevent the transmission of malaria.In order to spread such a modified trait through the wild-type population,better than Mendelian inheritance is necessary. To bring this about, various gene drive systems are being explored. Here, we develop and analyze continuous time and space models for two such systems: homing endonuclease and engineered under dominance. We also consider the use of the sterile insect technique as a preliminary tool.

138. Lie Groups, Lie Algebras, and Symmetric Spaces.

Robyn Kaye Brooks Trinity University
Karol Koziol New York University
Advisor(s): Derek Habermas, SUNY Potsdam

Symmetric space can be embedded isometrically into a Lie group by what is called the Cartan embedding. By intersecting the image of a symmetric space under this embedding with the Birkhoff decomposition of the Lie group, a symmetric space can be decomposed into levels that correspond to elements of the Weyl group associated with the embedding. We examine this decomposition for various compact symmetric spaces, and provide criteria for the existence of non-empty levels of the decomposition of the symmetric space.

139. Ultraproducts of Finite Alternating Groups

Sherwood J. Hachtman Rutgers University
Advisor(s): Prof. Simon Thomas, Paul Ellis, and Scott Schneider, Rutgers University

Given a nonprincipal ultrafilter U on the set of natural numbers, let $G_U = \prod_U A_n$ denote the ultraproduct by U of the collection of finite alternating groups A_n. Although G_U is not a simple group, Elek and Szabó have shown that G_U has a unique maximal proper normal subgroup. Extending their analysis, we prove that the set $\mathcal{N}_\mathcal{U}$ of normal subgroups of G_U is linearly ordered by inclusion. With this result, we are able to compute the number of groups G_U up to isomorphism. We find that this number may be either $2^{\aleph_0}$ or $2^{2^{\aleph_0}}$, depending on whether the continuum hypothesis or its negation is assumed. As such, the answer to this question is seen to be independent of the axioms of ZFC.

140. Calculating class numbers of ray class extensions over imaginary quadratic fields

Ila Varma California Institute of Technology
Advisor(s): Matthias Flach, California Institute of Technology

It is well-known that elliptic units over imaginary quadratic fields are the analogue of the cyclotomic units, which can be used to calculate the class number h^+ of the maximal totally real subfield of prime cyclotomic fields. One resembling characteristic is that the index of the group of elliptic units inside the unit group of the ray class extension they are associated to is very closely related to the class number. Oukhaba and Stark independently extended the group of elliptic units in certain cases using analytic constructions involving Klein forms and theta functions to produce an

index formula that directly gives the class number of these ray class extensions without any parasitic factors. Here, we generalize an algorithm of Schoof which uses cyclotomic units to calculate class numbers of real cyclotomic fields over $\mathbb{Q}$ to the case of ray class fields L of prime conductor over imaginary quadratic fields K of class number 1. In our case, we can explicitly write the generators of the group of elliptic units when considering it as a $\mathbb{Z}[Gal(L/K)]$-module. We furthermore extend the method to include imaginary quadratic fields K of nontrivial class number for which the index formula becomes coarser by including easily calculable parasitic factors.

141. Classifying the simplices of the 4-dimensional cube

Natalie Durgin Harvey Mudd College
Helen Highberger Harvey Mudd College
Jacob Scott Harvey Mudd College
Advisor(s): Francis Edward Su, Harvey Mudd College

A simplex of the 4-dimensional cube is the convex hull of any 5 distinct vertices of the cube. We find there are exactly 27 isomorphism classes of these simplices under symmetries of the cube, 10 of which are degenerate. Our methodology is based on geometric considerations that produce insights beyond computational enumeration. In particular, we provide a complete description of these simplex facets and how they can fit together in any triangulation. Using this, we are able to provide a graph representation of several triangulations of the 4-cube, leading to a new understanding about Mara's minimal triangulation.

146. On Cayley Graphs of the Form $C_n[1, a]$

Paul Savala CSU Fresno
Advisor(s): Carmen Caprau, Professor

We define a graph $\Delta := C_n[1, a]$ as follows: a graph on n vertices, numbered from 0 to n-1. Each vertex v is incident to an edge directed to $v+1, v-1, v+a, and v-a$ (all mod$n$). If $a^2 \equiv +-1 \pmod{n}$, then Δ is called semi-transitive. As semi-transitive graph is a digraph such that some subgroup of the automorphism group acts transitively on vertices and edges, but not on directed edges. Our research shows the generating groups of certain Δ given certain restrictions on a. Furthermore, when $a^2 \equiv 1 \pmod{n}$, we have a general form for the underlying group of the Cayley graph. We conjecture that when $a^2 \equiv -1 \pmod{n}$, Δ has no Cayley representation.

147. A Sinkhorn-Knopp Fixed Point Problem: A Matrix and its Doubly Stochastic Equivalent

William B. Cousins Pepperdine University
Advisor(s): David Strong, Pepperdine University

Doubly stochastic matrices frequently arise in a number of areas of mathematics and the sciences. Additionally, in some situations it is useful to apply a transformation to a given nonnegative matrix, N, to produce an equivalent doubly stochastic matrix. An algorithm has been developed by Richard Sinkhorn and Paul Knopp which finds this equivalent matrix by alternatively scaling the rows and columns of N. This talk will discuss the convergence of this algorithm, as well as introduce a restatement of the algorithm in fixed-point form. The convergence of the fixed-point algorithm will be discussed, as well as the convergence of other numerical methods when applied to the same problem.

149. Model comparison for mosquitofish population dynamics

Luke Y. Stannard University of Alabama at Birmingham
Clayton T. Kelleher University of Alabama at Birmingham
Advisor(s): John Mayer, University of Alabama at Birmingham

The research goal is to study mathematically 2- and 3-stage models of mosquitofish (*Gambusia affinis*) populations. Mosquitofish display cannibalism toward their offspring. The 3-stage model is:

$$\begin{aligned} A_t &= sA_{t-1} + mJ_{t-1} \\ J_t &= ge^{-kA_{t-1}}F_{t-1} \\ F_t &= fA_{t-1} \end{aligned}$$

The parameters are: $0 \leq s \leq 1$, adults survival probability; k,strength of the cannibalism factor of adults on fry, F_{t-1};$0 \leq m \leq 1$, juvenile maturation probability; $0 \leq g \leq 1$, fry maturation probability; and f, fecundity (the

number of births per adult per time step). A single time step is the maturation time for juveniles and fry.The 3-stage model is more complex and realistic than the 2-stage model. The cannibalism factor $e^{-kA_{t-1}}$ affects the fry stage,the youngest and smallest of juveniles. Operating diagrams(fecundity versus adult survival with other parameters held constant) provided numerical evidence of period doubling and invariant loop bifurcations in the 2- and 3-stage models,respectively. Both models lead to chaotic behavior as parameters are varied. Our goal is to compare discrete 2- and 3-stage models to parallel differential equation models and provide analytical evidence for the bifurcation. We hope to gather data from laboratory mosquitofish populations that we can use to parameterize and further develop our models.

150. Exploring Gassmann Triples

Michael Robert DiPasquale Wheaton College
Advisor(s): Robert Perlis, Louisiana State University

A triple (G, H, K), where G is a group and H and K are two subgroups of G, is called a Gassmann triple if the coset spaces G/H and G/K have the same permutation character. If (G, H, K) is a Gassmann triple, H and K are called Gassmann equivalent. Such triples have formed the crux of several fascinating results over the past several decades, including a condition for the equality of zeta functions over number fields by Perlis and Sunada's construction of Riemannian manifolds that are isospectral but not isometric. This poster presents the results of research conducted over the summer of 2008 at the Louisiana State University REU under the direction of Robert Perlis. Given a nontrivial Gassmann triple, I show how one may modify a construction due to Beaulieu in order to obtain another nontrivial Gassmann triple in the symmetric group. I also present a method for reversing Beaulieu's original construction. Furthermore, using a theorem of de Smit and Lenstra, I demonstrate that the order of a group containing nontrivial Gassmann equivalent subgroups must be divisible by at least five primes, not necessarily distinct.

151. Rigidity of Frameworks in the Plane

Greg Clark Calvin College
Ben Dekker Calvin College
Advisor(s): James Turner, Gerard Venema, Calvin College

Rigidity theory is a relatively new and unexplored field. We examine the fundamental concepts and theorems of rigidity, including Laman's theorem and Henneberg's theorem. We also explain our own approach to rigidity–flexibility numbers. We also present a computer model for rigidity and open questions for possible further research.

152. r-Reduced and Vertex Attrition of Multipartite Graphs

Joshua M. Crunkleton North Georgia College & State University
Dusti Amber Nisbet North Georgia College & State University
Advisor(s): Brad Bailey, North Georgia College & State University

The r-reduced cutting number for a cycle, C in simple connected graph G, is the number of components in $G \setminus E(C)$ containing at least r vertices. We determined the r-reduced cutting numbers for some families of multipartite graphs and defined vertex attrition and component attrition at level r. We determined the boundary results of vertex attrition at level r. Also, we determined the vertex attrition of simple connected graphs containing cycles with common edges.

153. Metrical Results for Rosen $\sqrt{2}$-Fractions

Michael Ontiveros New York University
Advisor(s): Benjamin Levitt, California State University Chico

Following the work of Burton, Kraaikamp, and Schmidt on metrical results in the theory of Rosen continued fractions, we derive an explicit measure invariant under the $\sqrt{2}$-fraction generating transformation, from which we obtain associated Khintchin-Levy type constants.

154. A Generalization of the Approximate Core-Almost-Everywhere Density Topology

Philip M. Gipson St. Olaf College
Advisor(s): Dr. Paul Humke, St. Olaf College

The Approximate Core-a.e. Topology, first characterized by E. Wagner-Bojakowska, has been extended from a definition based on null sets to a definition involving any sigma-algebra. Specific examples, such as the topology based on the countable sets, have been explored in depth with significant results.

155. Methods of guarding galleries

Francesca Schott Sonoma State University
James Shikashio Sonoma State University
Advisor(s): Jean B. Chan, Sonoma State University

Our poster explores the Art Gallery problems originated by Victor Klee.The focus of our work is on a polygonal art gallery with any number of polygonal holes. We seek to determine the minimum number of vertex guards needed to cover the gallery.The results obtained are based on methods of combining known results with original algorithms and methods of calculating the least number of required vertex guards.

156. Exploring nearly planar graphs

Pratik A. Talati University of Alabama at Birmingham
Advisor(s): Peter O'Neil, University of Alabama at Birmingham

In graph theory, a graph is nonplanar if it cannot be embedded in the plane without crossings of edges. A graph G is nearly planar if G is nonplanar but $G-v$ is planar for every vertex v of G. Using Kuratowski's characterization of nonplanar graphs, this research is aimed at generating the connected nearly planar graphs by giving explicit constructions for all of them.

157. Clustering Coefficient: Math Applicable to Science

Amanda D. Peck North Georgia College and State University
Lauren Prill North Georgia College and State University
Advisor(s): Dr. John Holliday, North Georgia College and State University

The clustering coefficient of a large scale network is a graph theoretical term used in different areas of biology, chemistry, and other sciences. The research done by the students included characterization of the clustering coefficient for different types of graphs, obtaining true facts regarding the clustering coefficient, a formula and proof of that formula for calculating the clustering coefficient, and finally, possible new applications for the clustering coefficient. The poster board will include, but not be limited to, the above research done by the students. The new formula and applications will be the main focus of the board, with other true, new facts included as well.

158. On partitioning $\mathbb{Z}_n$ into arithmetic progressions

Kathleen Cronin University of Missouri, Columbia
Amanda Paganin Nazareth College
Advisor(s): Saad El-Zanati, Illinois State University

Let $\mathbb{Z}_n$ denote the group of integers modulo n. We investigate the problem of finding all possible partitions of Z_n into combinations of arithmetic progressions. We will report on our results and on variations of the problem. This work was done as part of REU Site for pre-service and in-service secondary mathematics teachers at Illinois State University.

159. On nearly-graceful 2-regular graphs

Dontez Collins Delaware State University
Venishia Morgan Mississippi Valley State University
Advisor(s): Saad El-Zanati, Illinois State University

A graph G with n edges is *nearly-graceful* if there exists a one-to-one function $f : V(G) \to \{0, 1, \ldots, n+1\}$ such that $\{f(u) - f(v)| : \{u, v\} \in E(G)\} = \{1, 2, \ldots, n-1\} \cup \{n+1\}$. We find several classes of nearly-graceful 2-regular graphs. This work has applications in cyclic graph designs and in finding certain solutions to the Oberwolfach problem.

160. Proper Graph Coloring Using Integer Weights

Lauren Vickroy Illinois State University
Advisor(s): Saad El-Zanati and Papa Amar Sissokho, Illinois State University

Call a graph *non-trivial* if it is connected and has at least 3 vertices. Karonski, Luczak, and Thomasson recently raised the following Question: Is it possible to weight the edges of any non-trivial graph with the integers 1, 2, and 3 such that if we color each vertex v of G by the sum of the weights of the edges incident with v then we obtain a proper coloring of G? We present some new results on this problem.

161. Life is a Series of Leaps, Especially for us Grasshoppers

Jelsi Bolt Illinois State University
Michael Norris Illinois State University
Advisor(s): Olcay Akman, Illinois State University

Out of different populations of lubber grasshoppers (*Romalea microptera*) native to southern Florida, data of these grasshoppers was analyzed in terms of the sizes of both sexes. The goal was to establish whether there is a correlation between morphological (physical) characteristics and the sex of the grasshopper and the time and site of the observation. This work was done as part of a project to expose secondary education majors to research in biomathematics. The project was supported by NSF as part of he Teacher-Scholar program in mathematics at Illinois State University.

162. Probabilistic Cube Cuts

Eric Riedl University of Notre Dame
Veronica Thomas Francis-Marion University
Advisor(s): Neil Calkin, Kevin James, Clemson University

How many hyperplanes does it take to cut all of the edges of a hypercube? For dimensions 2 through 5, the answer is known to be the dimension d. For dimension 6, O'Neil exhibited 5 hyperplanes which cut the 6 cube, thereby disproving the obvious conjecture. For $d \geq 7$ the answer is unknown. The answer is somewhere between the lower bound of order $\sqrt{d}$ and the linear upper bound given by O'Neil's planes. We approach the hypercube slicing problem from a probabilistic perspective. We select a probability model and find several probabilities related to this problem, often using geometry to find simple expressions for complicated-looking integrals. Using these probabilities, we obtain several results, including the number of random hyperplanes required to cut all edges of the hypercube with high probability, a probability-preserving bijection between classes of homogeneous and nonhomogeneous planes in neighboring dimensions, and an inter-dimensional relationship between the probabilities. This research was completed at an REU at Clemson University, which was funded by an NSF grant.

163. Do Grasshopper Chicks Dig Scars?

Andres Santana Illinois State University
Advisor(s): Olcay Akman, Illinois State University

Data on several populations of eastern lubber grasshoppers (*Romalea microptera*) were collected by a team of biologists in southern Florida. The data set includes several morphological characteristics of the grasshoppers along with their locations and presence of parasites. Morphological characteristics were examined to predict the presence of parasites. In addition, whether a grasshopper's color can be predicted by its size, sex, and location found was studied. To determine whether these predictions can be made, several data analysis methods were implemented. Using the provided data, different types of models were constructed. We will report on the results of our study. This work was done

as part of a project to expose secondary education majors to research in biomathematics. The project was supported by NSF as part of he Teacher-Scholar program in mathematics at Illinois State University.

164. Models of Antibiotic Resistance and Hospital-Acquired Infections

Colleen Labutta University of Richmond
X'auntasia Johnson University of Richmond
Advisor(s): Dr. Lester Caudill, University of Richmond

Infections caused by antibiotic resistant bacteria are becoming more prevalent and increasingly more life-threatening in the hospital environment. A number of groups have proposed strategies and protocols for preventing the development of antibiotic resistance in bacteria, and controlling existing outbreaks. Mathematical models of antibiotic resistance and infection spread offer the possibility of testing these strategies, without many of the complications inherent in experimental live-patient tests. The objective of this research project is to develop models that will simulate the long-term effects of certain prevention techniques on the spread of antibiotic resistance in a hypothetical hospital environment. The project includes models built to predict the effect of four separate interventions: vaccination, patient isolation, antibiotic cycling, and the use of antibiotics in food. Model analysis suggests that each of these control strategies, with the exception of antibiotic cycling, promises a substantial impact on the prevention and control of antibiotic-resistant infections. Vaccinations and patient isolation can greatly reduce the long-term number of patients with antibiotic resistant infections. However, they are not always practical and possible to implement, depending on the situation. Furthermore, the use of antibiotics in food actually increases the number of patients with antibiotic resistant infections. These results open the door for further investigation of these and other infection control measures.

165. Elevator Trip Times: Comparison of Traditional Analysis and Computational Simulation

Thomas Britton Coe College
Advisor(s): Dr. Gavin Cross, Mr. Calvin VanNiewaal, Coe College

The results of two approaches to elevator traffic are presented and analyzed. The work was done as a project for an upper-level probability and statistics course. The goal was to analyze the distribution of trip times (defined from when someone presses the call button to disembarkation) of people in the Murray Hall dormitory on the Coe College campus. The first approach looked at elevator trip times based on a first-principle mathematical analysis of a simplified system involving only two floors while strictly assuming a Poisson distribution of people arriving to ride the elevator. Secondly, a larger scale computer simulation was built to model in more detail a real world situation based on parameters empirically derived from actual observations made on the elevators in Murray Hall.

166. Solitons for the Korteweg-de Vries Equation

Ernesto Garcia University of Texas at Arlington
Advisor(s): Dr. Tuncay Aktosun, University of Texas at Arlington

The Korteweg-de Vries equation has solitary wave solutions known as solitons. A compact and explicit formula is obtained to express such solitons using three constant matrices, and behavior of solitons are analyzed in terms of such constant matrices. Animations of solitons are presented by preparing a Mathematica computer program.

167. Soliton solutions to the nonlinear Schrodinger equation.

Samuel Henry Rivera University of Texas at Arlington
Advisor(s): Dr. Tuncay Aktosun, University of Texas at Arlington

Solitary wave (soliton) solutions are considered for the nonlinear Schrödinger equation $iu_t + u_{xx} + 2|u|^2u = 0$. Their physical importance is studied, and a Mathematica program is used to demonstrate such multiple soliton solutions as well as those with multiplicity.

168. Average distance of points in fractals

Dennis A. Ruppe SUNY Geneseo
Advisor(s): Chris Leary, SUNY Geneseo

Fractal geometry provides many quantitative descriptions of objects that have been useful in a range of scientific disciplines, from biology to physics. One such measure is lacunarity, which measures how a shape fills space and how

clustered it is. We discuss some examples in which lacunarity fails to distinguish between sets that appear to cluster differently. We define a measure of the average distance between points in a set. We calculate the average distance for many variations of the Cantor set. We find that our measure can provide new insight into the structure of a fractal.

169. Beyond Perception: Eyelid Dynamics

Kyle R. Kelley Colorado State University
Andreea L. Erciulescu Colorado State University
Advisor(s): Michael Kirby, Research Mentor, Professor

Detecting eye blinking among humans is very important in face recognition. Although this is beyond our perception, high-speed and high-resolution CMOS cameras can be used to study the dynamics of eyelids and their characteristics. In the process of closure and opening during eye blinking, a series of moving points has characteristic features. We consider the problem of measurement from high-speed videos and we pursue with algorithms to improve recognition accuracy.

170. Fence Painting: The Number Theoretic Approach

John W. Hoffman Youngstown State University
W. Ryan Livingston Youngstown State University
Jared M. Ruiz Youngstown State University
Advisor(s): Dr. Jacek Fabrykowski, Youngstown State University

A system of congruences $S = \{x \equiv a_i \bmod m_i) : 1 \leq i \leq k\}$ is a set of k arithmetic progressions given by $\{x = nm_i + a_i : 1 \leq i \leq k and n \in \mathbb{Z}\}$. During an REU conducted at Youngstown State University this summer, the authors considered covering systems and some classical results about these arithmetic progressions. The poster introduces the audience to this relatively unknown topic and presents two new results about covering systems, proven by the authors during this summer research by means of fence painting. These results provide an upper bound on the number of consecutive integers which need to be checked to determine if a system is a special type of covering system, called disjoint. The bound mentioned is determined simply by the number of congruences in the system. These results provide an analog of a theorem by R. B. Crittenden and C. L. Vanden Eynden from 1969.

171. Weakly Sum-Free Sets in Finite Abelian Groups

David Yager-Elorriaga Gettysburg College
Daniel Ziegler Gettysburg College
Advisor(s): Bela Bajnok, Gettysburg College

This paper investigates two questions in additive number theory. Let k and l be distinct positive integers. A subset A of G is weakly (k, l)-sum-free if the sum of k distinct elements in A never equals the sum of l distinct elements in A. A subset A in G is weakly zero-h-sum-free if h distinct elements in A do not sum to zero. Let $M_{k,l}(\mathbb{Z}_n)$ denote the maximum size of a weakly (k, l)-sum-free set, and let $Z(\mathbb{Z}_n, h)$ denote the maximum size of a weakly zero-h-sum-free set. We looked at the specific cases where $(k, l) = (2, 1)$ and $(3, 1)$, and where $h = 3$ and 4. We present preliminary results for $M_{k,l}(\mathbb{Z}_n)$ and $Z(\mathbb{Z}_n, h)$ for certain values of k,l, and h.

172. Genetic Algorithms: Exploring Reduction Methods

Kerry Conrad Illinois State University
Kyle Knee Illinois State University
Melissa Reed Illinois State University
Advisor(s): Olcay Akman, Illinois State University

During the last decade or so Genetic Algorithms (GA) have been routinely used in high-dimensional optimization problems. As they get implemented in various problems, GA natural selection and evolution tools, such as methods of mating, rates of mutation keep getting modified by users. Most, if not all of these modifications aim to increase GA efficiency at the expense of available computer resources. We propose a modification that reduces the needed computations without losing efficiency.

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

Bui Thanh Tung University of Houston - Downtown
Marsida Lisi University of Houston - Downtown
Advisor(s): Dr. Akif Uzman and Dr. 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.

174. Mathematical Modeling for Structured Textures

Derek DeSantis California State University Channel Islands
Margaret Freaney California State University Channel Islands
Kathleen A. Lewis California State University Channel Islands
Advisor(s): Dr. Kathryn Leonard, California State University Channel Islands

In the 1950s, scientists predicted the development within ten years of robots capable of performing most human tasks. The primary obstacle to building such robots is the problem of interpreting visual data, or image processing. At the most basic level, images consist of shapes and textures. These textures range from completely regular (wallpaper patterns) to completely random (white noise). This project consists of two parts. First, to mathematically formulate, and explore the consequences of, algorithms developed by computer scientists to model textures that are closer to regular than to random. Our experimental approach utilizes the autocorrelation coupled with circular statistical methods. Second, to explore the relationships of coefficients in various bases (wavelet, Legendre, monomial) of periodic functions before and after deformation.

175. Circular Statistics: Applications in Cricket and Ozone Levels

Michael Marcelino Nava California State University of Channel Islands
Advisor(s): Sreenivasa Rao Jammalamadaka, University of California, Santa Barbara

Within statistics, there is a novel area of study called directional statistics where one measures directions on the plane (circular) or space (spherical). Applications of circular statistics are modeling the wind directions or the directions in which the batsman tend to play in Cricket.Circular mean direction and concentration parameters are the key components to circular data analysis. Using cricket teams I will model batsmen's preferences and playing tendencies using circular methodology. Based upon this data, I will test whether batsmen have a preference in the direction in which they hit, or they play all around the field, which amounts to a test of uniformity. Players who did not have a uniform distribution were modeled by a *best fit* method using the R statistical computing package. Several types of distributions for circular data are considered while determining which would provide the best fit. With this estimation, we will attempt to assess the directional hitting tendencies for certain batsmen. The measure of air pollution caused by neighboring large cities can also be measured using circular statistics. Data from a Texas database consisting of the variables; wind direction, wind speed, temperature, and ozone levels are used for analysis. We can relate the circular data (wind direction) with the three other linear variables to see the effect neighboring cities have on each other. Correlations between all these variables are explored.

176. Taking the Convoluted Out of Bernoulli Convolutions: A Combinatorial Approach

Michelle J. Delcourt Georgia Institute of Technology
Julia L. Davis Grove City College
Advisor(s): Neil Calkin, Clemson University

We consider a discrete version of the Bernoulli convolution problem traditionally studied via functional analysis. We discuss several innovative algorithms for computing the sequences in this new approach. In particular, these algorithms assist us in gathering data regarding the maximum values. Moreover, by looking at a family of associated polynomials, we gain insight into the sequence itself. This work was completed as part of the Clemson University REU, an NSF funded program.

177. Combinatorial Aspects of P-superarcs

Chad M. Griffith Sonoma State University
Advisor(s): Jean B. Chan, Sonoma State University

In this poster we will explore combinatorial aspects of p-superarcs in the plane. A p-superarc joining x and y in the plane is an arc $A(x, y)$ with endpoints x and y such that $A(x, y)$, except for x and y, is outside of the triangle with vertices p, x, and y, but inside the convex sector bounded by rays py and px. Our preliminary result is: Given a fixed point p in the plane, and a compact and simply connected set S in the plane not containing p, if every three points in S can see some point in S by p-superarcs, then there exists a point k in S such that every point x in S can see k by some p-superarc in S.

179. A New Approximate Core Topology

Thomas McConville University of Lodz
Nathan Clement University of Lodz
Advisor(s): Wladyslaw Wilczynski, University of Lodz

We introduce a new topology based on the approximate core topology on the real plane but contained in a different sigma-algebra. Open sets in our topology are those sets in the sigma-algebra contained in their approximate core density points. We show this forms a topology and compare the topology to other density topologies on the plane. In addition, we consider the class of continuous functions mapping from the real plane with our topology into the real line with the natural topology. This class is compared with other classes of continuous functions mapping the real plane into the real line. Our results are analogous to those obtained using previously considered approximate core topologies.

180. Fungal Communities Along Buffalo Bayou: Influence Of Salinity and Other Environmental Gradients

Pantea Mohammadi University of Houston- Downtown
Nida Fatima Rizvi University of Houston- Downtown
Advisor(s): Dr. Phil Lyons, University of Houston- Downtown

We are considering the correlation between environmental gradients such as salinity, pH, elemental composition, and the diversity of soil fungal communities along Buffalo Bayou. Upon determining which correlations exist mathematical models will be formulated representing the relationship between specific environmental factors and different fungal taxa. We used biological analyses such as direct isolation of soil fungi and indirect determination of fungal taxa based on DNA sequence variations to determine the diversity of fungi within the Buffalo Bayou ecosystem. As a sufficient data is accumulated, efforts will be directed toward mathematical analyses including statistical model and multivariate analysis.

181. Geometric Structures of Solutions

Samantha L Baietti University of Scranton
Advisor(s): Stacey Muir, University of Scranton

Geometric properties of the solutions to the first order linear differential equation of one complex variable, $zf_\lambda'(z) + \lambda\Psi(z)f_\lambda(z) = \lambda\phi(z)$, $\lambda > 0$, $z \in \Delta$, will be studied. The differential equation will have the preconditions $\Psi(z)$ has positive real part and the ratio $\frac{\phi(z)}{\Psi(z)}$ and the function $\phi(z)$ have geometric structures.

182. Computing Box-Counting Dimension in High-Dimensional Phase Space

Kassie R. Archer College of William and Mary
Advisor(s): Sarah Day, College of William and Mary

Computing the box-counting dimension of an attractor associated with a dynamical system provides a measure of the fractal structure of the attractor. When working with attractors defined as subsets of in infinite dimensional spaces, it is possible to project the attractor into a high (but finite) dimensional phase space, $\mathbb{R}^m$. Because of the *curse of dimension*, where computation becomes exponentially more expensive as m increases, the conventional subdivision method is too inefficient for large m. In order to find a way to compute box-counting dimension of an attractor lying

in infinite-dimensional space, it is necessary to first find some practical method of computing box-counting dimension of an attractor lying in high dimensional phase space. I will present progress made towards this goal.

183. The Periodic Properties of Light Beams in Infinite Labyrinths

Benjamin Coate The College of Idaho
Advisor(s): Yevgeniy Kovchegov, Oregon State University

We use a combinatorial approach to analyze the path of a light beam in the two-dimensional lattice, $\mathbb{L}^2$, traveling through a randomly generated infinite labyrinth of two-sided mirrors. We will look at this specific case of the Lorentz Lattice Gas Model (LLGM) and utilize an analogue of Russo's Formula to further explore some of the intriguing details of the recurrence phenomenon that arise in this model. We will simplify the question of recurrence by breaking it down into a two case scenario that is significantly more tangible, and provide a theorem that brings the recurrence hypothesis well within grasp.

185. An Improved Bound on When Delta Sets of Numerical Monoids Become Periodic

Anton S. Malyshev Princeton University
Advisor(s): Scott Chapman, Sam Houston State University

In general, there is more than one way to factor the elements of a numerical monoid (a submonoid of the natural numbers) M into irreducibles. Each element $a \in M$ has a set of possible lengths of factorizations $\mathcal{L}(a) = \{l_0, \ldots, l_n\}$, with $l_0 < l_1 < \ldots < l_n$. We call $\Delta(a) = \{l_1 - l_0, \ldots, l_n - l_{n-1}\}$ the delta set of a, and we call the union of these delta sets the delta set of the monoid itself. It is known that for sufficiently large a (larger than a bound cubic in the generators of M), $\Delta(a)$ is periodic in a. We provide a bound which is quadratic in the generators of M. This allows faster computation of the delta set of a numerical monoid.

186. Building a Diatom Succession Model for a Fresh Water Marsh

Yvonne Hernandez University of Houston-Downtown
Advisor(s): Ronald Barnes, Bradley Hoge, Steven London, The University of Houston-Downtown

The richness and diversity of diatom assemblage can be used to determine the properties of water in natural and mitigated banks. The goal of this project is to develop a Diatom Succession Model which can then be used to analyze the path of succession of mitigated wetlands as their diatom assemblage converges toward that of a natural wetland. Data mining techniques will be utilized to discover if patterns occur within and among the various assemblages. This study is part of a five year NSF Grant to the University of Houston-Downtown's Computer and Mathematical Sciences, and Natural Sciences to show Biology and Math students how to work collaboratively with faculty on research projects.

187. Characterization of Ford Links

Axel Brandt Ohio Northern University
Advisor(s): Dr. Donald A. Hunt, Ohio Northern University

Utilizing standard techniques of knot theory, we will focus on a particular class of planar graphs known as Ford trees to create knots known as Ford Links. In this poster, we will investigate Ford Links using the Kauffman Bracket Function, together with Reidemeister moves and other techniques developed for Ford Links in an attempt to characterize all Ford Links.

188. Art Galleries and Fractals

Dylan J. Field Sonoma State University
Cori Brucato Sonoma State University
Advisor(s): Dr. Jean Bee Chan, Sonoma State University

The art gallery problem is to find the number of guards needed to observe any polygonal art gallery. Each guard is located at a point and assumed to have the ability to see in all directions. The art gallery theorem asserts that given a polygon with n vertices, floor$(n/3)$ guards is always sufficient and sometimes necessary. We attempt to find the minimum number of guards for various art galleries arising from fractals. An example of such art galleries would be iterations of the Sierpiński Carpet. The Sierpiński carpet is formed by removing a square in the middle of a given

square. Each subsequent iteration removes eight squares surrounding every removed square. The results of our findings will be summarized in our poster.

189. Integral Formulas and Linking Numbers

Stefan Sabo University of Pennsylvania
Advisor(s): Dr. Dennis DeTurck,

Carl Friedrich Gauss defined an integral formula for the linking number of two curves in $\mathbb{R}^3$. Intuitively, the linking number measures the number of times the curves loop around one another, or to what extent they are "linked." With this informal definition in mind, one would expect that the linking number is an integer topological invariant, and this assertion is true. Linking integrals are important in electrodynamics, plasma physics, and molecular biology. In the 1960's, Calugareanu and White showed that if the two curves bound a ribbon in $\mathbb{R}^3$, the linking number can be expressed as the sum of two separate contributions called the "writhe" and "twist." Writhe is defined as the linking integral of one edge of the ribbon with itself. Twist, on the other hand, measures the extent to which the unit vector pointing across the ribbon twists around the edge. Although the writhe and twist of a ribbon are geometric invariants, they are not topological nor are they integer-valued in general. The object of our current research concerns extending the notions of link, writhe, and twist to higher dimensional Euclidean spaces. For example, the linking integral formula can be generalized to compute the linking number of two smooth, closed, compact surfaces in $\mathbb{R}^5$. We prove the Calugareanu-White Theorem in this case and generalize to m-dimensional submanifolds in $(2m + 1)$-dimensional Euclidean space. It is perhaps surprising that when m is even, the writhing number is always zero, so that the twist integral is also an integral topological invariant. We show that the twist equals half of the Euler class of the m-dimensional subbundle of the normal bundle of the submanifold. We further generalize these results to the case where the ambient space is the $(2m + 1)$-dimensional sphere or hyperbolic space.

190. The Average Connectivity of Graphs of Automorphisms of $\mathbb{Z}_p^*$

Daniel E. Franz Kenyon College
Advisor(s): Patrick Bahls, UNC Asheville

We investigate the average connectivity of a family of graphs based on the automorphisms of $\mathbb{Z}_p^*$, extending a result by Bahls for the inverse automorphism. The vertices of these graphs are the members of $\mathbb{Z}_p$, where x is connected to $x \pm 1$ and its automorphic image $\phi(x)$. We characterize the automorphisms of $\mathbb{Z}_p^*$ and then use a result from probabilistic number theory to understand the structure of these graphs. For the main result, we show that for a given automorphism the average connectivity approaches 4 as p approaches infinity through an appropriate sequence of primes.

191. Graphical Proof of Hyperbolic Circles from the Euclidean Plane.

Alma Gonzalez Sonoma State University
Advisor(s): Jean Chan, Sonoma State University

It is a remarkable fact that hyperbolic circles are also Euclidean circles. However, the hyperbolic center of a hyperbolic circle in the Poincare Disk is not located at the center of the identical circle considered as an Euclidean circle, the proof will be presented pictorially.

192. A metapopulation model for California grasslands infected by the barley yellow dwarf virus

Samuel Potter University of Minnesota, Morris
Advisor(s): Peh Ng; Vrushali Bokil, University of Minnesota, Morris; Oregon State University

Despite being competitively superior, native perennial grasslands in California are being replaced by invasive annual grasses. In a 2007 paper, Borer et al. used numerical results from an integrodifference model to show that the presence of the barley yellow dwarf virus was responsible for this altering of the competitive balance. One important aspect of mathematical models in epidemiology is the spatial partitioning of hosts and vectors (in this case grasses and aphids, respectively) into different patches between which both viruses and virus vectors travel. My research, building on that done by Borer et al., includes a spatially implicit metapopulation model that incorporates dry and growing seasonality into a system of dynamical equations. I will present analytical results and numerical simulations using field-tested parameters obtained from prior experiments.

193. Solving the Maximum-Weight Connected-Subraph Problem on a subclass of graphs

Charles P. Rudeen University of Minnesota Morris
Advisor(s): Dr. Peh Ng, Professor of Mathematics, University of Minnesota Morris

Given a connected graph $G = (V, E)$ and any rational valued weight function on the edges, E, we would like to find a connected subgraph with the maximum total edge weight. This is called the Maximum-Weight Connected-Subgraph Problem (MWCSP). It has been shown that the MWCSP is NP-Hard, meaning there exists no known efficient algorithm to solve it and there probably never will be. It would be beneficial to find subclasses of graphs where we can provably solve the MWSCP to optimality. We will describe a subclass of graphs and present an algorithm to solve an instance of the MWCSP on this subclass to optimality. In particular, we will first reduce the MWCSP on the given subclass of graphs to an instance of Prize Collection Steiner Tree Problem, followed by an algorithm to solve the PCSTP on that graph.

194. Multivariate Data Analysis: Relationship between Environmental Factors and Vector Frequencies Affecting the Spread of Pierce's Disease across Texas

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Audrey Gonzalez University of Houston - Downtown
Advisor(s): Jeong-Mi Yoon, Phd / Lisa Morano, PhD, University of Houston - Downtown

Pierce's disease (PD) is caused by Xylella fastidiosa (Xf), a plant pathogen that infects grapevines. Sharpshooter insects transfer the bacterium, which multiplies in the xylem (water-conducting vessels), causing plant death. The objective of this study is to analyze the relationship between environmental factors and sharpshooter frequencies. The multivariate data set includes a sample of ($n > 30$) insect frequencies and environmental variables (i.e. elevation, precipitation, cold hardiness, etc.) at different vineyard sites. The insect counts were yielded from vineyards which had traps set out over a period of one year. For the statistical analysis of the project, we chose a canonical analysis method, Canonical Correspondence Analysis (CCA), which is developed by the Eigen-analysis technique. This method will be utilized to represent the significance of the vector-environmental variable relationships. The statistical analysis will be completed with the aid of the XLSTAT software package.

195. Exploring Nonlinear Oscillator Models for Auditory Transduction

Andrew J. Binder University of Arizona
Advisor(s): Dr. Christopher Bergevin, University of Arizona

The inner ear exhibits remarkable sensitivity and sharp tuning, as manifest via the transduction process that converts sound-induced vibrations into electrical signals. Physiological data in both vertebrates and non-vertebrates suggest that a given transduction element can be modeled as a nonlinear second-order oscillator. One possibility is that the nonlinearity arises in the stiffness of the transducer. When two sinusoidal tones are simultaneously input into the model, new frequencies in the output (distortion products) are observed and are natural phenomena of a nonlinear system. This poster will describe the spectral analysis of the time waveform produced by the model. Distortion generated by the model can then be compared with distortion found in the inner ear, thereby providing insight into the underlying physiology of the auditory transduction process. Specifically, we aim to address the question: What can we learn about the nonlinearity of the inner ear based upon a single oscillator model exhibiting a nonlinear stiffness?

196. Perceptually Adaptive Bilateral Filtering: An Image Denoising Technique for Optimizing Perceptual Fidelity

Amanda Sgroi Duquesne University
Advisor(s): Stacey Levine, Duquesne University

Perceptually Adaptive Bilateral Denoising is a method for removing noise from image data. Bilateral filtering is an edge-preserving, non-local regularization method. The proposed work improves upon this technique with a new methodology for automatically determining input parameters based on human perception. Noise removal algorithms in image processing typically seek to minimize numerical error rather than perceptual qualities. This isn't ideal for handling images with both highly textured and smooth regions. Our goal is to locally vary the bilateral filter parameters as a function of the expected level of human visual perception. The parameters are learned from noisy data for which the ground truth is known. Daly's visual difference predictor is used to estimate the error perceived by the human

visual system. Simultaneously, power maps measuring the high frequency components of the signal are also generated. The error from Daly's VDP is used in conjunction with these power maps to locally determine the most efficient parameters in a given region. The denoising result is more aggressive in smooth regions and does not over smooth textured regions. Experiment results demonstrate the proposed method yields cleaner results based on standard visual difference prediction.

197. Mathematical Modeling of Cartilage Regeneration via Hydrogel

Daniel R. Marous, Rachel F. Arnold, April J. McLamb, Karmethia C. Thompson, William R. Woodruff Wittenberg University
Advisor(s): Dr. Mansoor Haider, North Carolina State University, Janine M. Haugh, Graduate Assistant

Because of the increasing number of individuals with cartilage problems, whether due to sports injuries or diseases such as arthritis, there is a medical need for effective cartilage regeneration. To facilitate the development of a procedure for regeneration, a mathematical model is desirable. In this project, we present and discuss a mathematical model for cartilage regeneration via hydrogel, a biocompatible scaffolding material. When an unhealthy aging process or extensive injury renders cartilage naturally irreparable, one possibility for repair, which researchers are investigating, involves injecting the damaged site with hydrogel. This hydrogel is nutrient-rich and seeded with cells (chondrocytes) ready to produce Extracellular Matrix (ECM), which is the structural material of cartilage. Our model is an ordinary differential equation (ODE) system that illustrates the accumulation of ECM using hydrogel as a repair mechanism.

198. Iterating the Euler-Dedekind Average and Difference functions

Tomasz Janusz Przytycki Bard College
Jenny Shi University of California, Berkeley
Advisor(s): Ryan Daileda, Trinity University

Consider n with prime factorization $\prod p_i^{a_i}$, then we consider the Euler's totient function $\varphi(n) = n \cdot \prod \left(1 - \frac{1}{p_i}\right)$, and Dedekind's ψ function where, $\psi(n) = n \cdot \prod \left(1 + \frac{1}{p}\right)$. We define the Euler-Dedekind average function $A(n)$ as

$$A(n) = \frac{\varphi(n) + \psi(n)}{2},$$

the Euler-Dedekind weighted difference function $D(n)$ as

$$D(n) = \frac{\psi(n) - \varphi(n)}{2},$$

as well as the Euler-Dedekind difference function. We define $A_1(n) = A(n)$, and $A_{k+1}(n) = A(A_k(n))$, and we define D_k analogously. We show that for all n there exists exists a positive integer N such that $D_j(n) = 0$ or $D_j(n) = 2^a 3^b 7^c$ for $j \geq N$, where $a, b, c \in \mathbb{Z}^+$. We obtain similar results for the Euler-Dedekind difference function, and we conjecture that for any integer n, $\{A_j(n)\}_j$ diverges as j goes to infinity, if and only if eventually the largest odd factor of the function value forms the periodic Daileda sequence: $41, 83, 167, 5 \cdot 67, 3 \cdot 31, 3 \cdot 37, 3 \cdot 11$.

200. Modeling Hormonal Regulation of the Menstrual Cycle

Jake B. Feldman Harvey Mudd College
Advisor(s): James Selgrade, North Carolina state University

The aim of this project was to improve and to make additions to a mathematical model for regulation of the menstrual cycle of a normally cycling woman, which accurately predicts levels of the essential reproductive hormones. Exposure to environmental estrogens, such as dioxin, polychlorinated biphenyls (PCBs), and oral contraceptives, in women today may have adverse effects on hormone levels and the metabolism of the body. Elevated levels of estrogen are a possible contributing factor to breast cancer in women. Two primary sources of reproductive hormone synthesis within the body: the pituitary gland located in the brain, and the ovaries. Follicle stimulating hormone (FSH) and luteinizing hormone (LH) are synthesized by the pituitary gland, while the ovary is the primary producer of estradiol (E2), progesterone (P4), and inhibin (Ih). We redeveloped an existing system of differential equations that models the rates of change of these five hormones. Optimization techniques, as well as informed adjustments of the parameters, allowed us to increase the accuracy of the hormone models. Our models were compared to published data and were

found to portray the profile of each hormone accurately. As a result of this project, these models can be used to predict the effects of changes in hormone levels on the reproductive endocrine system.

201. A Combinatorial Proof of the Characteristic Polynomial Roots Solution for a k^{th} Order Linear Homogeneous Recurrence Relation

Halcyon C. Derks Kalamazoo College
Advisor(s): Michele Intermont, Kalamazoo College

It has long been accepted that a solution to any k^{th} order linear homogeneous recurrence relationship

$$a_n = c_1 a_{n-1} + c_2 a_{n-2} + \cdots + c_k a_{n-k}, \tag{1}$$

with specified initial conditions $a_0 = A_0, a_1 = A_1, \ldots, a_k = A_k$, and distinguishable roots of the characteristic polynomial, $r_1, r_2, \ldots, r_k$, is the linear combination

$$a_n = l_1 r_1^n + l_2 r_2^n + \cdots + l_k r_k^n, \tag{2}$$

where $l_1, l_2, \ldots, l_k$ are constants determined by the initial conditions. Using the method of Description, Involution, and Exclusion published by Arthur Benjamin and Jennifer Quinn in the May 2008 Edition of the *College Mathematics Journal*, this equivalence can be proved, which it previously has not been. Benjamin proposed this problem in May 2008 to the writer and the proof was completed in late September using this method. The D.I.E. method provides a very visual way to discuss recurrence relationships, as well as allowing for a very clean proof of the solution.

202. A Study of the Solutions to the Family of Differential Equations: $f'(x) = \frac{1}{(f \circ f \circ \cdots \circ f)(x)}$

Veronica Sue Wills Southeastern Louisiana University
Advisor(s): Dr. Randall Wills, Southeastern Louisiana University

We will study the differential equation $f'(x) = \frac{1}{(f \circ f \circ \cdots \circ f)(x)}$ where there are n copies of f in the denominator. We begin by finding explicit solutions to our differential equation for $n = 1$ and $n = 2$. We then show that solutions exist for all $n \in \mathbb{N}$, and they depend solely on the positive roots of the polynomial $g_n(x) = x^n + x_1$. Finally we show that the sequence of solutions converges, and end by studying solutions of other differential equations involving composition.

203. Analysis of the Dynamics of the Landen Transformations Through $cot(4\theta)$

Bobby Wilson Morehouse College Atlanta, GA
Richard B. Garcia University of Puerto Rico Rio Piedras, PR
Advisor(s): Victor Moll, Tulane University New Orleans, LA

The Landen transformations for the coefficients of

$$\frac{cx^4 + dx^2 + e}{x^6 + ax^4 + bx^2 + 1}$$

has been studied through the change of variable $y = \frac{x^2-1}{2x}$. We analyze the transformations and study the dynamics of the recurrences of a and b through the alternative change of variable

$$y = \frac{x^4 - 6x^2 + 1}{4x3 - 4x}.$$

204. Turan's Graph Theorem and Extensions

Bret Thacher Williams College
Advisor(s): Frank Morgan, Williams College

We will present one elegant proof of Turan's Graph Theorem, and discuss extensions of extremal graph theory. Possible topics include discussions of graphs with no complete multipartite subgraphs, and graphs with no cycles.

206. Clique Replacements

Edmund Karasiewicz Lafayette
Advisor(s): Jed Mihalisin, Lafayette University

Clique Replacements are a process in which one polytope is transformed into another. Our work focused on determining how this procedure alters the structure on the polytope by observing how symmetries and lower dimensional faces were effected.

207. Delta Sets of Numerical Monoids

Christin Bibby Northern Arizona University
Caitlin Leverson Wellesley University
Advisor(s): ,

Suppose $S = \langle n_1, n_2, n_3 \rangle$ is a three-generated numerical monoid, that is, an additive submonoid of $\mathbb{N}_0$ with the property that for all $m \in S$ there exist $a_1, a_2, a_3 \in \mathbb{N}$ such that $m = a_1 n_1 + a_2 n_2 + a_3 n_3$. For an element $m \in S$, $a_1 n_1 + a_2 n_2 + a_3 n_3$ is a factorization with length $a_1 + a_2 + a_3$. Let $\mathcal{L}(m) = \{m_1, \ldots, m_t\}$ be the set of all lengths of factorizations of m. Then the *delta set of* m is $\Delta(m) = \{m_{i+1} - m_i \mid 1 \leq i < t\}$, and the *delta set of* S is $\Delta(S) = \cup_{m \in S} \Delta(m)$. We will explore the delta sets of specific types of three-generated numerical monoids. This includes *supersymmetric monoids*, which are of the form $\langle ab, ac, bc \rangle$ with $\gcd(a, b) = \gcd(a, c) = \gcd(b, c) = 1$, *supple monoids*, which are of the form $\langle n, cb, n + b \rangle$ or $\langle n, n + b, cb \rangle$ with $\gcd(n, b) = 1$, and monoids with three as the first generator.

208. Your Paths are Determined! Motzkin Numbers in Hankel Determinants

Andrew C. M. Yip Lewis and Clark College
Advisor(s): Naiomi Cameron, Lewis and Clark College

We consider the determinant of the following matrix

$$H_{r,t,n} = \left(m^t_{i+j+(r-2)} + m^t_{i+j+(r-1)} \right)_{1 \leq i,j \leq n}$$

where r is a nonnegative integer and m^t_k is the number of t-Motzkin paths, that is, paths from $(0, 0)$ to $(k, 0)$ using northeast steps $(1, 1)$, east steps $(1, 0)$ and southeast steps $(1, -1)$. (Note that these paths never go below the x-axis and the east steps have a weight of t.) Our major results include combinatorial expressions and proofs for $|H_{r,t,n}|$ in the case where $r = 0, 1$ and t is arbitrary. We demonstrate the major results using a method that counts due to Gessel-Viennot-Lindstroem. Of particular interest is when $t = 1$ and $r = 0$. The entries of $H_{0,1,n}$ are sums of consecutive Motzkin numbers and $|H_{0,1,n}| = n + 1$. We will also note the $2 \times n$ domino tiling problems embedded in the case when $r = 1$.

209. Matrix Number Theory

David Alexander Hannasch University of Nevada, Las Vegas
Donald Adams San Diego State University
Rene Ardila City College, New York
Audra Kosh University of California, Santa Barbara
Hanah McCarthy Lawrence University
Ryan Rosenbaum San Diego State University
Advisor(s): Vadim Ponomarenko, San Diego State University

Factorization theory is a prominent field of mathematics; however, most previous research in this area lies in the commutative case. Noncommutative factorization theory is a relatively new topic of interest. This paper examines the factorization properties of noncommutative atomic semigroups of integral matrices. In particular, semigroups with determinant conditions, triangular matrices, rank 1 matrices, and bistochastic matrices are studied with the operation of multiplication and, in a special case, addition. The authors find invariants of interest in factorization theory such as the minimum and maximum length of atomic factorizations, elasticity of the semigroups, and the delta set of the semigroups.

210. Elasticity in Quadratic Number Semirings

Patrick G. Cesarz Villanova University
Advisor(s): Scott Chapman, Trinity University

In this note we investigate the non-unique factorization properties of $\mathbb{N}_0[\sqrt{m}] = \{a + b\sqrt{m} \mid a, b \in \mathbb{N}_0\}$ where m is squarefree and congruent to 2 or 3 mod 4. Let $\mathcal{L}(\alpha)$ denote the set of lengths of factorizations of α into irreducible elements, let $L(\alpha)$ be the maximum of this set, and let $l(\alpha)$ be the minimum of this set. The elasticity of α is defined to be $\rho(\alpha) = \frac{L(\alpha)}{l(\alpha)}$. The elasticity of the entire semiring, $\rho(\mathbb{N}_0[\sqrt{m}])$ is defined to be the greatest lower bound of the elasticity of all all the elements in the semiring. We prove that $\rho(\mathbb{N}_0[\sqrt{m}]) = \infty$. We also prove that $\mathbb{N}_0[\sqrt{m}]$ is fully elastic, meaning every rational number greater than one is the elasticity for some element in $\mathbb{N}_0[\sqrt{m}]$. Finally, let $\Delta(\alpha)$ be the set of differences between consecutive lengths in $\mathcal{L}(\alpha)$. We prove that $\mathbb{N}_0[\sqrt{m}]$ is Δ-complete, meaning every natural number is in $\Delta(\alpha)$ for some α.

211. Radio Labeling Grid Graphs

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Eduardo Calles Bakersfield College
Advisor(s): Drs. Maggy Tomova and Cindy Wyels, University of Iowa; California State University Channel Islands

For a graph G, let $d(u, v)$ denote the distance between any two distinct vertices u and v, and let $\text{diam}(G)$ denote the diameter of G (the maximum distance in G). A *multi-level distance labeling* (or *radio labeling*) for G is a function c that assigns each vertex of G a positive integer so as to satisfy the condition $d(u, v) + |c(u) - c(v)| \geq \text{diam}(G) + 1$ for all vertex pairs u and v. The *span* of c is the largest integer assigned by c. The *radio number* of G, $\text{rn}(G)$, is the minimum span taken over all radio labelings of G. We determine upper and lower bounds for the radio number of Cartesian products of paths.

212. Effects of El Nino Over Michigan Areas

Emily Elise Baker Central Michigan University
Advisor(s): John Daniels, Central Michigan University

El Nino can be explained as an unusual change in the sea surface temperature off the west coast of South America. This change is irregular but it typically occurs every three to seven years and always begins around Christmas time. This climate change generally lasts for several months at a time. The data used in this research comes from the El Nino region and in conjunction with monthly air temperature data from ten Michigan areas dating from January 1950 through May 2008, is used to see if El Nino does in fact have a significant influence on Michigan air temperatures.

213. Thin Film Evolution over The Porous Layers

Kumnit Nong George Mason University, Fairfax, Virginia
Advisor(s): Dr. Daniel M. Anderson, George Mason University, Fairfax, Virginia

We study the simulated models of the aqueous layer on the pre-corneal tear films of a human eye. These models describe the behavior of fluid films with and without the inclusion of the permeable porous medium that models a contact lens. A fluid dynamic model for the thin fluid film over thin porous layers is formulated by using a nonlinear fourth order partial differential equation with four boundary conditions and one initial condition. The evolution equations are solved numerically in Matlab in order to predict the effect of various parameters (at realistic values) on time of the thin films rupture. The results indicate that the presence of thin porous layers is a dominant effect and the different slip conditions at the liquid-lens boundary also have significant impact on thinning the thin aqueous layers. The computed numerical results allow us to predict film break up times for tear films on a contact lens.

214. KlustaKwik and Semi-Automatic Spike Sorting

Gina-Maria Pomann The College of New Jersey (Research conducted at Princeton University)
Advisor(s): Dr. Carlos Brody and Dr. Jeff Erlich, Princeton University

Experiments involving the acquisition of electrical readings from the brain often require high level statistical analysis. The main problem addressed here is the isolation of particular cells which emit signals. One of the difficulties encountered is to identify which data is coming from the brain and which is generated by external noise. Once the external noise is removed we aim to classify the electrical readings and identify the cell from which the signals are emitted.

The analysis can be done manually; however, this is an arduous task and has been known to produce imprecise results. KlustaKwik isa C++ program that facilitates the semi-automatic classification of neuronal signals. KlustaKwik uses the Classification Expectation Maximization (CEM) algorithm to sort through high dimensional neuronal data. We explore some complexity measures that can be used for this algorithm and their efficacy in KlustaKwik. We also present a hypothesis regarding the filtration of electrical noise from neuronal data. The hypothesis is tested on neuronal data, obtained from rats, which is then classified. The features used to describe the signals are extracted using Principle Components Analysis. We discuss how KlustaKwik can be implemented for semi-automatic spike sorting and the augmentations available to the user. We also explore the mathematical structure of the CEM algorithm as well as its implementation in KlustaKwik.

215. Representations of the Partition Algebra

Bernd Verst Macalester College
Advisor(s): Tom Halverson, Macalester College

The partition algebra $P_k(n)$ is an algebraic structure with a basis given by the set partitions of $\{1, 2, \ldots, 2k\}$ and a multiplication given by concatenation of set partition diagrams. The partition algebra contains the group algebra of the symmetric group S_k as a subalgebra. This project studies matrix representations of the partition algebra. We use an infinite tree, called the Bratteli diagram, which has vertices labeled by the integer partitions of k for $0 \leq k \leq n$ and edges given by removing and adding boxes to the partitions. Our representations are generalizations of Young's seminormal representation of the symmetric group. We use the combinatorial structure of the Bratteli diagram to describe the matrix entries in the representation. There are three kinds of generators of the partition algebra: p_i, b_i, and s_i. We have completely described the matrix entries of the p_i and the b_i and we have strong conditions on the entries of the s_i, which are the simple transpositions in the symmetric group.

216. The Radio Number of Ladder Graphs

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Kathleen Lewis California State University Channel Islands
Advisor(s): Cindy Wyels, California State University Channel Islands

The radio labeling of graphs originated from the real world problem of radio transmitter frequency assignment, which depends on distance between transmitters. For a connected graph G, let $d(u, v)$ denote the distance between any two vertices u and v. The diameter, $diam(G)$, is the longest distance in G. A radio labeling c of G is an assignment of positive integer values to the vertices of G that satisfies $d(u, v) + |c(u) - c(v)| \geq diam(G) + 1$, for all vertex pairs u and v. The maximum integer produced by the labeling is the span of the labeling. The radio number of G, $rn(G)$, is the minimum achievable span. Let L_n be a ladder graph with n rungs and $2n$ vertices. We completely determine the radio number for L_{2k+1} and we find upper and lower bounds for $rn(L_{2k})$ that differ by 5.