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Joyati Debnath
Winona State University

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blah, blah blah

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Titles, Authors, Advisors and Abstracts

1. Patterns in the Coefficients of Powers of Polynomials Over a Finite Field

Kevin Garbe Research Science Institute at Massachusetts Institute of Technology
Advisor(s): Prof. Pavel Etingof, MIT

We examine the behavior of the coefficients of powers of polynomials over a finite field of prime order. Extending the work of Allouche-Berthe, 1997, we study $a(n)$, the number of occurring strings of length n among coefficients of any power of a polynomial f reduced modulo a prime p. The sequence of line complexity $a(n)$ is p-regular in the sense of Allouche-Shalit. For $f = 1 + x$ and general p, we derive a recursion relation for $a(n)$ then find a new formula for the generating function for $a(n)$. We use the generating function to compute the asymptotics of $a(n)/n^2$ as $n \to \infty$, which is an explicitly computable piecewise quadratic in x with $n = \lfloor p^m/x \rfloor$ and x is a real number between $1/p$ and 1. Analyzing other cases, we form a conjecture about the generating function for general $a(n)$. We examine the matrix B associated with f and p used to compute the count of a coefficient, which applies to the theory of linear cellular automata and fractals. For $p = 2$ and polynomials of small degree we compute the largest positive eigenvalue, λ, of B, related to the fractal dimension, d, of the corresponding fractal by $d = \log_2(\lambda)$. We find proofs and make a number of conjectures for some bounds on λ and upper bounds on its degree.

2. On the Winning and Losing Parameters of Schmidt's Game

Michael Zanger-Tishler Brandeis University/Gann Academy
Saarik Krishan Kalia Brandeis University/St. Johns School
Advisor(s): Tue Ly, Brandeis University

First introduced by Wolfgang Schmidt, the (α, β)-game and its modifications have been shown to be a powerful tool in Diophantine approximation, metric number theory, and dynamical systems. However, natural questions about the winning-losing parameters of most sets have not been studied thoroughly even after more than 40 years. There are a few results in the literature showing that some non-trivial points and small regions are winning or losing, but complete pictures remain largely unknown. Our main goal in this paper is to provide as much detail as possible about the global pictures of winning-losing parameters for some interesting families of sets.

3. A Biometric Random Number Generator from EEG Signals

Maja Rudolph Massachusetts Institute of Technology
Advisor(s): Prof. Gilbert Strang, MIT

We propose a novel method to use electroencephalography (EEG) signals for random number generation. The method is fast and efficient and a battery of statistical tests is used to verify the pseudorandom properties of the generated sequences.

4. The Traveling Salesman Problem in Square and Rectangular Grids

Eileen Bruns Nazareth College
Advisor(s): Dr. Yousuf George, Nazareth College

The traveling salesman problem (TSP) is one that has been studied by mathematicians since the mid-twentieth century. Much of the complexity of the TSP is captured in the Hamiltonian path problem. We specifically examine the existence of Hamiltonian paths and circuits in both square and rectangular grids. We prove the existence of Hamiltonian paths and circuits in some cases, and their impossibility in others. Additionally, we prove that the degree of each vertex in a graph changes by only one degree along any Hamiltonian path in a square or rectangular grid of any dimension.

5. Do Transitive Tournaments Minimize Graph Costs?

Tynan Lazarus University of Hawaii at Hilo
Anna Payne Ashland University
Aquia Richburg Morehouse College
Advisor(s): Dan Pritikin, Miami University

Let G be an undirected graph and let T be a tournament on the same vertex set as G. Define the cost of G relative to T to be $\sum_{u,v\in E(G)}(T(u,v)+T(v,u))$, where $T(u,v)$ denotes the number of two-step paths from u to v, in T. In this paper, we determine for several classes of graphs which tournaments minimize the cost. Pelsmajer, et al. conjecture that for each graph there is a transitive tournament that minimizes the graph's cost. We prove that a transitive tournament minimizes the cost for complete graphs, nearly complete graphs, paths, star graphs, and cycles.

6. Good Gradings of Tournament Directed Graphs and a Mathematical Puzzle

John Dewitt University of Wisconsin, Oshkosh
Advisor(s): Dr. Kenneth Price, University of Wisconsin- Oshkosh

A tournament directed graph T_k consists of vertices $1,\ldots,k$ and arrows between any vertices a and b such that $a<b$. For any additively written Abelian group G a labeling of all of the arrows of T_k with elements of G is called a G-grading of T_k provided that for any vertices a, b, and c such that $a<b<c$, if g is the label on ab and h is the label on bc, then $g+h$ is the label on ac. An arrowgram is a mathematical puzzle where some arrows are unlabeled but there are enough labeled arrows to uniquely determine the G-grading. Solving the puzzle consists of labeling the unknown arrows subject to the grading condition. The research presented here is centered on counting the number of different arrowgrams that can be constructed on T_k. This question, of natural interest to puzzle constructors, reduces to counting the number of unique ways to grade T_k.

7. Embeddings of Complete Multipartite Graphs in Finite Projective Planes

Ryan Vaughn University of Mary Washington
Advisor(s): Oscar Vega, California State University, Fresno

We give results relating the number of embeddings of complete bipartite and multipartite graphs to the subplane structure of finite projective plane. Some of these results are obtained by looking at point-line configurations in the plane. We prove that for projective planes of certain order, the number of embeddings of complete multipartite graphs may be obtained directly the configuration of subplanes of a given size. We then give bounds on how many points and lines of a subplane an embedded graph may contain.

8. Connected Sums of Polynomial Knots and Series Expansions for Parameterizations of Wild Knots

Magdalena Mulvihill Adelphi University
Advisor(s): Lee Stemkoski, Adelphi University

A polynomial knot is the image of a parametric function whose components are polynomials. We discuss a technique of Craig Kaplan for constructing self-similar planar curves from smooth base curves, extend this technique to the case of space curves, and apply these new results to polynomial knots. This enables us to construct new classes of polynomial knots. In particular, we develop parameterizations of connected sums of polynomial knots. Finally, we discuss series expansions for wild knots and knots with fractal-like properties.

9. Invariants for graph embeddings

Jennifer Elder Fresno State
Elaina K. Aceves California State University, Fresno
Advisor(s): Carmen Caprau, Fresno State

We use knot theoretic methods to construct, and study, invariants for certain type of graphs embedded in three-dimensional space.

10. Digits of powers of numbers in an arbitrary base

Benjamin Wright Fresno State
Advisor(s): Oscar Vega, Fresno State

We explore the digits of powers of numbers in an arbitrary base and their connection with cellular automata. We present a result relating the digits of the positive powers of a base b to the digits of the negative powers of b base a.

11. Cycles and Cycle-related Graphs in $PG(2,q)$

Jamie Peabody California State University, Fresno
Jordan Page White California State University, Monterey Bay
Advisor(s): Oscar Vega, California State University, Fresno

We establish that it is possible to embed k-cycles into $PG(2,q)$, for all $3 \leq k \leq q^2+q+1$, as long as a hypothesis on the generators of the finite field $GF(q)$ holds. We have verified this hypothesis to be true for finite fields of prime order $p < 10^{10}$. Furthermore, we expand upon this result to describe the behavior of embeddings of cycle-related graphs, such as wheels and gear graphs. For these families of graphs, we have obtained sharp bounds for embeddability and ways to embed all graphs allowed by these bounds. Many of our results may be generalized to $AG(2,q)$, and other projective planes.

12. Constructing Groups and Other Algebras out of Quasigroups and Loops

Marco Tapia-Guilliams University of Maryland
Hannah Hoganson Lehigh University
Advisor(s): Reza Akhtar, Miami University

A quasigroup is a set endowed with a binary operation, $*$, such that for any equation of the form $x*y=z$, where two of these variables are known, the third one is uniquely determined (Latin Square Property). A loop is a quasigroup that has a neutral element. An Equational Quasigroup is defined by these four identities: 1. $x*(x\backslash y)=y$, 2. $(y/x)*x=y$, 3. $x\backslash(x*y)=y$, and 4. $(y*x)/x=y$. There is a natural bijection between quasigroups and equational quasigroups. The three operations here are , $*$', known as star, /, known as right divide, and \, known as left divide. Both right and left divide are defined in terms of star. So if $x/y=z$ then $x=z*y$ and if $x\backslash y=z$ then $y=x*z$. We decided to investigate what properties quasigroups and loops would have when they satisfy an additional identity. To do this testing we used the automated theorem prover program Prover9 to check which identities were equivalent and which implications were valid, and we used Mace4 to check which implications were not valid as well as to come up with relevant counterexamples. In our research we define Boolean loops and connect non-associative algebras to group theory.

13. Real Root-Counting Techniques for Central Configuration Problems

Ashlee Kalauli University of Hawaii at Hilo
Samantha Warren University of Portland
Advisor(s): John B. Little, College of the Holy Cross

A central configuration in the gravitational n-body problem is an arrangement of masses for which the accelerations are all parallel to the displacements from the center of mass with equal proportionality constants. Central configurations also lead to explicit solutions of the n-body problem. An underlying question is whether there are only finitely many ways to arrange n given masses to form a central configuration (up to translation, rotation, and scaling). In terms of the mutual distances, central configurations are described as solutions of systems of polynomial equations. However, being that mutual distances must be positive reals, not all solutions (i.e. complex and nonpositive real) of the equations are physically relevant. We use methods of algebraic geometry to count the number of real solutions of systems of polynomial equations in a given region of Euclidean space, such as the positive orthant consisting of points with all positive coordinates. These root-counting methods yield the exact number of positive real solutions and do not rely on sensitive numerical techniques. We apply these methods to several cases of the n-body and n-vortex problem and use these methods to lower the bound on the number of central configurations for the 4-vortex problem.

14. The Effect of Mixed Conducting and Insulating Wall Segments on the Ideal MHD Duct Problem.

Jason Cornelius Delaware State University
Advisor(s): Pablo Suárez, Delaware State University

In this presentation, we study the effect of boundary conditions on the flow of a conducting fluid in the presence of a transverse magnetic field. We consider a fluid of modest Hartmann number, moving through both rectangular and circular channels. Of particular interest is the effect of perfectly conducting and perfectly insulating wall segments on the velocity of the fluid, as well as the intensity of the induced magnetic field. For a simple configuration, we provide a semi-analytical solution to the MHD duct problem using separations of variables in conjunction with Fourier series. For more complicated boundary conditions we use numerical methods only. We consider two, three and four piece segmented walls in which each segment is arbitrarily assigned either perfectly conducting or perfectly insulating characteristics. Utilizing the Finite Element Method, we obtain numerical solutions for the relative V and B fields under these various boundary conditions. Using these results, we conclude that regions near the perfectly conducting segments appear to exhibit the most restricted fluid flow.

15. Exploring Graphs of Triangulated n-gons: Connectivity and Diameter Bounds

Kerisha Burke Howard University
Advisor(s): Benson Farb, University of Chicago

Our research uses graph theory to understand the geometry of the space for triangulated n-gons with one interior vertex. The theory and applications of graphs are the basis of many strides in the field of science and mathematics. A quite notable graph theory problem, resolved by Sleator-Tarjan-Thurston, serves as the motivation for this research. In their findings, Sleator-Tarjan-Thurston explored the connection between the maximum rotation distance of binary trees and the graph $R_{n,0}$, a graph with triangulated n-gons as nodes. As an extension of the works by Sleator-Tarjan-Thurston, we study the graph $R_{n,1}$, for $n \geq 3$. Given the graph $R_{n,1}$ such that its nodes are triangulated n-gons with one interior vertex, this study explores the connectivity and bounds on the diameter. By constructing the graph $R_{n,1}$ and studying its properties, we proved that the nodes are connected by a sequence of flipped edges. Lastly, we found an algorithm to compute the distance between any of the nodes of $R_{n,1}$ and a special vertex in $R_{n,1}$ that is connected to all nodes. The proof of the diameter bounds is a corollary of the algorithm.

16. Probabilistic Prediction Models of Graduation Success for University of Tennessee at Martin Students

Johanna van Zyl University of Tennessee, Martin
Advisor(s): Desiree McCullough, University of Tennessee at Martin

The purpose of this research is to develop models that sufficiently determine the probability of graduation for University of Tennessee at Martin students through the use of their ACT sub scores and high school Grade Point Average (GPA). Graduation status for each student was coded in binary form and binary logistic regression was used to develop models for the university and for each college, department and major. Each model was assessed using the Pearson Goodness-of-Fit test. This study is beneficial to the University of Tennessee at Martin for evaluation purposes, and to students at the university who would like to determine whether their scholastic strengths fit the particular requirements found within each major. On a secondary basis, the study can serve as a guideline for other educational institutions who would like to conduct a similar investigation on their premises.

17. Perfect Graphs

Amanda Russo La Salle University
Advisor(s): Janet Fierson, La Salle University

Perfect graphs have been the subject of much research and discussion. A perfect graph G is a graph for which the chromatic number of every induced subgraph H is equal to the clique number of H. The chromatic number of a graph G is the minimum number of colors needed to color the vertices of G such that no two adjacent vertices share a color. The clique number of a graph G is the size of the largest complete subgraph of G. In 1960, a Strong Perfect Graph Conjecture was presented by Berge; in 2002, it was confirmed by Chudnovsky et al., resulting in the Strong Perfect Graph Theorem, characterizing perfect graphs in terms of forbidden subgraphs. Since 1960, many related concepts and problems have arisen. This work considers both. The concept is the application of strongly perfect graphs to

optimal selection of leaders. Strongly perfect graphs have not yet been characterized by forbidden subgraphs, and differ from perfect graphs in that the complement of a strongly perfect graph is not always perfect. The problem addressed is an outstanding open question that involves uniquely colorable perfect graphs and the intersection of maximal cliques within them. This work illustrates both the progress made on these topics and the conclusions that have been drawn from the research.

18. The Secret of Nim

Ashlee Evertt Nazareth College of Rochester
Larry Czubinski Nazareth College of Rochester
Advisor(s): Dr. Yousuf George, Nazareth College of Rochester

What is the secret to winning the classical game of Nim? Is it pure luck? Is it an algorithm? In our research we studied the game of Nim. Our starting game of Nim involved two players, one pile of ten pennies and the choice to choose one or two pennies each turn. The winner was the player who removed the last penny or pennies from the table. After many hours of playing Nim and analyzing our moves and results, we discovered that there is a secret to Nim and it is based on simple mathematics. This optimal strategy can be used by either player to guarantee a win. Diving deeper into our discovery, we created several variations of the classic game. For these games we were able to extrapolate and generate new strategies for each individual variation.

19. The Queen Chicken Problem

Ashley Binnert Nazareth College
Grace Crowell Nazareth College
Emiline Pelletier Nazareth College
Advisor(s): C. Yousuf George, Nazareth College

When you put chickens in a cage, they will fight to establish a pecking order. We started our research by defining queen chickens as chickens that win the most fights over the other chickens. Of course, more than one chicken could tie for the most wins. As a result, we defined princess chickens as chickens that tie for the plurality of wins. From there we have been looking at the number of possible scenarios with both queen and princess chickens in order to determine the chicken hierarchy. Along the way we determined the number fights for n chickens, and how many chickens can tie as princesses. From these proofs, we have been looking at partitioning with relation to the number of scenarios. We have been able to determine the number of scenarios for small numbers of chickens, and we are working on developing a formula for larger numbers of chickens. Our research relates to other real life situations involving rankings, such as sports.

20. Euler's Characteristic and Planar Graphs

Justin Sawran Nazareth College
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Advisor(s): Yousuf George, Nazareth College

Our research began with determining the winner of a two-player game. The game was originally set up by arranging 5 dots such that 2 of the dots lie within a triangle formed by the remaining 3. Players then took turns connecting pairs of dots to form line segments, or "edges," that would not intersect. The player who draws the last possible segment is the winner. Once we determined which player would win, we began to look at the same scenario with more and more dots inside and outside the triangle. The pictorial result of each completed game eventually led us to expand our research to polygons, polyhedrons, and planar graphs. Our main result is an interesting proof of Euler's Characteristic Formula ($2 = V + F - E$) for these geometric graphs in two and three dimensions. Finally, we were able to discover connections between these various types of graphs and express how they are all related.

21. Maximum Likelihood Estimation of the Signal Fat Fraction Using Magnetic Resonance Imaging

Jorly Chatouphonexay California State University, Fullerton
Advisor(s): Dr. Angel R. Pineda, California State University, Fullerton

One of the health problems associated with obesity is nonalcoholic fatty liver disease (NAFLD). NAFLD is diagnosed by a liver biopsy, which samples about 1/50,000th of the entire liver, leading to an inaccurate diagnosis. It may be

better to use MRI to diagnose NAFLD. NAFLD is diagnosed by using the signal fat fraction, defined as $\rho_{signal} = \mu_{fat}/(\mu_{fat} + \mu_{water})$, where μ_{fat} is the mean of the fat signal and μ_{water} is the mean of the water signal. The signal fat fraction is estimated by the magnitude and the maximum likelihood estimation (MLE) methods. The magnitude method generates the fat-fraction estimate by $\hat{\rho}_{magnitude} = |F|/(|F| + |W|)$. The magnitude of the complex fat and water signals, denoted as $|F|$ and $|W|$, follows the Rician distribution. The MLE method generates the fat-fraction estimate by $\hat{\rho}_{MLE} = \hat{F}_{MLE}/(\hat{F}_{MLE} + \hat{W}_{MLE})$, where $\hat{F}_{MLE}$ is the estimated mean of the fat and $\hat{W}_{MLE}$ is the estimated mean of the water signals obtained by the MLE, leading to a non-linear maximization problem. We will show for the first time that the MLE method leads to a smaller mean squared error in estimating the signal fat fraction than the magnitude method.

22. Module Bases for Splines with Boundary Conditions

Emma Sawin Haverford College
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Gordon Jones Syracuse University
Advisor(s): Lauren Rose, Bard College

In this project, we investigate piecewise polynomial functions in one variable, also called splines. The set of all splines over a given subdivided interval forms a module over the ring $\mathbb{R}[x]$, where $\mathbb{R}$ denotes the real numbers. In particular, we are interested in splines which are defined to be zero at the boundary, and which have specified differentiability conditions at the endpoints of the intervals. We call these splines *boundary splines*. The goal of our research is to find and characterize module bases for boundary splines. We extend existing results of Billera and Rose concerning splines to the new case of boundary splines. Where possible, we give explicit bases, and in other cases we give a characterization of the degrees of the basis elements. We also provide a correspondence between one-dimensional boundary splines and certain two-dimensional non-boundary splines, which allows us to extend our results to some two-dimensional spline modules.

23. Algebra associated to the Hasse graph of the n-cube

Cary Schneider University of Wisconsin, Eau Claire
Wai Shan Chan University of Wisconsin, Eau Claire
Advisor(s): Colleen Duffy, University of Wisconsin - Eau Claire

The primary goal of our project is to determine the structure of a graded algebra, $A(\Gamma)$, that is associated to the Hasse Graph, Γ, of an n-dimensional hypercube. We can consider a unit cube with one vertex at the origin. Each symmetry of the n-cube can be thought of as acting on the coordinates of the vertices. For each symmetry, we consider the Hasse graph consisting of fixed k-faces of the n-cube under the action. From each Hasse sub-graph, we determine the graded dimension of subalgebras of $A(\Gamma)$ by counting the directed paths between each pair of levels in the graph. We were able to determine the generating function that describes the algebra that is only dependent upon the symmetry.

24. The Combinatorial Area of Systolic Disks

Lingge Li Pomona College
Patrick Meehan Harvey Mudd College
Matthew Owen Pitzer College
Gillian Grindstaff Pomona College
Advisor(s): Rena M.H. Levitt, Pomona College

A triangulated disk is systolic if each interior vertex is contained in at least six triangles. Discovered independently by Chepoi, Januskiewicz and Swiatkowski, and Hagland, the systolic condition can be seen as a combinatorial version of non positive curvature. We prove constructively that the combinatorial area of a systolic disk is bounded quadratically by its perimeter. This implies that complexes with systolic spanning disks satisfy a quadratic isoperimetric inequality.

25. Beyond Alternating Permutations: Pattern Avoidance In Young Diagrams and Tableaux

Nihal Gowravaram Massachusetts Institute of Technology PRIMES
Advisor(s): Dr. Joel Brewster Lewis, University of Minnesota

We investigate pattern avoidance in alternating permutations and generalizations thereof. First, we study pattern avoidance in analternating analogue of Young diagrams. In particular, we extend Babson-West's notion of shape-Wilf equivalence to apply to alternating permutations and so generalize results of Backelin-West-Xin and Ouchterlony to alternating permutations. Second, we study pattern avoidance in the more general context of permutations with restricted ascents and descents. We consider a question of Lewis regarding permutations that are the reading words of thickened staircase Young tableaux, that is, permutations that have k-1 ascents followed by a descent, followed by k-1 ascents, et cetera. We determine the relative sizes of the sets of pattern-avoiding (k-1)-ascent permutations in terms of the forbidden pattern. Furthermore, inequalities in the sizes of sets of pattern-avoiding permutations in this context arise from further extensions of shape-equivalence type enumerations.

26. Totally Geodesic Surfaces in Hyperbolic Knot Complements

Warren Shull St. Olaf College
Advisor(s): Dr. Rolland Trapp, California State University, San Bernardino

A knot or link is called ”hyperbolic” if its complement (all of spherical 3-space excluding the knot) can be repeatedly glued to itself across hyperbolic 3-space, much like the torus can be repeatedly glued to itself across the Euclidean plane. A surface through said complement is ”totally geodesic” if its representation in this gluing is a union of disjoint hyperbolic planes. We have proven the absence of totally geodesic surfaces bounded or punctured by either the figure-eight knot or the 6_2^2 link. We've also found a case (Borromean Rings checkerboard) in which a Dehn filling (excluding a strand from the knot, and thus including it in the complement) changes a surface that is not totally geodesic into one that is.

27. Wyvern: A Dataflow Analysis Framework

Justin DeBenedetto Wake Forest University
Advisor(s): John Lasseter, Fairfield University

The family of multi-source data flow analyses encompasses data flow analysis problems in which the flow graph may be defined with more than one type of edge, with information about this edge type considered along with the flow value it carries. The degree of generality in such problems imposes a number of challenges for implementation. Systems that support the automatic generation of solvers for data flow problems usually require the user to provide a directed graph model of the program, a definition of the value domain (as a complete lattice), abstractions of program operations over this domain, and a mapping of concrete program operations to abstract operations. The general multisource data flow analysis problem requires in addition a specification of the constraints relating flow values between nodes, across the various edge types The work described here is an implementation of the ”data model” in such a system. We have designed a domain-specific language suitable for the specification of a directed graph model with arbitrary edge types and lattice-valued annotations of each node, and for the definition of complete-lattice value domains. Both the flow graph and lattice domain constructions are implemented as OCaml modules and are part of a larger work in progress.

28. A Multivariate Statistical Inference for the Analysis of Neuronal Spiking Rates

Reina Galvez California State University, Fullerton
Antouneo Kassab California State University, Fullerton
Duy Ngo California State University, Fullerton
Advisor(s): Dr. Sam Behseta, California State University, Fullerton

In this work, we propose a series of comparative statistical inferences that may be used to distinguish the firing patterns of a population of neurons recorded under two experimental conditions and classify neurons based on their differential intensity rates. To approach these objectives, we borrow from the existing features of multivariate Gaussian distributions and hierarchical clustering techniques. Thus, allowing us to simulate a large number of firing intensity curves from the underlying multivariate distributions for further inferential steps. Applying simulation-based methods in this work, we were able to construct a 95% confidence interval for the differences between two

curves fitted to each neuron. We found that a considerable portion of 139 studied neurons demonstrated significant differences throughout the entire experimental time window. Using two different metrics of distance between the simulated curves, a Kullback-Leibler divergence, and a binwise method, we constructed a 95% confidence interval for the mean of six clusters of the 139 difference curves.

29. Determining Conditions Sufficient for the Existence of Arc-Disjoint Hamiltonian Paths and Out-Branchings in Tournaments

Alex Beckwith Kenyon College
Aleesha Veronica Moran McKendree University
Melanie Ramona King Mercer University
Advisor(s): Dan Pritikin, Miami University

Two out-branchings in a tournament are arc-disjoint if they share no arcs. A hamiltonian path is an out-branching in which the out-degree of each vertex is at most one. We examine conditions sufficient for the existence in a tournament of a hamiltonian path and out-branching rooted at the same vertex that are arc-disjoint. We show that in a strong tournament the existence is guaranteed and that the out-branching can be taken to be path-like or star-like. We show that a regular tournament on $2n + 1$ vertices has a hamiltonian path and $n - 1$ out-branchings that are mutually arc-disjoint, and we improve several results related to the well-known Kelly conjecture.

30. Rook Placements on Young Diagrams: Towards a q-Analogue of the Harer-Zagier Formula

Max Wimberley Massachusetts Institute of Technology
Advisor(s): Alejandro Morales, UniversitÃ© du QuÃ©bec a MontrÃ©al

In an influential 1986 paper, Harer and Zagier computed a certain matrix integral to determine a closed-form formula for the number of (orientable) one-face maps (embeddings of graphs in orientable surfaces) on n vertices colored from N colors. Kerov (1997) provided a proof which computed the same matrix integral differently, which gave the interpretation of these numbers as also counting the number of placements of non-attacking rooks on Ferrers boards. Bernardi (2010) provided a bijective proof of this formula which put one-face maps in bijection with tree-rooted maps, which are orientable maps with a designated spanning tree. In this paper, we explore the combinatorial connection between these rook placements and tree-rooted maps by developing a bijection between them. We also propose a statistic related to inversions on rook placements to move towards a q-analogue of the Harer-Zagier formula. This leads us to conjecture an identity which is a q-analogue of Kerov's interpretation. This identity is also expressed in terms of moments of orthogonal polynomials which are a rescaling of the discrete q-Hermite I polynomials. We then use this moments formulation to give a recurrence for the proposed q-analogue.

31. Predicting the Presence of Multiple Sclerosis Using Semantic Categories and Logistic Regression

Brayan Ortiz California State University, Fullerton
Advisor(s): Mortaza Jamshidian, California State University, Fullerton

Multiple Sclerosis is a disease characterized by brain damage. Diagnosis and confirmation of MS involves investigation and discovery of that damage. An approach to this discovery is to take advantage of known facts about how the brain processes information. Research has shown that the brain processes visual information in an organized manner. Specifically, the human brain organizes visual information by using the three semantic categories of Animal, Fruit, and Object. There is evidence to support that MS patients are uniquely uniformly impaired in all three categories. Using this information, the goal of this study was to build a predictive model for estimating the probability of a subject having MS using gender and response times to visual stimuli in the three semantic categories. Patients meeting criteria for clinically definite MS volunteered to take the cognitive test alongside controls. The logistic regression model constructed is capable of predicting probability of MS, given the predictors. Internal validation of the model was performed using bootstrap and thresholds were determined by desired sensitivity and specificity. Finally, details surrounding the specifics of semantic organization are implied in the graphical behavior of the logistic regression model.

32. An upper bound of the double lattice covering density of regular pentagons

Peter Chang University of California, Davis
Jiahui Guan University of California, Davis
Advisor(s): Greg Kuperberg, University of California, Davis

We show that the largest p-hexagon inscribed in a regular pentagon has area $\frac{\sqrt{5+2\sqrt{5}}}{2} \approx 1.53884$, where the regular pentagon is sized and has unit side length. Using this theorem, we can find the least density of a p-hexagon covering of regular pentagons, which is also an upper bound of the double-lattice covering.

33. Carbon Dioxide Flux due to Soil Respiration

Tara Hudson State University of New York, Fredonia
Advisor(s): Ji Young Kim, Mount Holyoke College

A substantial amount of carbon dioxide is emitted from the respiration of microorganisms in the soil, which unfortunately is difficult to estimate. The goal of this project was to analyze the data gathered by researchers at Harvard Forest to determine trends in the emission of carbon dioxide. Mixed-effect models were applied to the data, and then alternative characteristics such as soil drainage and site descriptions were used to suggest rationale for the clusters which appear. As a follow up analysis, a model was selected to predict the carbon dioxide flux given a location.

34. Investigating the Water Quality of Lake Lillinonah

Derek Funk Carleton College
Advisor(s): Laura McSweeney, Fairfield University

Lake Lillinonah, located in Western Connecticut, has been experiencing harmful seasonal algal blooms. In this poster, statistical techniques such as regression and time series methods are used to investigate the water quality of Lake Lillinonah and to produce models that explain the seasonal patterns of algal blooms. Statistical analysis is performed on variables measuring water quality and atmospheric conditions, using chlorophyll and dissolved oxygen at 15 meters as the main dependent variables of interest. Autocorrelation of the errors is a persistent problem in simple and multiple ordinary least squares regression, which is addressed using Autoregressive Integrated Moving Average models and Generalized Least Squares. Using these latter two time series methods, several statistically significant models are produced.

35. Stability Analysis of Predator-Prey Models in Continuous Network Domains

Scott Manifold University of California, Riverside
Advisor(s): Kurt Anderson, University of California, Riverside

Population ecologists use a variety of analytical and computational models to study species dynamics. Combined with field data, these models are important in making predictions about how population stability and persistence respond to perturbations of environmental conditions over spatial scales. However, there is a lack of analytical models which focus on the effect of spatial heterogeneity in complicated continuous spatial domains. Existing PDE models which consider a continuous domain are usually restricted to simple geometries such as the interval or disk. Other models which consider complicated geometries usually do so by parsing space into discrete sections. Using Quantum Graphs, a modeling structure that has been largely restricted to physics, it is possible to use the machinery of PDEs on a continuous network to more accurately reflect how barriers of movement and intricate geometries can affect population dynamics. I construct a nonlinear reaction-diffusion system on a continuous network and present methods for analyzing stability properties of predator-prey systems. In particular, I examine ways in which graph structure influences the onset of Turing Instability. Current results are focused on star and tree graphs, though trends and areas of further inquiry are noted.

36. Innovation at the bottom of the pyramid: Modeling the adoption of manual irrigation pumps by subsistence farmers

Carol Brown Skidmore College
Advisor(s): Rachel Roe-Dale, Skidmore College

We use the concept of diffusion to describe the process by which a new innovation is adopted. The most commonly used model to express new product diffusion is the Bass model, a differential equation describing the rate of new adopters over time. In this study we fit the three parameters of the Bass model to data for the diffusion of manual irrigation pumps in Bangladesh, Kenya, and Tanzania, and analyze these parameter values in order to draw conclusions as to the effectiveness of the Bass model in describing the diffusion of an innovation targeted mainly at those below the poverty line.

37. A Computational Algorithm for Estimating Conductivities

Annika Jersild College of William & Mary
Advisor(s): Padmanabhan Seshaiyer, George Mason University

Inverse conductivity problems are widely applicable in many real-world problems such as groundwater flow and geothermal applications. One of the challenges in this area for scientists and researchers has been to develop efficient computational algorithms to estimate conductivity values that correspond to information underground through discrete data collected on the surface. In this work, we develop a computational algorithm that employs minimization of a cost function defined using the discrete data in conjunction with the solution to a coupled primal-dual formulation. The mathematical tools used in this research include the finite difference method, the steepest descent algorithm, Reisz representation theorem and definition of directional derivatives that help to formulate a unified computational algorithm to solve for the conductivities. Numerical results that validate the performance of the algorithm will be presented.

38. On the calculation of thermal resistance in concentric residential geothermal heat exchangers

Spencer Frei McGill University
Advisor(s): Burt Tilley, Worcester Polytechnic Institute

Residential geothermal ground-source heat pumps have been used for many years as a low-cost, green alternative to traditional heating systems. The limitation to wider acceptance is the initial cost of installation of a piping network for energy exchange, which is proportional to the piping length. We formulate a new mathematical modeling framework that calculates a characteristic length based on the geometry of the system and operating conditions using a vertical concentric geothermal heat exchanger as an example. These systems consist of a core flow and an annular return region in which heat exchange between the fluid and the soil occurs. When there is no thermal transport between the core and the fluid, we find that the characteristic length is determined by the smallest eigenvalue of the separable thermal problem. When core-annular heat transfer is possible, the eigenvalue problem no longer satisfies Sturm-Liouville conditions, and through direct computation we find that this energy transfer reduces the performance of the exchanger. In another modeling scenario, the soil temperature near the exchanger responds to the energy transport, and we find that the system performance is reduced over time. The impact of these results to system design considerations is discussed.

39. Mathematical Modeling Interactions Between Human and Fish Populations: A Bio-Economic Approach

Kimberly Vilimas University of Redlands
Advisor(s): Joanna Bieri, University of Redlands

Mathematically modeling interactions between fish and fisherman can be a powerful tool in the formulation of optimal management strategies. In our research, we utilized computer simulations in order to model a system of nonlinear recurrence relations which implement population mathematics as well as economic concepts. We then analyzed the system by means of fixed points, Jacobian stability testing, graphical interpretations, and parameter analysis using the Jury test. The main objectives of this piece are to: (i) recreate and verify the traditional pure open access bio-economic model pioneered by Gordon [1954], Scott [1955] and Schaeffer [1957] and (ii) discuss the implications these results have on the fish industry today, including what needs to be improved and updated.

40. Race Matters: Analyzing the Relationship Between Colorectal Cancer Mortality Rates and Various Factors Within Respective Racial Groups

Ismael Xique Bowdoin College
Jessica Lyle Maryville College
Jada Johnson University of Maryland
Advisor(s): Monica Jackson, American University

Colorectal cancer (CRC) is the third most commonly diagnosed cancer among Americans with nearly 147,000 new cases per year and the third leading cause of cancer death with over 50,000 deaths annually which represents 9% of all US cancer deaths (ACS, 2009). CRC incidence and mortality rates among African Americans are among the highest reported for a race/ethnic group (Horner al., 2009). Among Hispanics, CRC is the 2nd most frequently diagnosed cancer (ACS, 2009). This research utilized CRC incidence and mortality data obtained from the National Cancer Institute linked with data from the United States Census Bureau, the Center for Disease Control and Prevention, and the National Solar Radiation Database to visually examine geographic and racial/ethnic differences and develop a spatial regression model that adjusted for several factors that may attribute to health disparities among ethnic/racial groups. We found that sunlight, obesity, and socio-economic status were significant predictors of CRC. This study not only identified factors associated with the risk of CRC mortality but, more importantly, demonstrated how these factors varied within different racial groups. Accordingly, education on reducing risk factors for CRC should be directed at specific racial groups.

41. An Approximation of the Budyko-Widiasih Model with the Jormungand Albedo Function

Christopher Rackauckas Oberlin College
Advisor(s): James Walsh, Oberlin College

Recent research in climate modeling has lead to the development of the Budyko-Widiasih ice-albedo feedback model with ice line dynamics which, via a finite approximation using Legendre Polynomials, produces a five-dimensional system which gives a one-dimensional invariant manifold. However, the question arises as to whether a dynamically stable Jormungand climate state, a state where glaciers descend to tropical latitudes without causing a snowball Earth event, could be realized in the Budyko-Widiasih model. Here we extend the Budyko-Widiasih model to use a three-step albedo function, the Jormungand albedo function, which incorporates the dynamics of bare sea ice whose albedo is lower than snow covered sea ice. The preliminary results for the new model are presented for a finite approximation of the model using Legendre polynomials to get a large dimensional space which collapses down to give a 1-dimensional invariant subspace.

42. Paleoclimatoloy and Climate Field Reconstruction

Eric Cawi George Mason University
Advisor(s): TImothy Sauer, George Mason University

In climate change research, it is important to utilize accurate historical temperature approximations. Most methods use proxies such as tree rings to develop their approximations. We study these methods to develop error bounds for the estimates and discover the effect of adding other explanatory variables like carbon dioxide.

43. Integrodifference Population Models for Time-Varying River Habitats

Taylor McAdam Harvey Mudd College
Advisor(s): Jon Jacobsen, Harvey Mudd College

Population growth is frequently modeled through reaction-diffusion equations, which assume that a population is continually growing and dispersing at the same time. However, many species grow and disperse in separate stages, and in these cases discrete-time integrodifference equations may more accurately reflect population progression over time. Past research has used deterministic integrodifference equations to answer questions about population survival and critical domain size for populations in river environments with unidirectional flow. However, in the real world river flow and population growth are not constant and deterministic, but are instead probabilistic and time-varying. This research explores how time-dependence and randomness affect the behavior of integrodifference models for population growth in river environments.

44. Optimizing Wolbachia Release Strategies for Controlling Dengue Fever

Robert O'Brien North Carolina State University
Advisor(s): Dr. Alun Lloyd, North Carolina State University

Dengue fever is the most prevalent mosquito-borne viral disease that affects humans. Since there are no licensed vaccines or effective drug treatments currently available, disease control efforts have largely focused on controlling the vector of the disease, the mosquito Aedes aegypti. While traditional vector control methods, such as insecticide spraying and source reduction, can have a major impact on reducing transmission of the infection, they often require an intensive control effort and are difficult to maintain on a long-term basis. One new control measure that has been proposed involves the introduction of a strain of the bacterium Wolbachia into a native mosquito population. Infection with Wolbachia has been shown to reduce transmission of dengue virus, and it is thought that replacing a native mosquito population with one which is entirely infected with Wolbachia will lead to decreased incidence of dengue. Carefully planned releases of Wolbachia-infected mosquitoes are needed to effectively lower disease incidence while making efficient use of available resources. To this end, we applied principles of optimal control theory to design and assess potential release strategies.

45. Dynamics of Triatomine Infestation in a Population of Houses

Javier Baez Arizona State University
Komi Messan Mathematical and Theoretical Biology Institute
Advisor(s): Juan Aparicio, Universidad Nacional de Salta

Trypanosoma cruzi, is the causal agent and parasite of Chagas disease, a neglected tropical disease transmitted mainly by blood-sucking triatomine insects in Latin America. Because of the unavailability of a cure for Chagas disease, disease control relies on the control of the vector population. In this work, we developed deterministic and stochastic mathematical models for the dynamics of bug infestation in a community of houses. We used a Levins metapopulation approach in which houses are considered to be patches that can be in one of three states: empty, infested, or treated. First, we considered spatially implicit models for homogeneous and heterogenous populations. We studied the effect of differences in housing quality in infestation dynamics and the effect of heterogeneity in the distribution of the houses. Then, we developed more realistic spatially explicit, agent-based, metapopulation models. The models were used to assess the effect of different control strategies on house infestation. The results show that spraying only bad houses is mor beneficial than spraying the whole community while using the same treatment rate.

46. The Role of Incoherent MicroRNA Feed-Forward Loops in Gene Regulatory Network Robustness

Natalie Stanley Dickinson College
Advisor(s): David Murrugarra, Georgia Tech

Incoherent micro RNA feed-forward loops (miRNA FFLs) are recurring motifs in gene regulatory networks that link a transcription factor, a micro-RNA and a target gene. These FFLs have been shown to contribute to network stability. Specifically, miRNA FFLs assist in the maintenance of optimal protein levels in the cellular environment of an organism by providing a buffer against extrinsic and intrinsic noise. The stability of a gene network is correlated with a relatively larger number of initial conditions leading to a steady state or a limit cycle (basins of attraction). It can be shown that the addition of miRNA FFLs also increases the maximum basin of attraction size and therefore indicates stability. In this study, we examined how miRNA FFLs contributed to gene regulatory network stability, using a discrete framework. Finally, a numerical simulation was performed on the sensory organ precursor network in drosophila to justify the stabilizing effect of the microRNA, miR-7 in a biologically relevant context. This work was completed at Virginia Bioinformatics Institute in the 2012 Modeling and Simulation in Systems Biology REU Program.

47. Salmonella: Assessing Causes and Trends

Sarah Salter Kean University
Advisor(s): Dr. Kate Cowles, University of Iowa

According to the Center for Disease Control and Prevention, it is estimated that each year foodborne disease is the cause of roughly 48 million illnesses, 128,000 hospitalizations, and 3,000 deaths among American citizens. Of the 31 known pathogens that contribute to domestically acquired foodborne illness, Salmonella is deemed the

leading pathogen causing hospitalization and death. Because statistical models are essential in detecting outbreaks, this research performed a model comparison, which focused heavily on using a Bayesian statistical methodology to determine change-points using a Markov Chain Monte Carlo computational method, as well as a Bayesian Poisson Analysis. In order to determine how well the tested models were able to successfully identity outbreaks, a simulation study was developed to examine their accuracy. In addition to model efficiency, the simulation study also provided insight to how different factors affect the model results. Results showed that the Bayesian Poisson analysis was the best at detecting outbreak trends of Salmonella. Furthermore, the simulation study showed that the two most influential factors in detecting the correct number of outbreaks are the frequency of outbreaks and a user-specified parameter value.

48. Measuring the Decline in Crime and Setting Reasonable Crime Reduction Targets

Austin Alleman Santa Clara University
Arturo Fernandez University of California, Berkeley
Advisor(s): Stacey Beggs, Institute for Pure and Applied Mathematics

The city of Los Angeles has experienced a steady decline in crime rates since the 1990s, to the extent that present day figures reflect historic lows. The question of whether this trend will continue is of great interest to the Los Angeles Police Department, particularly in terms of setting realistic crime reduction goals for each of the 21 policing divisions of the city. At present, these goals are set uniformly at 5 percent, though homogeneous expectations can be problematic since crime reduction is heavily dependent on the individual characteristics of each division. In this project, forecasting methods were developed, based on parametric and nonparametric methods, to project changes in the crime levels based on historic data with two purposes in mind: the provision of a quantitative methodology to help set reduction goals, and a flexible measure of police performance. In general, the accuracy of these methods indicates potential goal-setting utility at a variety of spatiotemporal scales.

49. Concepts in Color

Amanda Rose Colorado State University
Christie Burris Colorado State University
Fred Colclough Colorado State University
Rachel Popp Colorado State University
Allison Serafin Colorado State University
Advisor(s): Dr. Patrick Shipman, Colorado State University

Color is an integral part of a child's development, beginning with distinguishing different colors to describing colors with names. In math and science learning, principles of color are frequently enjoyed, used, and remembered by students - and, in fact, many scientific discoveries have been made by observing color changes. At Colorado State University, we are working with a local elementary school to develop a set of integrated math, science, art and writing materials using color as a theme. These materials provide a solution to the problem of severe disciplinary divisions that exist in the K-12 education, particularly between math and science. n our approach, children map colors to number, thereby learning mathematical concepts of mappings and quantification of non-numerical elements. We set up an experiment in which the students use their color map to quantify color changes in extracts of fruits and vegetables mixed with acids and bases. In another activity, the students use drops of colored dyes to construct a Munsell hue map as they use their knowledge of fractions. We observed that not only were these kids enjoying the activities, but that they were also retaining the concepts of mappings, fractions and concepts in chemistry.

50. Mitochondrial Iron: a Mathematical Model for Iron Regulatory Disease

Jessica Lunsford East Tennessee State University
Advisor(s): Erika Camacho, Arizona State University

Using a mathematical model that incorporates both the cytoplasm and mitochondria, we simulated the pathway of iron regulation in the cell. In particular we use seven nonlinear differential equations to model the disturbances in iron homeostasis brought about by low/ high extracellular iron levels as well as frataxin protein deficiency (which results from the genetic disease Friedreich's ataxia). Numerical and stability analysis suggests that there is a unique stable equilibrium. This is biologically significant as this robust feature is observed in the actual cell. We use sensitivity analysis to identify key processes responsible for bringing the cell to iron homeostasis. Our in-silico experiments

show the importance of combined gene therapy in counteracting cell death due various iron regulatory diseases. Our mathematical findings suggest some potential treatment options.

51. Information Theoretically Secure Computation Protocols in the Quantum Noisy Storage Model

Jenna Huston Westminster College
Advisor(s): Stacey Beggs, IPAM

Classical secure communication protocols rely on the unproven intractability of certain mathematical problems. In contrast, recent advances in quantum cryptography describe protocols with provable unconditional security under only physical assumptions. We examine the practicality of efficiently implementing a particular protocol of interest (*string equality*) under these physical assumptions (known as the *noisy storage model*) by considering a set of subprotocols. Following the security constraints derived in previous work, we analyze computer models to empirically measure computation time and bandwidth, both classical and quantum, for each protocol.

52. Modeling HIV Infection with Data Mining Techniques

Glenn Sidle Duquesne University
Lauren Grana St. Johns University
Advisor(s): John David, Virginia Military Institute

Many models of HIV infection require an underlying assumption about the biological mechanisms of infection, and simple statistical techniques often struggle to capture the nonlinear dynamics of this system. In order to capture these dynamics without impressing assumptions on the system, we will examine the use of data mining. The techniques we use are artificial neural networks, a type of generalized nonlinear regression modeled after biological neural networks, and regression trees, a type of data mining procedure modeled after a decision flow chart. We will use the techniques based on past patient CD-4 count, CD-8 count, viral load and drug adherence to predict future patient health. We will describe techniques for creating both patient-specific models and a model created for all patients. After analyzing the model's ability to predict both short and long term patient health, we will describe how we can use the techniques to create a virtual clinical cohort on which we can evaluate the impact of clinical trials. Finally, we will show how this model can be used to understand how to optimally treat each patient.

53. Machine Learning: Support Vector Machines Using Nonlinear Rescaling-Augmented Lagrangian Method

Emiline Pelletier Nazareth College
Advisor(s): Igor Griva, George Mason University

We have developed a MATLAB code using support vector machines to separate a dataset into output categories. To solve the SVM problem, we used the nonlinear rescaling-augmented Lagragian method along with Newton's method for unconstrained optimization. We have tested our algorithm on various datasets with various results. (This project was funded by the NSF REU at George Mason University)

54. Faster computation of the Kauffman polynomial

Jonathan Shi University of Washington
Lauren Anne Ellenberg Arcadia University
Gabriella Lynn Newman Carleton College
Advisor(s): Stephen F. Sawin, Fairfield University

The Kauffman polynomial is an important knot invariant that forms the foundation for a large class of other knot invariants. The problem of computing the Kauffman polynomial affords an accessible approach to differentiating knots by their knot diagrams. We show an upper bound on the time complexity of determining the Kauffman polynomial of tangles. The problem can be solved in time $O(n^2 2^g)$, where n is the number of crossings in the tangle diagram and g is the girth, the girth being defined as the cutwidth of the tangle diagram graph. Furthermore we show that $g \in O(\sqrt{n})$, with progress toward a stronger bound of $g \leq 4\sqrt{n}$.

55. Matrix Completions for the Matrix Equation $AX - XA^T = 0$

Jacob Buchholz Colorado State University, Pueblo
Advisor(s): Geoffrey Buhl, California State University, Channel Islands

In applied and theoretical mathematics, it is often desirable to complete a matrix whose entries are partially specified so that it satisfies a given property. We focus on completing a matrix so that is satisfies the matrix equation $AX - XA^T = 0$. If X is also symmetric, this transforms a non-symmetric eigenvalue problem to a simpler symmetric eigenvalue problem. Hence, given a square matrix A and a partial matrix pattern of specified and unspecified entries in a partial matrix X, we determine when X has a completion satisfying $AX - XA^T = 0$. We develop two methods using techniques from linear algebra. In the first method, we rewrite the matrix equation using Kronecker products and examine the resulting linear equation. For the second method, we construct a basis for the nullspace of the linear transformation corresponding to the matrix equation and use the basis to determine which partial matrix patterns have completions. In the case that every eigenvalue of A has geometric multiplicity one, we give a necessary condition for the partial matrix X to have a completion.

56. Non-Stable K-Theory of an Arbitrary Graph Algebra

Marissa Loving University of Hawaii at Hilo
Advisor(s): Efren Ruiz, University of Hawaii at Hilo

In 2005, Gene Abrams and Gonzalo Aranda Pino showed a way to associate an algebra to a row-finite, directed graph, which they generalized in 2008 to arbitrary countable, directed graphs. In 2007, Ara, Moreno, and Pardo computed the non-stable K-theory of a Leavitt path algebra and also showed that this monoid satisfies the refinement property and separative cancellation. They achieved this result by showing that the non-stable K-theory of the Leavitt path algebra can be completely described by generators and relations. Another consequence of their result is that they described the ideal structure of the Leavitt path algebra. We discuss our recent results which generalize the work of Ara, Moreno, and Pardo to arbitrary countable directed graphs. To obtain this result, we defined a similar monoid that accounts for the presence of infinite emitters. We then showed that our monoid is naturally isomorphic to the monoid generated by the desingularization of an arbitrary directed graph. This allowed us to use the results of Ara, Moreno, and Pardo to obtain the desired natural isomorphism.

57. Specializations of Generalized Rikuna Polynomials

Alex Rasmussen Colby College
Celeste Cass Bard College
Advisor(s): John Cullinan, Bard College

The generalized Rikuna polynomials are an iterative generalization of Rikuna's generic cyclic polynomials, which themselves generalize Shanks' cubic polynomials. We study Galois properties of the generalized Rikuna polynomials under specialization.

58. An Application of Principal Component Analysis to Educational Data in Indiana

Gina Deom Saint Mary's College
Advisor(s): Kristin Jehring, Saint Mary's College

This poster examines the educational status of girls in Indiana and provides an in-depth analysis of Indiana school corporations using a new approach. We collected data from the U.S. Census Bureau and the Indiana Department of Education concerning the demographic population of Indiana girls and boys age 10 to 19 years old. The data was first aggregated to show how boys and girls compare in Indiana on standardized testing, graduation rates, and college entrance exams. Our analyses shed light on educational gaps that still exist between girls and boys in the state and we hope our work will direct more action toward reducing those gaps. Given the large number of variables available relating to Indiana public school corporations, we then used principal component analysis (PCA) to determine which factors are the most meaningful and influential in relation to describing and comparing Indiana public school corporations. The results of the PCA demonstrate trends in the data with respect to the size of a school corporation as well as geographic location. We explain the theory behind PCA and also how it was applied to our data set.

59. Atomisticity and Coatomisticity of the Supercharacter Theory Lattices of Cyclic Groups

Daniel Stoertz Concordia College
Dylan Heuer Concordia College
Advisor(s): Anders O.F. Hendrickson, St. Norbert College

Although most study of the supercharacter theories of finite groups has centered on algebra groups, recent research has also begun looking at the set $Sup(C_n)$ of supercharacter theories of the cyclic group C_n. This set has a lattice structure, and we find necessary and sufficient conditions on n for that lattice to be coatomistic. We also find necessary conditions on n for $Sup(C_n)$ to be atomistic, and we conjecture that those conditions are also sufficient.

60. Support Vector Machines and the Exterior Point Method

Anna-Rose Wolff George Mason University
Advisor(s): Timothy Sauer, George Mason University

Support Vector Machine (SVM) learns an unknown function by recognizing underlying patterns within large data sets. One of the goals of the SVM is to find the support vectors, or data points that contain the most important information about the unknown function. We develop an optimization algorithm for finding the support vectors based on an exterior-point method and data decomposition.

61. The kernel of the matrix $i \cdot j \mod n$

Adam Telatovich Baylor University
Advisor(s): Maria Isabel Bueno Cachadina, University of California, Santa Barbara

Let $\hat{\mathbb{Z}}_n$ denote the group of characters of the cyclic group $\mathbb{Z}_n$. For a particular linear transformation from the group ring $\mathbb{Q}[\hat{\mathbb{Z}}_n]$ into $\mathbb{Q}[\mathbb{Z}_n]$, there is an $n \times n$ matrix representation whose (i, j)th entry is given by $i \cdot j \mod n$. It has been the goal of this project to determine the kernel of this linear transformation. We have conjectured that, when n is an odd prime number, the rank of the linear transformation is $\frac{n+1}{2}$. We have proven this conjecture for certain primes; in particular, for primes of the form $n = 2^r q^s + 1$ where r, s are positive integers and q is an odd prime. Furthermore, in this case, we can give a basis for the kernel of the function.

62. Design of laser beams in GRIN media for profile transformation and selective resonance

Tim Moon Rice University
Delani Cele Ithaca College
Hyunmoon Kim Princeton University
Philip Burnham Villanova University
Advisor(s): Daniel Flath, Macalester College

We perform a theoretical study of laser optics in gradient index (GRIN) materials, media with a continuously varying index of refraction. Geometrical optics is employed to model the behavior of light in external GRIN rods. The inverse problem is investigated to design rods that produce custom beam structure. For GRIN rods in optical cavities, light propagation is simulated with a paraxial approximation of the wave equation. We implement techniques to determine the modes of laser cavities and their respective attenuation, with the goal of finding configurations that support a strong fundamental mode while suppressing higher-order modes.

63. Generating Functions for Inversions on Pattern Avoiding Involutions

Ashley Broadwell Pepperdine University
Josh Thornton Pepperdine University
Advisor(s): Kendra Killpatrick, Pepperdine University

The generating function for inversions on 312-avoiding permutations is given by the q-Catalan polynomial $C_n(q)$ and can be determined by using the area statistic on Dyck paths. We will examine the generating function for inversions the subset of 312-avoiding permutations that consists of the 312-avoiding involutions. We prove that this generating function is equal to the generating function for inversions on 231-avoiding permutations and, in fact, characterize the generating function for inversions on all six subsets of pattern avoiding involutions.

64. Pursuit-Evasion in Polygonal Environments: When Can Two Cops Win?

Rosalie Carlson Harvey Mudd College
Maxray Savage Macalester College
Claire Djang Oberlin College
Stephen Ragain Pomona College
Advisor(s): Andrew Beveridge, Macalester College

Motivated by applications in robotics, we study pursuit-evasion in polygonal environments with polygonal holes. In this turn based game, a robber r is pursued by cops $c_1, c_2, \ldots, c_\ell$. The players have full information about the environment and the other players. The cops can coordinate their actions. On the cop turn, each c_i can move to any point at distance at most 1 from his current location. On the robber turn, he moves similarly. The cops win if some cop becomes co-located with the robber in finite time. The robber wins if he can evade capture forever. It is known that one cop can capture the robber in any simply connected environment, and that three cops are sufficient in any environment with holes. We study environments with a winning strategy for two cops. We focus on *monotone cop strategies*, where the area available to the robber decreases monotonically in each round. We characterize when an environment with a single hole is one-cop-win or two-cop-win. Using the polygon dual, we give an $O(n^2)$ algorithm to determine whether a given environment has a winning two-cop sweeping strategy. Finally, we give sufficient general conditions for the existence of a monotone 2-cop strategy, and describe how to construct a winning strategy.

65. Optimisation of the Cyber-security TRIAGE Method for Real-world Criminal Events

Joseph Page University of Oxford
Advisor(s): Stacey Beggs, IPAM at UCLA

The TRIAGE method was developed by Symantec as a novel attack attribution method for cybercrimes. It is based upon the use of aggregation functions within multi-criteria decision analysis. The aim of this project is to investigate it's applicability to real-world criminal events. It is desired to see if an optimised TRIAGE method is able to produce relevant and meaningful results, in this case clusters of crimes committed by the same perpetrator or group of perpetrators. In order to do this data on real world criminal events was required and this was provided by the Los Angeles Police Department. The current TRIAGE method was optimised using a method developed by the 2011 RIPS LA Symantec team and by incorporating the expert knowledge of the LAPD. This technique was able to produce a number of clusters which were believed to be both relevant and meaningful. However, some undesired results were produced and there are limitations to the use of the optimised TRIAGE method. It is believed that with further refinement optimal results could be obtained. In conclusion, it is believed that the TRIAGE method is applicable to real-world criminal events.

66. Pricing and Risk in the Credit Markets: Investigation of Credit Default Swaps

Vanessa Rivera Quiones University of Puerto Rico, Rio Piedras
Advisor(s): Stacey Beggs, Institute for Pure and Applied Mathematics

The purpose of this project was to provide Standard and Poor's (S&P) an evaluation of their Market Derived Signals (MDS) models that are used to assess the credit quality of a corporation. These are based on the Credit Default Swap (CDS), bond and equity markets. The informational value of prices have long been recognized in economics. We attempt to use the market's assessment of credit risk as a source of data different from the ratings analyst's assessment. Our initial objective was to evaluate the effectiveness of the MDS models in providing significant signals on changes in credit quality and to conclude if there exists a superior model among the three. The performance measures used were the Cumulative Accuracy Profile (CAP)and the Accuracy Ratio (AR). We also sought to determine the persistent signals that preceded an official rating change from S&P. This was carried out by measuring the significance of the discrepancies(signals)over different time frames and investment grades corporations. We proceeded to develop a multinomial logit model to assess credit quality by combining information from the three markets and evaluated its performance. Finally, we explored determining the optimal credit curve for pricing bonds using the outputs from the CDS and Bond-MDS models.

67. Effects of wildfire smoke and fog on highway visibility as shown by a mathematical model

Andrew Getz New Jersey City University
Advisor(s): Zhixiong Chen, New Jersey City University

We modeled the transportation of smoke particles from a wildfire and the presence of fog particles on a highway to determine the degree of decreased visibility for automobile drivers. Accidental wildfires and prescribed burns produce large PM2.5(smoke particle) concentrations that travel to highways and lead to major motor vehicle accidents as a result of driver impairment, especially when fog exists. We studied the concentration of PM2.5 and fog particles in the driving view of automobiles on the highway by using numerical and analytic methods to solve diffusion-advection partial differential equations. The final concentration of smoke and fog particles after a period of wildfire burning was compared to a visibility range chart to determine the level of visual impairment for drivers on the highway.

68. Urban Lead and Its Health Consequences on Children: A Mathematical Model

Bernard Lipat New Jersey City University
Andrew Getz New Jersey City University
Advisor(s): Dr. Zhixiong Chen, New Jersey City University

We model the transportation of atmospheric and soil-based lead at the macro- and meso-scales to study its health effects on children in Jersey City. The Crank-Nicolson numerical approximation of the diffusion-advection partial differential equation in three spatial and one temporal dimension is used to calculate the concentration of atmospheric lead that had settled onto the surface of the soil, using as an initial condition a polynomial interpolation which considers lead that had accumulated from automobile exhaust and as a boundary condition the mean lead emissions from a nearby smelting plant. Considering the bioaccessibility and bioavailability of lead, a proportionality based on cumulative exposure over time, as measured by blood concentration, is used to determine the relative health risks.

69. Modeling the Human Papillomavirus (HPV) with Female and Male Protected Classes

Arielle Gaudiello The Richard Stockton College of New Jersey
Advisor(s): Brandy Rapatski, The Richard Stockton College of New Jersey

HPV is sexually transmitted disease that affects an estimated 75% of the world. We created an ODE model for HPV, focusing on the female and male population between the ages of 13 and 26, the class highest at risk for infection. The population was split into 7 different groups: susceptible, protected, inactive, and infected females, and susceptible, inactive and infected men. With this model, we investigated how effective protecting females via vaccination would be in reducing R0, the reproduction number of the disease, below 1, the quantity needed to change the epidemic to an endemic. Improvements were then made regarding the structure, assumptions, and classifications of groups. This modified model allowed more flow between the groups, particularly changing the movement between the susceptible, protected, and inactive females. We determined the equilibrium solutions and their stability. From there, we added and 8th group, a male protective class, and determined the effectiveness in reducing R0. The addition of the male protected class significantly played a role in the in altering the prominence of HPV among the population.

70. Epidemic Models: Controlling Pest Populations with Sterilizing Pathogens and Vertical Transmission

Julie Pattyson University of Saint Joseph
Adrienna Bingham Angelo State University
Denali Molitor Colorado College
Advisor(s): Daniel Maxin, Valparaiso University

We analyze the effect of full vertical transmission in several epidemic models involving infectious diseases that cause sterilization in the infected hosts. Under certain conditions on the parameters, we found that the sterilization effect may prevent a susceptible extinction situation regardless of how large the infection rate may be. This effect is studied under several functional forms for the infection transmission term in order to assess its robustness. The implication in pest control measures is also discussed.

71. Recycling toward a Better Earth through Math

Yvette Niyomugaba Southwestern University
Advisor(s): Dr.Therese Shelton, Southwestern University

As the world population increases significantly, recycling is one of the effective ways to conserve energy and natural resources. In addition, recycling reduces landfill use and the environmental damage from pollutants and greenhouse gas emissions. Plastic is one of the most consumed products worldwide, and this research will focus on modeling plastic recycling and landfill usage in Bangladesh and the United States. We develop a Markov chain model in which state diagrams show the flow of plastic in a recycling system. Linear, exponential, and logistic functions are used to describe the amount of plastic at different stages, including virgin plastic and landfill. In addition, the relationship between landfill growth and plastic consumption are modeled using various mathematical procedures.

72. Eternal Sunshine of the Solar Panel

Sowmya Srinivasan Bryn Mawr College
Barbara Urena Arizona State University
Mackenzie Ginithan University of South Dakota
Daniel Lefevre Virginia Polytechnic Institute and State University
Advisor(s): Jose D. Flores, University of South Dakota

Using a modified compartmental model we study the dynamics of residential solar panel use between households in a theoretical population. Our model considers three solar power options commonly available to consumers: community block, leasing, and buying. In particular we are interested in studying how social influence affects the dynamics between these compartments. We determine a threshold value, beyond which solar panel use is established in the population over the long term. In addition, we perform uncertainty and sensitivity analyses on the threshold value to determine the effects of variation in the values of the parameters. We also perform uncertainty analysis on the population levels of each compartment. Our analysis shows that social influence plays a pivotal role in the adoption of residential solar power technology.

73. Evolution of within-host Antibiotic Resistance in Neisseria Gonorrhoeae

William Tressel University of San Diego
Advisor(s): Stephen Wirkus, Arizona State University

Gonorrhea is a sexually transmitted bacterial infection caused by Neisseria gonorrhoeae that has become resistant to a wider range of antibiotics in recent decades. We study the competition dynamics of multiple N. gonorrhoeae bacterial strains within a host in an effort to better understand the development of antibiotic resistance and examine individual-patient treatment regimes to determine conditions for within-host antibiotic-resistance emergence. To that aim, we propose a phenomenological model of nonlinear differential equations that takes into account essential ideas such as the effects of different treatment levels, the mutation rates of bacteria, and the response of the immune system. We find steady state solutions and use analytical and numerical techniques to analyze their biological significance and stability behavior. Numerical simulations also provide a more integral view of how model parameters affect the emergence of within-host resistance.

74. Modeling of Ground-Level Ozone Exceedances Measured in Five National Parks Using Non-Parametric Methods

Adaeze Ajoku University of Miami
Advisor(s): Dr. Javier Rojo, Rice Univeristy

The 1990 Clean Air Act (CAA) Amendments mandated implementation of ozone reduction proposals according to the severity of regional pollution. Analysis of the trend of ground- level ozone exceedances in parks, which pick up pollutants from nearby cities, can indicate the effect of the CAA. We analyzed data from seven different sites in five national parks from 1987 to 2012 to observe a variety of ozone trends, hypothesizing that there would be an overall decreasing trend. We clustered exceedances over a predetermined threshold at time intervals yielding independence. Our chosen threshold of 0.068 parts per million maximized the number of annual clusters; we clustered exceedance points within 72 hours of each other. Each cluster maximum was grouped by year and evaluated using the non-parametric Jonckheere-Terpstra (JT) Test, which stochastically ordered the years. Also, Lehmann's statistic (1975)

trend (LST) test stochastically ordered the annual cluster count frequency. Analysis at alpha 0.05 rejected the null hypothesis at three sites for the JT test and one for the LST test indicating significant statistical differences in ozone levels. Ozone quality in surrounding regions may account for this difference. Rejecting the null hypothesis provides is useful for future legislation.

75. West Nile Surveillance: Is Disease Risk Being Underestimated?

Yi Ming Yu New York City College of Technology
Advisor(s): Nina H. Fefferman, Dept. of Ecology, Evolution and Natural Resources

Since the West Nile Virus was discovered in 1999 in New York, it has spread all over the United States and has caused several outbreaks, with a total number of over 1,100 deaths. The prediction of the spread of WNV becomes very important for the prevention of the disease. Many county and statewide ecologic surveillance programs have been established to accomplish this task. Since the WNV spreads between birds and mosquitoes, the surveillance program has to make a choice on the species it wants to investigate and monitor. While bird and mosquito surveillance is used to estimate expected human cases, WNV cannot be transmitted from infectious birds to human directly; infectious mosquitoes are necessary bridge vectors. In this paper, models of spread of WNV were used to test the liabilities of the prediction by detecting the number or percentage of infected dead birds and mosquitoes in their populations, with the assumption that the mosquitoes will feed more often on birds with WNV than other birds. The simulations suggest that the surveillance programs should not make their predictions of the risk of the WNV in humans by estimating the prevalence of WNV in the birds' population alone. [This work was done during the 2012 DIMACS REU program at Rutgers University.]

76. Spatial Simulation of Chaparral Vegetation Response to Frequent Wildfire

Wancen Jiang Pepperdine University
Noah Benjamin Clark Webster Pepperdine University
Charlotte Willens Pomona College
Cassandra Seubert University of Southern California
Advisor(s): Timothy Lucas, Pepperdine University

The recent increase in fire frequency in the Santa Monica Mountains (SMM) has drastically impacted the surrounding vegetation. Chaparral shrubs represent the dominant vegetation type in the SMM. Chaparral can be divided into three life history types that characterize their response to wildfires. Nonsprouters are completely killed by fire and reproduce by seeds that germinate in response to fire cues. Obligate sprouters survive by resprouting because their seeds are destroyed by fire. Facultative sprouters both resprout and reproduce by seeds post-fire. We created a spatial simulation that models the growth, reproduction and resprouting behavior of individual plants that interact in an environment similar to our study site adjacent to Pepperdine University. We estimated simulation parameters using over 27 years of local data on species density, growth, rainfall and recorded fires. Our simulations show that short fire return intervals can eliminate nonsprouting species such as Ceanothus megacarpus; this reflects the change in plant community structure of our study site. If the average fire return interval of 6.5 years continues, we project that the vegetation cover would shrink from 74.5% to 8.7% over 60 years. This would lead to an increased risk of mudslides near our site.

77. Public Health Policies and Managing Bioterrorism

Annalisa Moore University of the Incarnate Word
Advisor(s): Zhanbo Yang, University of the Incarnate Word

The possibility of bioterrorism and experiencing a bioterrorist attack has been steadily increasing throughout history. The use of diseases and infectious agents as weaponry dates back to hundreds and hundreds of years ago. Recently biological advancements and research have made the mutation of infectious agents possible and life threatening. This research uses mathematical modeling to simulate the effects of possible bioterrorist agents on a closed population. By using variations of an SIR model, this research simulates several possible epidemic scenarios caused by a bioterrorism attack with the smallpox virus, as well as the avian and bird influenzas. The parameters of the model were manipulated to demonstrate the effects of various public health policies on minimizing the impact of those attacks. The results convey that public health policies are more effective when both preventative and responsive measures are implemented.

78. Modeling Elastic Interface Waves with the Parabolic Equation Method

Laura Tobak Marist College
Advisor(s): Scott Frank, Marist College

Underwater acoustic waves can be modeled using the elastic parabolic equation in range dependent environments with elastic sediment layers. Here we use the rotated variable parabolic equation method which is more accurate than either the mapping method or the coordinate transformation method. We generate solutions that allow investigation of underwater acoustics due to both compressional and shear seismic sources. In particular we will study the generation of Scholte and potential Stoneley interface waves. We examine the effects of varying frequency, sound speed, and sediment layer thickness on the Scholte and Stoneley wave amplitudes.

79. Computational Reliability Statistics of an Electrical Power Grid

Blanche Ngo Mahop Howard University
Advisor(s): Javier Rojo, Rice University

Have you ever stopped to wonder what are the odds of you losing power? You may not have but your electric service provider contemplates the question on the daily basis. In order for electrical companies to maintain happy customers they must depend on a system that can efficiently predict the probabilities of failing lines and locate the faulty distribution point. Thus, the main goal of our research project is to develop an algorithm, using the programming language R Studio, that will compute the reliability of a large system with multiple distribution points. We will first develop an algorithm that can calculate the number of customers without service, or power, while considering all components to be independent. Next, the algorithm will be able to calculate the number of customers without power while taking into account local dependence. In conclusion, the resulting algorithm will calculate how many customers are without power and which distribution points failed, or caused the interruption.

80. Using New York Cities 2009 Historical Traffic Data to Develop an iPhone Routing Application

Ixtli-Nitzin Sanchez San Jose State University
Advisor(s): Eugene Fiorini, Rutgers University

It is reported that the United States uses about half of the world's gasoline and the exhaust produced contributes to 60 percent of all the carbon monoxide emissions in the US. As the commuter's driving becomes more educated with the use of technology, such as smart phones, sustainable navigation for smart phone applications will be a necessity for the future reduction of carbon monoxide emissions. Beginning with New York City as a proof of concept, the intended iPhone application will use 2009 hourly traffic data, provided by the New York State Department of Transportation, and algorithmic graph theoretic techniques to generate a results page showing the path for the best route and it's total cost where edge weight is determined by traffic density along each segment. The routing program will also show traffic quantities for other time intervals that precede the driver's perspective present time, providing the user with alternative starting times, thus allowing the user to choose an optimal alternative starting time with subsiding traffic conditions that fits within the traveler's time frame. Future research includes extending the iPhone application to include a ride share program that will allow users to carpool with others interested in taking similar routes.

81. Principal Component Analysis in Financial Risk Management

Kwasi Platt Savannah State University
Andrew P. Herrera Amherst College
Advisor(s): Dr. Tao Pang, North Carolina State University

The volatility of stock returns is important to both financial institutions and regulatory bodies, both of whom aim to accurately measure the risk of investments. Value at Risk (VaR) is a common measure of portfolio risk in use today. Initially we calculated the Value at Risk under the assumption that the daily stock returns were normally distributed, but found that calculations of VaR under that method underestimated risk because the distribution of daily returns had fatter tails than the normal model. We improved the accuracy of the calculations through the consideration of distributions with fatter tails, specifically Student's-t distribution. Expanding the model based upon Student's-t to consider a portfolio of these assets resulted in similar successful calculations. We also evaluated the method of Principal Components Analysis (PCA) for dimension reduction, and discovered that dimensionality could

be significantly reduced without much sacrifice of accuracy. We then applied PCA to try and find macroeconomic factors to explain asset price movement in particular industries.

82. Competition Model between the Invasive Sahara Mustard and Native Plants in the Sonoran Desert

Kyle Dahlin University of Hawaii at Manoa
Austin Wehn Arizona State University
Amanda Laubmeier University of Arizona
Erika Koenig University of Maryland, Baltimore County
Advisor(s): Karen Rios-Soto, University of Puerto Rico at Mayaguez

Sahara Mustard (*Brassica tournefortii*) is an invasive weed that has become wide-spread throughout the southwestern United States. Its early germination, high fecundity, and dispersal effectiveness augment its ability to out-compete and possibly displace local flora. In this work, we model the dynamics of Sahara Mustard as it competes with winter annuals native to the Sonoran Desert, such as the widespread forb *Lepidium lasiocarpum*. A discrete-time competition model of plant-plant interactions is constructed to study factors that may affect competition between invasive and native species in favor of the native species. Through a system of non-linear difference equations we quantify each species' seed banks and flowering adult populations over several generations. We take into consideration the dependence of fecundity, survivability, and germination on total annual rainfall. A stochastic simulation is used to examine the effect of seasonal variability on existence of native species in competition with Sahara Mustard. We found that rainfall variability was advantageous to the native population, though the native forbs that compete with Sahara Mustard will likely be reduced in population or driven to extinction in absence of any control strategy.

83. Modeling antibiotic resistance in intensive care units

Andre Waschka North Carolina State University
Advisor(s): Ralph Smith, North Carolina State University

We introduce an individual based model (IBM) formulated as a system of stochastically determined events to describe the spread of nosocomial (hospital acquired) and antibiotic-resistant infections in intensive care units. Corresponding deterministic models describe the average behavior of the IBM over a large number of simulations. Hence, by randomly assigning patients' infection statuses and health care workers' contamination statuses, the model shows the possible scenarios for the disease outbreak in an ICU. Using these possible scenarios, we are able to model the on/off switch of antibiotics.

84. Prisoner Reform Programs, and their Impact on Recidivism

Kimberly Gutstein Humboldt State University
Advisor(s): Luis Melara, Shippensburg University

The California prison system has a high percentage of people who return to prison within a three year period after release. A mathematical model is formulated to study the effectiveness of Reentry Court programs for first time offending parolees designed to reduce the prison return rates when implemented alone or in conjugation with an in prison educational program. Parolees who participated in both in/out of prison programs are referred to as an ideal class in the model. Stability analysis and numerical simulations were carried out to study the impact of the programs. The results show that the reentry program reduces the recidivism rate more than the Basic Educational program within the prison system, but only when social influence of criminals is low outside of prison. However, for populations with high rates of social influences, incarceration rates should be large in order to get the same impact of the reentry program.

85. How Ideas Grow: Critical Mass in the Linear Threshold Model

Hossein Alidaee Macalester College
Advisor(s): Andrew Beveridge, Macalester College

We study how ideas spread through a social network using a linear threshold model. Each node i on the complete graph K_n is given a threshold ϕ_i chosen uniformly from $[0, 1]$. This threshold indicates the fraction of the social network that must be active, or believe the idea, prior to node i becoming active. We start with an activated group of early adopters, called the *seed set*. Considering various scenarios, we use the probabilistic method to find lower

bounds on size of a seed set which guarantees that $n(1-o(1))$ nodes become active with high probability. We characterize seed sets for both homogenous and heterogeneous influence by nodes. In the special case of a single seed node, we draw connections between the linear threshold model and the Catalan numbers.

86. On Rationally Ergodic and Rationally Weakly Mixing Rank-One Transformations

Tudor Padurariu University of California, Los Angeles
Xavier Garcia University of Minnesota, Minneapolis
Advisor(s): Cesar Silva, Williams College

We study the notions of weak rational ergodicity and rational weak mixing as defined by Jon Aaronson for infinite measure-preserving transformations. We partially characterize the families of rank-one transformations which possess (or do not posses) these properties, based on the construction of the transformations. We also consider the relation between rational weak mixing and other notions of mixing in infinite measure; to this end, we prove rational weak mixing implies double ergodicity and is independent of zero-type.

87. L^p Bounds for the Zonal and Sectoral Harmonics and the Connection to the Quantum-Classical Correspondence

Stephen Pietromonaco University of New Mexico
Advisor(s): Matthew Blair, University of New Mexico

The Spherical Harmonics are a well known family of functions. The *Zonal Harmonics* are defined to be the subset $\{Y_l^0 | l = 0, 1, 2, ...\}$ while the *Sectoral Harmonics* are the subset $\{Y_l^l | l = 0, 1, 2, ...\}$. My research has been focused on proving claims made by Szego, Sogge, and Zelditch on bounds of the L^p norms for the zonal and sectoral harmonics in the case of large l values. This is a nice illustration of the Quantum-Classical Correspondence. In the case of the zonal harmonics I proved the following claim made by Szego. Given L^2 normalization:

$$||Y_l^0||_p \backsim \begin{cases} 1 & p < 4 \\ (\log l)^{\frac{1}{4}} & p = 4 \\ l^{\frac{1}{2}-\frac{2}{p}} & p > 4 \end{cases}$$

The above claim illustrates that as $l \to \infty$, Y_l^0 exhibits Dirac delta function behavior at the north and south pole of $\mathbb{S}^2$. With regard to the sectoral harmonics, I prove the following assertion made by Sogge/Zelditch:

$$||Y_l^l||_p \backsim l^{\frac{-1}{2p}+\frac{1}{4}}.$$

The above claim shows that as $l \to \infty$, Y_l^l again exhibits Dirac delta function behavior around the equator of $\mathbb{S}^2$.

88. Signature Change and Linear Dependence of Curvature Tensors

Sarah Schmidt California State University, San Bernardino
Advisor(s): Corey Dunn, California State University San Bernardino

We consider the linear dependence of 3 canonical algebraic curvature tensors and extend previous results of others by working in the higher signature setting.

89. Square free coloring of graphs

Christopher Simmons The University of Texas, Tyler
Ashley Cardwell East Central University
Lousanne White University of Utah
Advisor(s): David Milan, University of Texas at Tyler

A coloring of the vertices of a graph G is *square free* if no path in G consists of two occurrences of the same string of colors. For example, a path consisting of colors "blue red blue red" is a square, whereas a path consisting of colors "blue red green blue red" is square free. The square free chromatic number of G, denoted $\pi(G)$, is the smallest number of colors required for a square free coloring of G. We extended the notion of square free coloring to allow squares up to length $2k$, defining the long-square free chromatic number $\pi^k(G)$. We compute $\pi^2(G)$ for paths, cycles, and trees.

90. Accurately Modeling Zooplankton Mortality Rates

Katherine Shipman College of William & Mary
Catherine King College of William & Mary
Advisor(s): Drew LaMar, College of William & Mary

Modeling zooplankton dynamics properly is increasing in importance because zooplankton grazing has been shown to impact critical issues ranging from eutrophication to climate change. Zooplankton mortality rates are the most critical aspect of the currently existing models; however, current models only include linear predatory mortality rates. This incomplete approach underestimates zooplankton mortality and therefore overestimates actual zooplankton abundances. In order to further determine the significance of the zooplankton mortality term, we performed both sensitivity and interval analysis on the currently existing model. These methods analyzed the changes in the eigenvalues and eigenvectors as the parameters were altered. Similarly, new techniques in interval analysis were used to determine the maximum epsilon, or error, allowed for a certain parameter that will still allow growth in the population. Analyzing the mortality term in this way will help us create more efficient and accurate models. Non-linear mortality terms that separate non-predatory and predatory mortality rates were also included. Correctly incorporating both types of mortality rates will improve current models for aquatic ecosystems around the world.

91. Comparing the genus of tangle closures

Kathryn Litzau University of Wisconsin, Eau Claire
Advisor(s): Carolyn Otto, University of Wisconsin-Eau Claire

The aim of my research project is to understand rational tangles and their relationship to genus. The numerator closure and the denominator closure are the focus of this project. When a closure operation is performed on a tangle, a knot or link is obtained. I am using Seifert's Algorithm to determine an upper bound for the genus. I studied tangles with 1 vector component, 2 vector components, and 3 vector components. For the more complicated tangles, I found patterns to find genus wither by reducing it to a lower level tangle of by creating formulas for genus based on the twisting involved.

92. On Total Domination and Cut Vertices of a Graph

David Amos University of Houston - Downtown
Advisor(s): Ermelinda DeLaViña, University of Houston - Downtown

The total domination number of a simple, finite, undirected graph $G = (V, E)$ with no isolated vertices, denoted γ_t, is the cardinality of a smallest subset S of V such that every vertex $v \in V$ is adjacent to a vertex in S. It is known that for trees, $\gamma_t \geq (n - l + 2)/2$. where n is the order of the tree and l is the number of leaves. Here, we generalize this bound to any graph with no isolated vertices. In particular, $\gamma_t \geq 1 + |C| - \mu(G[C])$, where $C \subseteq V$ is the set of cut vertices of the graph and $\mu(G[C])$ is the matching number of the subgraph induced by C. Furthermore, if the matching of this subgraph is perfect and even, then $\gamma_t \geq 2 + \mu(G[C])$. Both of these bounds are sharp.

93. Pandemic at Pacific: Comparing ODE Models with Random Network Models

Austin Tuttle University of the Pacific
Advisor(s): John Mayberry, University of the Pacific

The SIR model for disease spread utilizes a system of ODE'S that makes certain assumptions. In this project, we investigate how accurate this is by comparing the predictions of ODE models with more realistic random network models for flu spread in a medium sized college campus. For our network model, we used four different degree distributions to describe individual contacts: Uniform, Power Law, Binomial, and Bimodal-Binomial. We found that the ODE model severely over-estimates the size of the outbreak and its duration even after adjusting our ODE model parameters to take into account size biasing in the disease spread through our network. Next, we investigate the effect of distributing a limited amount of vaccinations to individuals in our network. We propose three vaccination strategies: 1.Target those with the highest number of unvaccinated connections. 2.Target those with the lowest number of unvaccinated connections. 3.Randomly vaccinate. Based on the results of Monte Carlo simulations, we discovered that strategy 1 was more effective than strategy 2 for Power Law(31% fewer infected)but not for Binomial(7% fewer). Thus we conclude that before a method for distributing a limited supply of vaccines can be made, the degree distribution of the population must be investigated.

94. Classification of Parseval Frames in $\mathbb{Z}_2^n$ by Transmission Error

Amanda Hoisington University of California, Riverside
Abby Lynn Pekoske Carthage College
Advisor(s): David Larson, Texas A&M University

It is common for information to be transmitted digitally, thus message vectors can be thought of as binary vectors. In practice, lossy connections produce errors in a transmitted message. In these cases, a spanning set of linearly dependent vectors known as a frame can be used to reduce reconstruction errors. Parseval frames have particularly nice properties that allow them to be used for both deconstruction and reconstruction. Vershynin (2005) proved that for $\mathbb{R}^n$, in order to bound the probability of erroneous reconstruction, the necessary amount of vectors required to survive the transmission is a multiple of $n \log n$. We seek to extend these results to $\mathbb{Z}_2^n$, and in doing so, have constructed a classification of Parseval frames with respect to the probability of faulty reconstruction.

95. Generic Polynomials for Transitive Subgroups of Order 8 and 9

Jonathan Jonker Michigan State University
Advisor(s): Jorge Morales, Louisiana State University

We compute generic polynomials for certain transitive subgroups of order eight and nine, namely SL(2,3), the generalized dihedral group: $C_2 \ltimes (C_3 \times C_3)$, and the Iwasawa group of order 16: M_{16}. Rikuna proves the existence of a generic polynomial for SL(2,3) in four parameters; we extend a computation of Gröbner to give an alternative proof of existence for this group's generic polynomial. We establish that the generic dimension and essential dimension of the generalized dihedral group are two. Finally, Ledet proved the existence of a generic polynomial for the Iwasawa group in five parameters ; we lower this number to four.

96. The Two-Dimensional Smoothing of Images via the Total Variational Model

Jo Fawna Reali California State University, Stanislaus
Paulos Alemu California State University, Stanislaus
Joshua Galvez California State University, Stanislaus
Susana Urquizo California State University, Stanislaus
Advisor(s): Dr. Jung-ha An, California State University, Stanislaus

An image is a matrix wherein each element represents a pixel's intensity for the purpose of image processing. Image processing is a form of signal analysis that refers to the process of computing with images. One important task in image processing is to smooth a noisy data set. The total variation based model of Rudin, Osher, and Fatemi is widely used to remove noise from digital images while preserving important structures in the data. The purpose of this research is to investigate the total variational model and its effectiveness in obtaining better images. Optimal solutions for the total variational minimization problem are found with Euler-Lagrange equations. This paper shows the derivations of these Euler-Lagrange equations in detail. Four original synthetic images of 256×256 pixels were created to test the total variational model. Our numerical experiments utilized finite differences to approximate the variation of an image and concluded that the central difference yielded the best results. With this, our numerical results show the effectiveness of the total variational model. Future work includes applications of this method to medical data and comparing numerical outcomes with other existing algorithms.

97. Leavitt Path Algebra Associated with Acyclic Graphs

Joyce Auau University of Hawaii at Hilo
Advisor(s): Brian Wissman, University of Hawaii at Hilo

In 2005, Gene Abrams and Gonzalo Aranda Pino constructed a universal algebra from a directed graph E. They called this algebra the Leavitt path algebra associated with E. My partner and I conducted research which discussed what Abrams and Pino constructed. We then describe the Leavitt path algebra when E is a finite acyclic directed graph, i.e., E has finitely many vertices, finitely many edges, and for each vertex v, there is no path that start and end at v. We showed that the Leavitt path algebra is completely determined by vertices in E called sinks and the number of paths to the sinks.

98. Unimodal sequences and quantum and mock modular forms

Sarah Pitman Emory University
Jennifer Bryson Texas A&M University
Advisor(s): Ken Ono, Emory University

We show that the *rank* generating function $U(t;q)$ for strongly unimodal sequences lies at the interface of quantum modular forms and mock modular forms. We use $U(-1;q)$ to obtain a quantum modular form which is "dual" to the quantum form Zagier constructed from Kontsevich's "strange" function $F(q)$. As a result we obtain a new representation for a certain generating function for L-values. The series $U(i;q) = U(-i;q)$ is a mock modular form, and we use this fact to obtain new congruences for certain enumerative functions.

99. A Statistical Model to Detect Copy Number Variation

Elizabeth Cangialosi University of Delaware
Aashish Gadani University of Maryland, College Park
Advisor(s): Stacey Beggs, IPAM at UCLA

Copy number variation (CNV) occurs when large segments of a genome are duplicated. Using a massive amount of DNA short read data from the species *Daphnia pulex*, we investigate the role that CNV plays in the species' adaptation to its environment. Among the tools we used, we present CNV-ripper, a new statistical model that identifies CNV regions using a depth of coverage approach. Given Next Generation Sequencing data from two populations of a species with a reference genome and an alignment step, our program can output relative CNV regions. Simulated genomic data is used to tune the program's parameters and regions are output in the form of gene annotation files. Methods for preprocessing read fragments are also suggested, as well as a metric to determine the overall similarity between two populations.

100. An Algorithmic Approach to the Semidirect Products of Permutation Groups

Kevin Halasz University of Puget Sound
Advisor(s): Rob Beezer, University of Puget Sound

I had the goal of updating the code in Sage, an open-source computer algebra system, so as to make it possible for users to create every group of order less than 32 with just a few easy commands. As I went about exploring the more intricate small groups, I discovered that there was an operation that could be used in the construction of nearly all necessary groups: the semidirect product. I thus set about crafting several algorithms that captured the operation's power. In the end, I added to Sage a semidirect product command, a command for a related operation known as the holomorph, and added to the Sage permutation group library three previously unimplemented families of groups whose construction algorithms essentially crafted a modified semidirect product. With these five routines, I met my goal of making accessible all groups of order less than 32, while at the same time adding infinitely many new groups to Sage's library.

101. Numerical Method for Fractional Differential Equations

Joel Coppadge Morehouse College
Advisor(s): Dr. Masilamani Sambandham, Morehouse College

Fractional differential equation is a differential equation of fractional order. Here for Caputo's fractional differential equation we develop numerical method. In particular for Caputo's fractional differential equation we will develop Improved Euler method and Runge-Kulta Method. To illustrate the theory we will present some numerical examples.

102. Planar rook algebra with colors and Pascal's simplex

Amy Shoemaker Pomona College
Sarah Mousley Utah State University
Nathan Schley University of California, Santa Barbara
Advisor(s): Stephen Bigelow, University of California, Santa Barbara

We define $P_{n,c}$ to be the set of all diagrams consisting of two rows of n vertices with edges, each colored with an element in a set of c possible colors, connecting vertices in different rows. Each vertex can have at most one edge

incident to it, and no edges of the same color can cross. We find a complete set of irreducible representations of $\mathbb{C}P_{n,c}$. We show that the Bratteli diagram of $\mathbb{C}P_{0,c} \subseteq \mathbb{C}P_{1,c} \subseteq \mathbb{C}P_{2,c} \subseteq \cdots$ is Pascal's $(c+1)$-simplex, and use this to provide an alternative proof of the well-known recursive formula for multinomial coefficients.

103. Development of Molecular Profiles to Predict Survival in Lymphoma Patients Treated with R-CHOP

Joseph Moen Wartburg College
Elizabeth Wolf Arcadia University
Sara Burns University of Connecticut
Advisor(s): Dr. Brian Smith, University of Iowa

Lymphoma, a cancer which affects the immune system, is the fifth most common cancer in North America. Rituximab-based chemotherapy (R-CHOP) has become the standard recommended cancer-management course for this disease. Using previously collected data from a 2008 study conducted by Lenz G. Wright and publicly available from the National Center for Biotechnology Information, we used statistical methods to identify genetic characteristics associated with survival in R-CHOP treated patients. Univariate screening reduced the 54,000 recorded genes per patient into a manageable group which displayed strong possible correlation with overall survival. The resulting gene collection was partitioned into clusters of related genes and then scored using principal components. Then, a multivariate Cox-Regression model of these principal components was developed to best predict survival in Lymphoma patients. The resulting model can be used to help identify genetic characteristics of patients who are less likely to respond to current therapy and are potential targets for new drug development.

104. Optimal Digital Elevation Model Estimation

Catherine Watkins Johns Hopkins University
Konstantina Tsintsiafa Rutgers University
Advisor(s): Stacey Beggs, UCLA IPAM

In this research, we explore techniques in digital elevation model generation without the use of fiducial points. A digital elevation model (DEM) is a three-dimensional representation of a terrain generated from a set of two-dimensional images. The current method of DEM formation consists of two steps: registration and DEM generation. The registration step involves identification and association of fiducial points, then in the generation step solves for DEM parameters. In this report we formulate a one-dimensional strategy, whose basis is a minimization problem, which can be used to generate a DEM without the use of fiducial points. The method we developed makes use of a variety of cost functions, which determine the similarity between photographs, and various deterministic and stochastic minimization techniques, which minimize the costs functions and give us the unknown DEM parameters, simultaneously. In our talk we discuss detailed descriptions our methodology and its results.

105. Semiparametric Regression for Measurement of Parts Data

Kristin Mara Winona State University
Samantha Meadows Central Michigan University
Rosie Roessel Lehigh University
Advisor(s): Dr. Chin-I Cheng, Central Michigan University

In this project, we approximated the smooth function in a nonparametric model by a truncated polynomial basis of degree 2, which contained the basis and the splines constructed by knots. After we fixed the number of knots, the function was estimated by ordinary least squares, penalized spline regression, and linear mixed model methods. We proposed our own Bayesian penalized spline, which gave comparable results. The prior distribution was chosen to be "objective" so it'd minimize the influence to the posterior distribution and maintain the advantages of Bayesian statistics. The non-informative Jeffreys prior was adopted for the polynomial basis and the variance component, while the prior for the splines was elicited from the penalty term in the penalized likelihood. To ensure the posterior distributions were proper, we used an informative prior on the smoothing parameter. To achieve the goal of having an "objective" prior for the smoothing parameter, we used the df_{fit} to determine the hyperparameter in the prior distribution. After we fit a nonparametric model, we looked at a semiparametric model. This combined our nonparametric model with a categorical variable. We used the AIC to compare all methods proposed on both a simulated and a manufacturing data set.

106. Improving Cross-lingual Search Quality

Christie Quaranta Plymouth State University
Eric Schwartz Columbia University
Imanol Arrieta Ibarra Instituto Tecnológico Autónomo de México
Elena Sizikova University of Oxford
Advisor(s): Stacey Beggs, Institute for Pure and Applied Mathematics

Advancements in Information Retrieval (IR) focus primarily on increasing the speed and accuracy of search upon large collections of data. One branch of IR is Cross-Language Information Retrieval (CLIR). With so many different languages across the world, it is imperative to be able to search in several languages effectively. Most CLIR methods involve machine translation; however automated translators are still very imprecise. Our research presents eight methods for cross-lingual search on the Shoah Foundation Institute Visual History Archive, as well as metrics to analyze the effectiveness of each method. We used the standard definitions of precision and recall, as well as a third metric, the F-measure, which is a weighted harmonic mean of the first two. First, a method in which the entire thesaurus is translated and searched is compared to another method SQTM to determine which technique yields superior results. Moving forward with the more-effective SQTM, we separately improved recall and precision, and studied the methods for merits and downfalls. Recall-improving techniques presented involve expanding each search query to more related terms, while precision-improving methods utilize context-based filtering to narrow-down search queries by weeding out irrelevant ones.

107. A 2-Parameter Family of Kernels

Casey Bylund University of San Francisco
Will Mayner Brown University
Advisor(s): Greg Fasshauer, Illinois Institute of Technology

In many application areas, one encounters a function f which is difficult or expensive to evaluate, for example the output of a sophisticated computer simulation. In such cases, one desires an approximation of f that is easier to evaluate than f itself, sometimes called a "surrogate" function. A popular way of constructing these surrogate functions is to use *positive definite kernels*, which can be thought of as generalizations of positive definite matrices. In practice, the choice of which kernel to use has a significant effect on the accuracy of the resulting approximation. We present a family of kernels doubly-parametrized by smoothness (β) and shape (ε) which arise as the solutions of families of ordinary differential equations, and discuss methods for solving them. In particular, we elaborate on a specific case in which we produce a kernel that stems from the differential operator $(\frac{d^2}{dx^2} + \varepsilon^2)^\beta$, with the shape parameter $\varepsilon > 0$ and the smoothness parameter $\beta = 2$. We also exhibit evidence from numerical experiments that illustrates the effectiveness of introducing the smoothness parameter.

108. Quantifying Operational Risk

Raymond Perkins Morehouse College
Leyla Korkut University of Maryland, College Park
Advisor(s): Stacey Beggs, Institute for Pure and Applied Mathematics

Financial institutions have and continue to suffer substantial financial losses because of operational risks and risk management insufficiencies. Quantifying operational risk is a critical component of an institution's ability to manage risks. We are interested in defining and modeling operational risk. Finally, using various statistical methods, we estimated the likelihood of various risk events and potential losses so that those who use our model can determine the appropriate capital requirements to prevent said losses. We created a model that objectively quantifies local operational risk events and expresses their impacts nationally and regionally. Our model can be used to regionally manage operational risk and determine a sufficient capital requirement to hedge those risks.

109. Low dimension Lie algebra dimension reduction by modding by the center

Nick Benthem Grand Valley State University
Advisor(s): Firas Hindeleh, Grand Valley State University

We investigate reducing the order of real low dimensional Lie algebras by modding by the center. We find the isomorphism between the reduced algebra and one of the non-decomposable Lie algebras and explain why in certain cases the reduced algebra decomposes.

110. Using ideal-divisor graphs to classify ideals of finite commutative rings with identity

Lane Bloome Millikin University
Hailee Peck Millikin University
Advisor(s): Joe Stickles, Millikin University

For nearly fifteen years, the study of zero-divisor graphs has provided algebraists with a graphical tool to analyze the structure of commutative rings. In all, over 200 papers have been published on the subject. Ideal divisor graphs are defined in an analogous fashion, and their insight on the structure of commutative rings with unity has been a recent topic of interest in the area. We look to expand upon existing results, with particular interest in classifying some ideals of a commutative ring with identity R from properties of ideal-divisor graphs.

111. Co-circular Kite Central Configurations in the 4-body Problem

Tasheena Barrett Brigham Young University, Idaho
Alicia Lozano Bryn Mawr College
Liliana Manrique California State Polytechnic University, Pomona
Advisor(s): John Little, College of the Holy Cross

A central configuration is defined as a system of masses in which the gravitational acceleration vectors point toward the center of mass and are proportional to the displacement vectors from the center of mass with the same proportionality constant. Central configurations play an important role in the study of the Newtonian n-body problem because from these it is possible to construct explicit solutions. We consider a special case of the 4-body problem, specifically the co-circular kite. This special case of the 4-body problem can also be used to construct examples of 5-body configurations. Central configurations can be described using a system of polynomial equations called the Albouy-Chenciner equations. When using techniques from computational algebraic geometry on these equations, it appears that the exponents of the univariate elimination polynomials are multiples of three and the polynomials can be factored into perfect squares. We study the algebraic patterns in the elimination polynomials that occur in this special case.

112. Embedding Cycles and Bipartite Graphs in PG(n,q)

Ashley Klahr University of San Diego
Elaina Aceves California State University, Fresno
David Heywood California State University, Fresno
Advisor(s): Oscar Vega, California State University Fresno

Our work builds from that of Lazebnik, Mellinger, and Vega about the embedding of graphs in finite projective planes. First, we expand on their findings on embedding cycles in $PG(2,q)$ by taking cycles in 2 dimensions and piecing them together to get a cycle in three dimensions. Then similarly we piece together cycles in $n-1$ dimensions to get a cycle in n dimensions. Additionally, we expand their findings on embedding bipartite graphs in $PG(2,q)$ by looking at bounds for complete bipartite graphs that can be embedded in $PG(3,q)$.

113. Tangle Solutions For Site-Specific HIN RECOMBINASE On DNA

Jennifer Lazarus University of North Texas at Dallas
Advisor(s): Noureen Khan, University of North Texas at Dallas

Biological observations and topological analysis aid in adjusting the tangle model of distributive recombination; which produces composite knots. Hin recombinase acts on DNA by both processive and distributive recombination. We explore the adjustment of the tangle model to distributive recombination using Hin recombinase.

114. Numerical Integration of Rational Bubble Functions with Multiple Singularities

Michael Schneier University of Pittsburgh
Advisor(s): Michael Neilan, University of Pittsburgh

This talk is concerned with the numerical integration of a class of Zienkiewicz-like rational bubble functions proposed by J. Guzmán and M. Neilan to approximate Stokes flow and the equations of planar elasticity. Due to the presence of multiple singularities of these rational functions, traditional methods such as the Duffy transform cannot be

employed to effectively approximate these integrals. Instead, we present a new quadrature scheme via a partitioned Duffy transformation and show that the resulting errors converge exponentially. Numerical experiments are provided which support the theoretical results

115. Chaotic Dynamics of an Epidemic Model with Periodicity

Tyler Wales Louisiana State University
Christina Davis Louisiana State University
Veronica Bunn University of Kentucky
Teresa Shoemaker University of Southern Indiana
Advisor(s): John Franke, North Carolina State University

We analyze the bifurcation behavior of an SIS model with 2-periodic constant demography. A traditional non-periodic SIS model does not result in period doubling bifurcations; however, when adding periodicity, the model undergoes a period doubling route to chaos. We numerically detect the first period doubling bifurcation as a function of one and multiple parameters. We simplify the original transcendental equation by using the Taylor approximation of the transmission rate. The total population is globally attracted to a 2-cycle, so we must use the 2-fold composition of the infected class equation to encompass both population values. By using the Period Doubling Bifurcation Theorem, we are able to analytically find parameter values that give rise to these bifurcations. The two major conditions in this theorem reduce to two cubic equations in I, the infected class, and the 5 model parameters. Using conditions imposed on the parameters in our model together with one other reasonable condition on the parameters, we establish that each of the cubic equations has one real root. Equating these real roots gives an equation in terms of our parameters that, when satisfied, results in a period doubling bifurcation.

116. Java Implementation of C. Ernst's tangle Equations II

Jonathan Sullivan Universty of North Texas, Dallas
Advisor(s): Noureen Khan, unt dallas

Solutions to Tangle Equations are important in mathematics, bio-chemistry, molecular biology, and biophysics. The "knotting" of bio structures has even recently been attributed to competitive advantage in evolution. In this paper we present a computational algorithm to find the O, P, and R; when N(O + P) and N(O + R) are given.

117. A Bijection from Shi Arrangement Regions to Parking Functions via Mixed Graphs

Michael Dairyko Pomona College
Claudia Rodriguez Arizona State University
Schuyler Veeneman San Francisco State University
Advisor(s): Matthias Beck, San Francisco State University

Consider all the different regions in three dimensions bounded by the planes $x_1 = x_2$, $x_1 = x_3$ and $x_2 = x_3$. This is a three-dimensional *braid arrangement*. More generally, in dimension n, B_n is the braid arrangement of hyperplanes of the form $x_i = x_j$ for $1 \leq i < j \leq n$. A *Shi arrangement*, $Shi(n)$ is an expansion of B_n that includes the hyperplanes $x_i = x_j + 1$. Pak and Stanley have shown that there exists a bijection between the regions of $Shi(n)$ and a combinatorial object called *parking functions* of length n where both objects have the cardinality of $(n+1)^{n-1}$. Our goal is to expand on the work of Pak and Stanley and provide a different approach to this bijection. We will establish our bijection by linking the regions of $Shi(n)$ and parking functions to *mixed graphs*, which are well known in the area of Graph Theory. This work provides an exciting link among three areas of mathematics.

118. Database for Local Function Fields

Angela Kraft Bethany Lutheran College
Alfeen Hasmani Molloy College
Advisor(s): Jim Brown, Clemson University

Jones-Roberts created a database for all degree n extensions of $\mathbb{Q}_p$ for $n \leq 11$ and $p \leq 23$. We work on extending their work to characteristic p fields focusing on the field of formal Laurent series, $\mathbb{F}_p((T))$. Namely, we classify all degree n extensions of $\mathbb{F}_3((T))$ for $n \leq 11$ where $3 \nmid n$. We also show information about each of these extensions including the Galois group, the defining polynomials for the extensions, and information about the subfields.

119. Computational Modeling of Glioblastoma Multiforme

Lena Snyder Arizona State University
Advisor(s): Eric Kostelich, Arizona State University

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

120. Using a Computer Algebra System to Compute Wilcoxon Power Curves

Daniel Luckett College of William & Mary
Advisor(s): Tanujit Dey, College of William & Mary

We consider the nonparametric Wilcoxon signed-rank test. Power curves for this test are plotted and compared for several population distributions. The power of the Wilcoxon signed-rank test is compared to the power of the sign test. Computations to calculate power are performed using a computer algebra system and an algorithm is presented to perform these computations.

121. Single-Peaked Preferences Over Multidimensional Binary Alternatives

Hoang Ha Bryn Mawr College
Lindsey Brown Baker University
Advisor(s): Dr. Jonathan Hodge, Grand Valley State University

Single-peaked preferences are important throughout social choice theory. In this poster, we will present results that come from work done at the Grand Valley State University REU on single-peaked preferences over multidimensional binary alternative spaces. These types of preferences are particularly significant in referendum elections, where voters must register simultaneous votes on multiple questions or proposals. We show that single-peaked binary preferences are nonseparable except in the most trivial cases, and that electorates defined by single-peaked preferences always contain weak Condorcet winning and losing outcomes. We then develop a general method for enumerating single-peaked binary preference orders.

122. Investigation of a Werner State Basis

Kelsey Moore Lebanon Valley College
Advisor(s): David Lyons, Lebanon Valley College

Werner states are potentially useful resources in quantum computation and communication tasks due to their unique properties, including their resistance to certain types of noise. We investigate the properties of the mixed Werner states, which are composed of n quantum bits and are those states left unchanged when acted upon by the same local unitary transformation on each quantum bit. By experimenting with matrices represented by certain non-crossing polygon diagrams, we attempt to discover a basis for these mixed Werner states. Using a uniqueness argument on input-output string pairs, we attempt to show that matrices arising from all such diagrams are independent, supporting our conjecture that the non-crossing diagram states form a linear basis for the Werner states.

123. Dominance on $\mathbb{N}$

Tyler Ball Pacific Lutheran University
Advisor(s): Tom Edgar, Pacific Lutheran University

Famous theorems due to Lucas and Kummer are deeply connected to the study of Pascal's Triangle mod p for p prime. We discuss these connections by studying a class of partial orders on $\mathbb{N}$, called b-dominance orders,

denoted $\ll_b$. On the surface, the innocent definition of these orders may lead one to believe that the orders are unremarkable; yet, we found fascinating connections between the combinatorics of these partial orders and number theory. In particular, we defined a new class of sequences and their associated generalized binomial coefficients. These coefficients, which turn out to be integral, along with the rank function for b-dominance allow us to prove a (previously unknown) analog of Kummer's Theorem for non-prime numbers. Moreover, we investigate more deeply the connection between dominance orders and these generalized binomial coefficients mod b.

124. Stochastic Modeling of Wolbachia-Infected Mosquitoes

John Lombardi University of North Carolina at Asheville
Sean Plummer North Carolina State University
Advisor(s): Alun Lloyd, NCSU Biomathematics

Dengue fever, caused by a mosquito-borne virus, affects millions of humans each year. Currently, there are no prophylactic drug treatments or vaccinations available to guard against infection, so control of the disease relies primarily on controlling the principal mosquito vector, Aedes aegypti. One proposed strategy is to introduce mosquitoes infected with the bacterium Wolbachia into a native mosquito population. Wolbachia infection reduces the lifespan of Ae. aegytpi and interferes with their ability to transmit the dengue virus. Mathematical modeling of mosquito population dynamics, dengue epidemiology, and Wolbachia dynamics can help assess the feasibility of Wolbachia-based vector control methods for controlling dengue fever. We developed a stochastic model to study the spread of Wolbachia in a mosquito population in a one patch and two patch system and explored strategies for releasing Wolbachia-infected mosquitoes into an entirely uninfected population.

125. Apparel Size Standards Within the Fashion World

Jenny Gomez University of the Incarnate Word
Advisor(s): Dr. Yang, University of the Incarnate Word

The intent of this experiment was to examine the theory of standardized clothing within the fashion industry. This research concentrated primarily on the apparel size standard for waist measurements of size 12 black-colored female skirts and size 32 black-colored male dress pants. Moreover, this study investigated factors Style, Fabric, and Store Category, which affected adherence to the apparel size standard developed in the study. Throughout the investigation additional interactions were discovered and included into the final statistical model. The final statistical model was explored to examine the statistical significances these interactions had on the waist length. The apparel size standard developed within the study was also compared to apparel standards developed by the United States Department of Commerce.

126. Convolutional Gridding Approximation of Inverse Frame Operator for Nonuniformly Sampled Signals

Sean Walker Arizona State University
Advisor(s): Eric Kostelich, Arizona State University

We investigate a method of reconstructing signals from non-uniformly sampled Fourier data by using frames and approximating an inverse frame operator by using convolutional gridding to produce reconstruction weightings. This produces an efficient reconstruction of the original physical domain that is robust enough to effectively handle piecewise continuous functions. Errors are very nearly equivalent to the ordinary frame reconstruction while the computational efficiency is several orders of magnitude faster than the inverse frame operator. The method also allows for additional weighting coefficients to further increase accuracy without excessive increase in computational costs.

127. Accepted Elasticity in Arithmetic Congruence Monoids

Marla Williams Willamette University
Lorin Crawford Clark Atlanta University
Jason Steinberg Princeton University
Advisor(s): Vadim Ponomarenko, San Diego State University

Given $M(a, b)$, a singular local arithmetic congruence monoid (ACM), all elements of $M(a, b)$ other than 1, can be factored into irreducibles, but this factorization is not necessarily unique. Given an element $r \in M(a, b)$, and $\mathcal{L}(r)$

the set of factorization lengths of r in $M(a,b)$, then the elasticity of r is defined to be $\rho(r) = \frac{\max \mathcal{L}(r)}{\min \mathcal{L}(r)}$, and the elasticity of the monoid is $\rho(M(a,b)) = \sup\{\rho(r) | r \in M(a,b)\}$. The elasticity of the monoid is accepted if there is some $r \in M(a,b)$ such that $\rho(r) = \rho(M(a,b))$. We introduce a notation which allows us to characterize new families of ACMs having accepted elasticity.

128. Growth Functions of Finitely Generated Algebras

Kelsey Wells Brigham Young University, Idaho
Advisor(s): Harold W. Ellingsen, The State University of New York at Potsdam

At a summer REU program in New York, my group studied the growth of finitely generated, finitely presented two-generator monomial algebras. In particular we tried to improve an upper bound found by our Advisor. A conversation with a visiting professor led to a connection to de Bruijn graphs and a drastically improved bound.

129. Factor Poset and Duals of Frames

Eric Evert Virginia Polytechnic Institute
Sean Nghiem Berea College
Kylie Berry Berry College
Advisor(s): Sivaram Narayan, Central Michigan University

A frame in $\mathbb{R}^n$ is a redundant spanning set. Equivalently, a frame is a sequence of vectors $\{f_i\}_{i=1}^k$ for which there exist constants $0 < A \leq B < \infty$ such that, for every x in $\mathbb{R}^n$, $A\|x\|^2 \leq \sum_{i=1}^k |\langle x, f_i\rangle|^2 \leq B\|x\|^2$. A frame is tight if $A = B$. We will present results about the combinatorial structure of tight frames using factor posets. A factor poset of a frame is defined to be a collection of subsets of I, the index set of our vectors, ordered by inclusion so that nonempty $J \subseteq I$ is in the factor poset if and only if $\{f_i\}_{i\in J}$ is a tight frame in $\mathbb{R}^n$. We assume that $\emptyset$ is also in the factor poset. We will then discuss some results on dual frames. A set of vectors $\{g_i\}_{i=1}^k$ is said to be a dual frame if for a frame $\{f_i\}_{i=1}^k$ we have that $x = \sum_{i=1}^k \langle x, g_i\rangle f_i, \quad \forall\ x \in \mathbb{R}^n$. We will relate the two topics by discussing the connections between the factor posets of frames and their duals. Finally, we extend the notion of diagram vectors for frames in infinite dimensions. The diagram vectors of a frame are calculated from the frame vectors and may be used to determine if any given subframe of the frame is tight.

130. Hetero-Crystal Generation from an Existing Database

Jake Bruggemann Rice University
Sameer Deshpande Massachusetts Institute of Technology
Advisor(s): Stacey Beggs, Institute for Pure and Applied Mathematics

Creating semiconductor processing chips is a constant arms race. New materials are needed in order to continue the trend of developing smaller and smaller transistors to put on these chips. One class of materials that shows promise is hetero-crystals, materials made by growing one kind of crystal on top of another. Our work shows a method for predicting whether or not two crystals can be made into a hetero-crystal, using an existing database of crystal structures. The program we developed scans through several different orientations and surfaces of these crystals and see whether they might be able to form a hetero-crystal.

131. Geometer's Sketchpad Presentation of Solutions to College Mathematics Journal Problems 983 and 984, Vol. 43, NO. 4, September 2012.

Oleg Timuta Edison State College
Advisor(s): Douglas Magomo, Edison State College

Sometimes undergraduate studies do not leave room to research outside of the courses we are registered in. But the College Mathematics Journal provide an opportunity to learn beyond classroom mathematics and credits, instead presents what other students in mathematics elsewhere do in their spare time. We present solutions to two of the proposed problems and gain visual comprehension through the use of Geometer's Sketchpad software.

132. Intrinsically Linked Graphs

Liang Zhang Lafayette College
Advisor(s): Joel Foisy, SUNY Potsdam

A graph is intrinsically linked if every embedding of the graph contains some pair of cycles which form a non-split link. Robertson, Seymour, and Thomas originally proved the minor-minimal set of intrinsically linked graphs to be the Petersen Family Graphs in 1995. We seek strategies to reprove this result in a simpler way by defining new concepts such as weak flexible planarity and flatness and by exploring the conflict graphs of maximally planar subgraphs, analogous to Tutte's work with conflict graphs associated to cycles. We also discuss results regarding intrinsic linking of the join of a graph and two disjoint vertices.

133. An Example of Student/Faculty Summer Research in Actuarial Mathematics: Using Mathematica to do Demographic Modeling and the Surprising Relevance of HyperGeometric Functions

Jacob Smith Bethel University
Advisor(s): William Kinney, Bethel University

For a summer research project at Bethel University my Professor and I researched with an emphasis on actuarial mathematics. In general we explored basic demographic models and tweaked them. *Mathematica* was a very valuable tool for this exploration that allowed us to consider the behavior of life expectancy functions under nonstandard assumptions about the force of mortality. Models explored included one where the force of mortality was assumed to be periodic and another where the force of mortality was assumed to be the sum of a periodic term and a Makeham term. *Mathematica* provided us with very nice ways to approximate life expectancy functions, visualize the effects of changes in parameters, and simulate sampling from the resulting survival distributions. We also were surprised to find that a sinusoidal force of mortality with a single frequency was sufficient to generate a life expectancy function whose description required the use of hypergeometric functions. Demonstration of the relevant *Mathematica* code and an explanation of how hypergeometric functions arise along with valid estimations in these models will be given.

134. Classifying Extensions of Characteristic p Local Fields

Daniel Scofield Grove City College
Lindsey Hiltner University of North Dakota
Advisor(s): Jim Brown, Clemson University

In previous works, Jones-Roberts and Pauli-Roblot have studied finite extensions of the p-adic numbers $\mathbb{Q}_p$. We focus on extending these results to local fields of characteristic p. In particular we are able to produce analogous results to Jones-Roberts in the case that the characteristic does not divide the degree of the field extension. Also in this case, following from the work of Pauli-Roblot, we prove that the defining polynomials of these extensions can be written in a simple form amenable to computation. Finally, if p is the degree of the extension, we show there are infinitely many extensions of this degree and thus these cannot be classified in the same manner.

135. Brownian Motion and Harmonic Functions

Harini Chandramouli University of Pittsburgh
Nora Ellen Hennessy Stack St. Mary's College of Maryland
Advisor(s): Igor Nazarov, Michigan State University

In this research we are looking at Kakutani's classical result on the connection between Brownian motion, a form of random movement, and harmonic functions, which are solutions to the Laplace equation. Kakutani's theorem is basically a generalization of the mean value property of harmonic functions. We will use this result to solve the Laplace equation in various regions with certain boundary conditions. Walk on Spheres (WoS) is used to simulate the Brownian motion of a particle suspended in liquid. The average time needed for the particle to hit the boundary of certain regions will be discussed. The distribution of the point of first encounter with the boundary of the region is of interest to us. We will also discuss our use of conformal maps to find probability density functions on certain regions. Additionally, the rate of convergence of the Brownian motion to the boundary as well as the overall computational effort needed to estimate values of the harmonic function using the Monte Carlo algorithm will also be discussed. Lastly, we looked into less expensive real world applications of our research.

136. Fibonacci Sequence, Cluster Algebras and Integrable Systems

Alonza Terry Xavier University of Louisiana
Advisor(s): Maarten Bergvelt, University of Illinois at Urbana-Champaign

There is a relation between cluster algebras and integrable systems. The aim of this paper is to illustrate the relation between the two concepts using the Fibonacci Sequence.

137. Comparative Analysis Pairwise Method

Luis Mestre Universidad Metropolitana Cupey
Advisor(s): Luis F. De la Torre, UMET Cupey

The Pairwise alignment is a method of two any sizes sequences. The most relevant Pairwise aligning programs are ACANA, Ngila, and Dialign. These programs are the most efficient and accuracy sequences alignment programs related to the overall and constraint sensitive, and the running time. The purpose of this research was performed an analysis of these programs to determine the efficient and accuracy; to perform this comparison the programs where tested in performance, sensitive and spend time using as input different length of sequences selected in a range from 40 to 2000 characters. Each experiment was run 50 times in a common desktop computer with an I3 dual core processor. As result ACANA appears to be one of the faster and more consistent sequences alignment program.

138. Sensitivity analysis of discrete biological models using Polynomial Dynamical Systems

Christopher Miles Lafayette College
Advisor(s): Franziska Hinkelmann, Mathematical Biosciences Institute

Discrete biological models are often intuitive to construct and able to reveal the qualitative dynamics of a complex system. Sensitivity analysis, which provides insight toward the effect of perturbations and uncertainty in a system, is typically regarded as essential in the modeling process. While methods for performing sensitivity analysis of continuous models have been studied extensively, far fewer analogous methods exist for discrete models. In this presentation, a novel method is proposed for performing sensitivity analysis on discrete models based on analogous continuous model techniques. The method of quantifying sensitivity is based on artificially introducing unknown parameters to the model and comparing the resulting dynamics to the original model. A mathematical framework, namely polynomial dynamical systems, is used to algebraically compute the dynamics of models with unknown parameters, a computation that might otherwise be computationally infeasible without the developed theory. An implementation of the algorithm is publicly available as a Macaulay2 package and was applied to published gene regulatory networks to provide a benchmark for the sensitivity of discrete biological models.

139. Mathematical Analysis of Runtime Complexity for Sorting Algorithms on a Spartan 6 SP605 FPGA

Joseph Colon Universidad Metropolitana
Advisor(s): Luis F. de la Torre, Universidad Metropolitana

As of today, sorting is still one of the most studied and practiced topic in computer programming. In addition, advances in technology have made sorting easier, faster, and more precise. However, the problem has always been choosing the fastest and most efficient device and sorting algorithm. Past investigations have revealed that sorting with microprocessors is better, faster, and more precise- even though not much- over sorting with Field Programmable Gate Arrays (FPGAs), due to Hertz (Hz) capacity. On the other hand, the FPGA has an advantage: it does one work at a time, and it does it fast. This work compares the performance of five sorting algorithms (Quicksort, Heap Sort, Merge Sort, Bitonic Sort and Radix Sort) using the Spartan 6 FPGA versus a common desktop computer. Each code was implemented in VHDL and C languages. The runtime of the sorting algorithms on both devices is comparable, while the Hz capacity is not (the ratio of FPGA:Processor is 2:21). It is expected that a FPGA with higher Hz capacity should outperform the processor.

140. The Effect of Experiment Design on Network Inference

Camila Reyes California State University, Stanislaus
Jacqueline Marie Yanchuck Seton Hill University
Caleb Brown University of Nebraska, Lincoln
Advisor(s): Alan Veliz-Cuba, University of Nebraska-Lincoln

The network inference or reverse engineering problem consists on estimating the connectivity of a system from data. This problem is an important aspect of many areas of applied mathematics, specially when modeling biological systems. Recently, algorithms to reverse engineer Boolean network models have been developed; however, methods for collecting the data sets have not been examined sufficiently and it is not known what is the best way to collect data in order to obtain the best infered network. In this talk, we show that for Boolean networks there are optimal ways to collect data for the network inference problem, based on the number of nodes in the network and the amount of data that is available. The results of our work provide a basis for researchers to obtain the most efficient data set, depending on experimental circumstances, to perform network inference.

141. Polarized Morphogenetic System (PMS)

Teresa Portone The University of Alabama
Daniel Savelle St. Mary's College of Maryland
Lucas Ortiz Wilkes Honors College, Florida Atlantic University
Advisor(s): Sharon Lubkin, North Carolina State University

Epithelial morphogenesis is driven by the formation, growth, and bending of thin sheets of cells with distinct interior (apical) and exterior (basal) sides. In this study we attempted to improve on past particle-based cell models to form a model of morphogenesis based on a two-particle polarized cell structure. We began by modeling a stable cyst-like structure. We then tested and calibrated the viscoelastic properties of our model by compressing the cell structure between two plates, which is comparable to real world data collected by Forgacs et al. (1998). We also simulated the growth of a hollow sphere into a tube-like structure using directed cell growth and a theoretical version of a basal lamina. With minimal refinement, this model should generalize to 3D.

142. Algebra of Tangles for Classical and Virtual Knots

Elizabeth Reyes University of North Texas at Dallas
Advisor(s): Dr. Noureen Khan, University of North Texas at Dallas

Knots and links can be formed by taking the numerator closure of a tangle or a sum of tangles. We introduce the algebra of rational tangles on classical and virtual Reidemeister moves and present combinatorial approach to show its invariance for rational tangles.

143. The Triangle Algorithm: Applications and Visualizations

Colin Jarvis Macalester College
Advisor(s): Bahman Kalantari, Rutgers University

Given a finite set S of m-dimensional points, we can determine whether a distinguished point p is in the convex hull of S or not. This gives rise to two simple sibling algorithms that iterate to approximate the target point one using knowledge of the coordinates of p while the other is blind, converging only using a set of given radii $r_1, ..., r_n$ that are associated with each vertex $v_1, ..., v_n S$. A discussion on the applications of the Triangle Algorithm to art and linear programming is also included.

144. Area and Hausdorff Dimension of Convex Quadrilateral Fractals

Rebecca Vasquez University of North Texas at Dallas
Michelle Okura University of North Texas at Dallas
Advisor(s): Byungik Kahng, UNT Dallas

We will describe a class of self-similar fractals, which we define as "convex quadrilateral fractals (CQF's)". Our goal is to discover the greatest possible contraction ratio, which satisfies the open set condition. We will then explore the greatest possible area and Hausdorff Dimension of CQF's.

145. The Varieties of One-Sided Loops of Bol-Moufang Type

Rachel Aldrich Otterbein University
Sarah J. Drummond Eastern Illinois University
Advisor(s): Reza Akhtar, Miami University

In this presentation we will extend the work of J.D. Phillips and P. Vojtechovský, who found the relationships among 26 different varieties of quasigroups and 14 different varieties of loops of Bol-Moufang type. We will show that there are 20 varieties of one-sided loops of Bol-Moufang type, and also which of these varieties have the left and right inverse properties of quasigroups. All proofs and counterexamples have been aided by the automated theorem prover, Prover9, and the finite model builder, Mace4. We will demonstrate the use of this software, and how we used the results to create Hasse Diagrams showing the relationships between the different varieties of one-sided loops of Bol-Moufang type.

146. On the Computability of Groups

Vikram Saraph University of Notre Dame
Advisor(s): Julia Knight, University of Notre Dame

In computable structure theory, a structure $\mathcal{A}$ is often identified with its *atomic diagram* $D(\mathcal{A})$, or its set of basic truths. Therefore, we call $\mathcal{A}$ *computable* if $D(\mathcal{A})$ is computable. An *index* of $\mathcal{A}$ is a number encoding a function that computes $D(\mathcal{A})$, and the *index set* of $\mathcal{A}$ is the set of indices for all computable copies of $\mathcal{A}$. For a group, this is essentially the word problem. For a finitely-generated group, the index set is only as hard as Σ^0_3, but it may be simpler. Indeed, all finitely-generated Abelian groups and finitely-generated free groups are known be $d\text{-}\Sigma^0_2$, where $d\text{-}\Sigma^0_2$ is a difference of two Σ^0_2 sets. It is unknown whether any finitely-generated groups are strictly harder than $d\text{-}\Sigma^0_2$; however, the torsion-free Abelian groups of finite rank need not be finitely generated. We present a subgroup of $\mathbb{Q}$ that is strictly Σ^0_3, and even m-complete Σ^0_3. We also discuss criteria that determine the complexity of other subgroups of $\mathbb{Q}$.

147. Hyperbananas: A Family of Flexible Frameworks

Christopher Clement University of Michigan
Advisor(s): Jessica Sidman, Mount Holyoke College

A bar-and-joint framework is a structure of bars with fixed lengths attached by universal joints. We call these structures flexible if they admit internal motions, otherwise they are rigid. Edge-counting conditions due to Maxwell are necessary and sufficient for classifying rigidity for planar frameworks, but fail for certain examples in higher dimensions. The classical example of a flexible graph satisfying Maxwell's conditions is the double banana. We extend the double banana example to a family of graphs called hyperbananas. Using tools from linear algebra and combinatorics, we show that these structures have similar properties as the double banana, that is, they satisfy Maxwell's conditions and are flexible.

148. Matrix Completions for Commutativity

Wesley Chang California State University, Channel Islands
Advisor(s): Dr. Geoffery Buhl, California State University at Channel Islands

A partial matrix pattern is a set of entries in a matrix that are locations for specified entries and unspecified entries. Specified entries are considered to be arbitrary and fixed, yet unspecified entries are free to be chosen in order to satisfy some property for the matrix as a whole. In particular we consider the tricky case of completing a partial matrix pattern B with respect to a fully specified matrix A so that these matrices commute under multiplication. The approach is to impose the condition that A be nonderogatory, which allows us to have a basis for the solution space of B. We analyze a type of matrix called a companion matrix, and we will show that the companion matrix commutes with a wider variety of partial matrix patterns than matrices examined in the past.

149. Limiting Behavior of the System $x_{n+1} = \frac{\alpha_n}{B_n x_n + y_n}$, $y_{n+1} = \frac{\gamma_n}{C_n x_n + y_n}$ with periodic coefficients

Jessica Krawec Mount Saint Mary College
Advisor(s): Zachary Kudlak, Mount Saint Mary College

We investigate the behavior of solutions of the following system of rational difference equations in the plane: $x_{n+1} = \frac{\alpha_n}{B_n x_n + y_n}$, $y_{n+1} = \frac{\gamma_n}{C_n x_n + y_n}$, $n \geq 0$, for periodic, positive coefficients and nonnegative initial conditions such that the denominators are non-zero. In particular, we provide necessary conditions for the existence of unbounded solutions. It is interesting to note that every solution of the autonomous version of this system is bounded.

150. Modeling Mutidimensional Tolerance Stack-up Using Monte Carlo Methods

Gregory Zajac University of Missouri
Garrett Cody Castle Idaho State University
Salil Gadgil Swarthmore College
Advisor(s): Matthew Willyard, Pennsylvania State University

As a product is manufactured, it is subject to multiple sources of variation in its physical characteristics. If the accumulation of the variations in individual product components is large enough it can compromise the functionality of the final product, which is costly to the manufacturer. Tolerances define ranges of allowable variation in the individual components. Their use in the design stage of a product to predict the proportion of products which fail due to component variation accumulation is known as tolerance stack-up analysis. In this project we developed a model to perform tolerance stack-up analysis in multiple dimensions using Monte Carlo methods to simulate component variations in virtual products. The component variation is simulated using random numbers generated from correlated normal or log-normal distributions. Our model predicts the proportion of products that will be defective with a 95 percent Agresti-Coull confidence interval. This gives information which can then be used to determine if a given design will yield a sufficiently small proportion of defective products when manufactured or whether changes must be made to achieve a satisfactory level of quality.

151. CSP and Connectedness: Constraints in Universal Algebra

Benjamin Fish Pomona College
Advisor(s): Bob McGrail, Bard College

In the 1990's, Jeavons showed that every finite algebra corresponds to a class of constraint satisfaction problems (CSP). Vardi later conjectured that idempotent algebras exhibit P/NP dichotomy: Every non NP-complete algebra in this class must be tractable. Here we discuss how tractability corresponds to connectivity in Cayley graphs. In particular, we show that dichotomy in finite quandles follows from a very strong notion of connectivity. Moreover, P/NP membership is first-order axiomatizable in involutory quandles.

152. Estimating the Prevalence of Tuberculosis Infection

Ceara Somerville Salem State University
Advisor(s): Ji Young Kim, Mount Holyoke College

Using tuberculin skin testing to estimate the prevalence of Mycobacterium tuberculosis infection has become more difficult since the Bacillus Calmette-Guerin (BCG) vaccination was introduced because the vaccination causes reactions to tuberculin similar to the Mtb infection. Using data supplied by the Center for Disease Control (CDC), we use mixture modeling to estimate the prevalence of tuberculosis among people with and without a BCG vaccination scar who were skin tested in South Korea in 1975. The data have been analyzed in Neuenschwander et al. (2002) by age group and gender. We propose a single model for each gender, which accounts for the varying ages by letting our model parameters depend on age. The proposed model is applied to more recent TB data.

153. The Structure Groups of Algebraic Curvature Tensors in Low Dimensional Vector Spaces

Malik Obeidin University of Georgia
Advisor(s): Corey Dunn, California State University, San Bernardino

The groups of symmetries of algebraic objects of are of vital importance in multiple fields of mathematics; here, we examine a less well-known family of these objects which arise as the symmetry groups of algebraic curvature

tensors. These tensors themselves are of interest because of their connection to the Riemann curvature tensor, which is central in the study of differential geometry. Here we focus on weak model spaces, which ignore the inner product, instead considering only the algebraic properties of the tensor itself. The structure group is then the subgroup of the general linear group which, under the action of precomposition, fixes the curvature tensor. Our main result is two-fold: we find that the symmetries of algebraic curvature tensors yield a quick algorithm to compute the Lie algebra, which itself can be used to give a family of one-parameter subgroups in a neighborhood of the identity. Additionally, in this connected component of the identity, we find that structure groups respect direct sums; the direct sum of curvature tensors becomes the direct sum of the structure groups. We use this to construct structure groups of arbitrary dimension.

154. Trirings and Trifields

Brandon Alberts Michigan State University
Advisor(s): Dr. Rajesh Kulkarni, Michigan State University

There are many results on the properties and classification of groups, rings, and fields. These have led to the solutions of many well known problems in mathematics, such as insolvability of the general quintic equation and the impossibility of trisecting a general angle. Rings and fields are extensions of the group structure to two operations rather than one with both operations jointly obeying the distributive law. The content of this presentation will be extending these definitions to three operations rather than two creating structures called trirings and trifields (previously presented as 3-rings and 3-fields). We will prove some results on classification and properties of these new structures.

155. Stability of traveling-wave solutions to the Whitham equation

Nathan Sanford Seattle University
Advisor(s): John Carter, Seattle University

Modeling the evolution of water waves is a problem of much interest in physics and applied mathematics. Two equations that model surface waves in shallow water are the Korteweg-de-Vries (KdV) equation and the Whitham equation. KdV was first derived in 1895 and has been studied extensively. It is an effective model for long waves, but it fails to accurately model short waves. Bottman and Deconinck (2009) proved that all periodic traveling-wave solutions of KdV are linearly stable. The Whitham equation is a generalization of KdV that addresses this issue and should accurately model the evolution of waves of all lengths. The Whitham equation was introduced in 1967 and has not been studied in as much detail as KdV. Ehrnstrom and Kalisch (2009) established that Whitham admits periodic traveling-wave solutions of a wider variety than KdV. The Whitham solutions with steep profiles are of particular interest due to their physical importance. We examine the stability of this broad class of traveling-wave solutions to the Whitham equation using linear stability analysis. We draw conclusions as to whether these solutions are likely to maintain their profile as they evolve in time.

156. A New High-Order Filter for Leapfrog Time Integration of Wave Problems

Scott Van Buren Arizona State University
Advisor(s): Mohamed Moustaoui, Arizona State University

Asselin-filtered leapfrog is a standard numerical time integration scheme used in applications relating to atmospheric dynamics and climate modeling due to its favorable computational efficiency and stability. However, the Asselin filter requires a very small time step to avoid damping of the physical computational modes and significant degradation of the numerical solution. We present a new high-order filter for use with the leapfrog method that improves upon the Asselin filter. Our filter damps leapfrog's non-physical computational modes more than the Asselin filter, while maintaining a better accuracy in physical computational modes. In this poster, we compare the numerical solution of a wave equation obtained using the Asselin filter to the numerical solution obtained using our high-order filter. Data computed with our high-order filter is then used to simulate the atmospheric flow associated with Earth's polar vortex. [Note: A Lagrangian analysis of the data is presented in a companion poster.]

157. Multi-Scale Vessel Extraction Using Curvilinear Filter-Matching Applied to Digital Photographs of Human Placentas

Marilyn Vazquez California State University, Long Beach
Advisor(s): Jen-Mei Chang, California State University Long Beach

Current medical interest in the placenta has inspired the work of vascular network extraction on placenta images. The focus of this research is to develop an automated program that detects vessels in these images. The placenta's irregular surface and variation in vessel coloration are some of the various challenges to extract these vessels. The multi-scale filter, based on eigenvalues of second derivatives, has been shown to be successful in identifying vessels of varying sizes on medical images. However, with the multi-scale frame work, the placenta's rough and irregular surface is also detected as part of the vessel network; therefore, we propose a new filter, a special form of the Ridgelet filter, in combination with the multi-scale filter to further enhance extraction results. This filtering process has been tried on a 181-by-181 placenta patch and a whole placenta image of size 1600-by-1200. The results on the whole placenta image have been compared to tracings of the vessel structure for the same image, the results of the multi-scale filter on its own, and the previous work on placenta images. These experiments show that the proposed filtering process has improved the multi-scale filter results and the previous work done in placentas.

158. Frobenius Modules and Generic Polynomials

Anthony Sanchez Arizona State University
Advisor(s): Jorge Morales, Louisiana State University

Given a finite group G and field k, one may ask whether there exists an extension L/k such that $Gal(L/k) \simeq G$. In this case, we say G is realizable over k. If k is a Hilbertian field (i.e. number fields, finitely generated extension of $\mathbb{F}_q$), then the existence of a G-generic polynomial over k tells us that G is realizable over k. Thus, the construction of G-generic polynomials are worthwhile. In this presentation, we study the case $G = E^*$, the group of units of some finite-dimensional algebra E over $\mathbb{F}_q$. We use Matzat's Theory of Frobenius Modules to not only show that E^* is realizable over $\mathbb{F}_q(t_1, \ldots, t_n)$, but to explicitly construct generic polynomials. In addition, we supply concrete examples that demonstrate the potency of this method.

159. Abelian Varieties with Real Multiplication and Maximal Image of Galois

Zane Li Princeton University
Tony Feng Harvard University
Advisor(s): Ken Ono, Emory University

We study the image of the adelic Galois representation associated to certain abelian varieties. We first work this out in the case of an elliptic curve with CM. We then specialize to the case of abelian varieties with real multiplication. Necessary and sufficient criteria are given to determine if the adelic representation is surjective for two-dimensional abelian varieties over $\mathbb{Q}$ with real multiplication, also defined over $\mathbb{Q}$, by an order $\mathcal{O}$. We develop tests to effectively verify the criteria and give the first known example of such an abelian variety with surjective adelic Galois representation. Finally, conditional on the Generalized Riemann Hypothesis, we bound the largest exceptional prime of an abelian variety with real multiplication, making effective the work of Ribet in his PhD thesis.

160. Graph Theoretical Comparison of Coprinus cinera Wild Type and Mutant Networks

Samantha Taylor Washington & Jefferson College
Catherine Monahan Washington & Jefferson College
Advisor(s): Dr. Faun Doherty, Washington & Jefferson College

Coprinus cinerea is a multicellular mushroom that is of interest to biologists studying meiosis due to its synchronous meiotic development and prolonged prophase (Burns et al.). Burns et al. are interested in determining how the *Coprinus cinerea* mutant resulting from the damaged gene MSH5 is affected in the meiotic process. From a mathematical standpoint, network analysis and graph theoretical techniques can be used to help the biologists visualize and compare biological gene networks and draw conclusions from the data. We used the networking computer program Cytoscape to create a visualization of the Coprinus cinerea wild type and MSH5 networks. Within Cytoscape, we applied Pearson's Correlation to the nodes to create the networks. We examined several centrality measures to determine centrally located genes in both the Wild Type and MSH5 networks, including Eigenvector centrality and

degree centrality. By applying these graph theoretical methods, we were able to narrow the original list of 2851 genes down to a manageable list of genes that are interesting to the biologists based upon their biological functions. These genes are the focus of further biological research.

161. Mathematical Strategy for Football Matches

Abubakar Abubakar American University of Ras Al-Khaimah
Advisor(s): Dr. Bong Sik- Kim, American University of Ras Al-Khaimah

We will show on the poster, the strategy of teams in a football match. We will show a model of a football match based on Players'Passing Index using graph theory and Lanchester Theory of Combat Model. We analyze the model to compare the results of football matches among teams from the English Premier League, which show our model is consistent with the results of the real football matches. We will choose one team, Manchester United, and use our Mathematical model to give them a best possible strategy to use against one of the teams in the English Premier League.

162. Modeling White Nose Syndrome

Loren Santana Skidmore College
Advisor(s): Rachel Roe-Dale, Skidmore College

White Nose Syndrome is a fungal disease caused by Geomyces destructans affecting hibernating bats in the northeast region of the United States and extending westward. The fungus destroys the wings and disrupts thermoregulation, water balance and compromises the bat's overall immune system. We discuss a simple mathematical model, which describes the dynamics among the susceptible (S), infected (I), and recovered (R) classes of bats.

163. Nowhere-Zero $\vec{k}$-Flows on Graphs

Molly Stubblefield Western Oregon University
Gordon Rojas Kirby Stanford University
Alyssa Cuyjet Trinity College
Advisor(s): Dr. Matthias Beck, San Francisco State University

A flow on an oriented graph Γ is a labeling of edges from a group such that the sum of the values flowing into each node is equal to the sum of values flowing out of each node. When the group is $\mathbb{Z}_k$ or $\mathbb{Z}$ (with the labels bounded by k in absolute value), there is an established theory of counting nowhere-zero flows, i.e., the flows where no edge gets labeled 0. This theory includes results about polynomiality of the flow-counting function and combinatorial reciprocity theorems. We introduce nowhere-zero $\vec{k}$-flows, where each edge has a different range of allowable values, and propose an analogous theory. Our method is to translate $\vec{k}$-flows into parametric polytopes and use Ehrhart theory to obtain piecewise-defined polynomials and reciprocity theorems.

164. Catadioptric Sensors: MOSA Mirror's Ultra Wide Field of View

Mahalia Sapp Wofford College
Advisor(s): Emek Kose, St. Mary's College of Maryland

It has been desired to capture a wide angle field of view for photography, surveillance, autonomous vehicle operation, and telepresence. To address the problem of wide angle imaging catadioptric sensors have been developed. Catadioptric sensors are imaging sensors made from a combination of mirrors and lenses. As observed in fisheye lenses or spherical mirrors, the wider the field of view the more distorted the image. To minimize distortion different mirror surfaces can be combined into one catadioptric sensor. Other studies have captured images with minimum distortion using catadioptric sensors for a wide field of view. However, capturing an ultra-wide field of view had not been obtained before. In this research we designed a catadioptric sensor that uses a three mirror combination to capture 180 degree field of view with minimum distortion. This design works with orthographic projection, in which light rays travel parallel to the optical axis.

165. A Uniform Distribution Result for k-Paradoxical Directed Graphs

JC Schroeder Ohio Northern University
Advisor(s): Mihai Caragiu, Ohio Northern University

In their 1971 paper "A Constructive Solution to a Tournament Problem" Graham and Spencer used Paley digraphs to provide explicit examples of k-paradoxical tournaments. As a central ingredient, they used estimates for character sums with polynomial arguments. In the present work we use incomplete character sums estimates of the Polya-Vinogradov type in order to provide a uniform distribution result for the set of elements in $GF(p)$, the finite prime field with p a prime of the form $4k+3$, defeating every element in a given k-subset of $GF(p)$ in the corresponding Paley tournament. Similar results for other k-paradoxical directed graphs will be investigated.

166. Orders and Orbits of Generalized Symmetric Spaces

Jasper Weinrich-Burd Bard College
Russell Stinson University of Indiana, Bloomington
Andrew Tollefson University of Nevada, Reno
Advisor(s): Aloyius Helminck, North Carolina State University

The theory of symmetric spaces was originally developed in the study of quotients of real matrix groups. The generalization of these symmetric spaces to other groups is a new direction of research. We develop a classification of generalized symmetric spaces for the permutation group S_n.

167. Procedure Verification in a Functional Quantum Programing Language

Anthony Hoover Lebanon Valley College
Advisor(s): David Lyons, Lebanon Valley College

As there are now quantum programing languages which can be run on classical computers, it is necessary to develop a means of checking whether the procedures created on these devices are performing correctly. This study aims to create a method of testing the correctness of such procedures. The study involves the discovery of two different methods of inputting data into the processes and two different ways of analyzing the resulting output. These methods can be combined in a variety of ways in order to evaluate the behavior of a quantum procedure.

168. Perimeter-minimizing Planar Tilings by Pentagons

Zane Martin Williams College
Advisor(s): Frank Morgan, Williams College

Hales proved that regular hexagons provide the least-perimeter way to partition the plane into unit areas. What are the best tilings by pentagons? Could it possibly help to mix in some non-convex pentagons?

169. Programming Grover's Search Algorithm and Quantum Counting

Ian Bond Lebanon Valley College
Advisor(s): David Lyons, Lebanon Valley College

Grover's search algorithm and quantum counting are two important quantum algorithms that are provably more efficient than their classical counterparts. We have encoded these algorithms in a functional quantum programming language and have obtained results from this code. Creating code in the Quantum IO Monad in Haskell allows us to simulate a quantum algorithm on a classical computer for a small number of qubits.

170. Radio Number for 5th Power of Paths

Krista Leal California State University, San Bernardino
Alberto Acevedo California State University, San Bernardino
Blair Blokzyl California State University, San Bernardino
Joana Luna California State University, San Bernardino
Alex Marrujo California State University, San Bernardino
Advisor(s): Dr. Min-Lin Lo, California State University, San Bernardino

Let G be a connected graph. For any two vertices u and v, let $d(u,v)$ denote the distances between u and v in G. The maximum distance between any pair of vertices is called the diameter of G and denoted by $diam(G)$. A

$radio-labeling$ (or multi-level distance labeling) of a connected graph G is a function $f : V(G) \to \{0, 1, 2, 3, \ldots\}$ with the property that $|f(u) - f(v)| \geq diam(G) - d(u, v) + 1$ for every two distinct vertices u and v of G. The $span$ of f is defined as $max_{u,v \epsilon V(G)} \{|f(u) - f(v)|\}$. The $radio\ number$ of G is the minimum span over all radio-labelings of G. The 5th power of G is a graph constructed from G by adding edges between vertices of distance five or less apart in G. The $radio\ number$ for paths, square paths, and cube paths were solved. In this presentation we will discuss the progress we made towards finding the radio number for 5th power of paths during a 2012 MAA summer research program funded by NSA (grant H98230-11-1-0215) and NSF (grants DMS-0845277 and DMS-1156582).

171. A Classification of Uniform Edge-c-Colorings of Uniform Tilings

John Hyde The University of Texas at Tyler
Laura Asaro East Central University
Tyler Schroeder North Central College
Melanie Jensen Tulane University
Advisor(s): Casey Mann, The University of Texas at Tyler

A *uniform* tiling of the plane is an edge-to-edge tiling by regular polygons in which every vertex is in the same transitivity class with respect to the symmetry group of the tiling. There are exactly 11 uniform tilings of the plane. If the edges of a uniform tiling are assigned one of a set of c colors, then the uniform tiling is said to be *edge-c-colored*. If the vertices of an edge-c-coloring are all equivalent under color-preserving symmetries of the edge-c-coloring, then it is said to be *uniform*. In Grünbaum and Shephard's book, *Tilings and Patterns*, the problem of classifying the uniform edge-c-colorings of uniform tilings is posed. In this poster presentation, we present such a classification.

172. Directed rigidity: Persistence of body-and-distance constraint formations

David Breese Pomona College
Advisor(s): Jessica Sidman, Mount Holyoke College

A question that presents itself in engineering is how to give succinct rules for motion to each individual member of a group of autonomously moving vehicles, in such a way that the group's formation will persist throughout any rule-abiding motions by the vehicles. By *persistence* of a formation, we mean that the relative positions between every pair of vehicles remains constant. We provide foundations for the rigorous study of this problem, considering specifically a type of order called a *distance constraint*, in which a vehicle is commanded to maintain a constant distance between a specified point on itself and a specified point on another vehicle. Persistence of formations can be viewed as an extension of the well-established concept of rigidity of *bar-and-body frameworks*, groups of rigid bodies linked together by rigid bars attached at universal joints; a rigid bar is effectively an undirected distance constraint. We identify the precise mathematical relationship between persistence and rigidity. We then conjecture and give partial proof for a characterization of persistence in $\mathbb{R}^3$, making use of related results in rigidity theory.

173. Non-Trivial Pursuit: The Game of Cops and Robbers on Graphs

Aashish Srinivas Swarthmore College
Kirstyn Baker Alma College
Philip Thomas Indiana University
Caitlin Graff University of Idaho
Anthony Graves-McCleary Vassar College
Advisor(s): Robert Bell, Michigan State University

Cops and Robbers is a game played on a reflexive graph by a robber and a team of cops. The cops and the robber take turns moving between adjacent vertices of the graph with the goal of the cops being to eventually occupy the same vertex as the robber, and the robber trying to avoid this result indefinitely. The cop number of a graph is defined as the fewest number of cops needed to capture the robber given intelligent play from both sides. We examine the properties of the cop number for various classes of graphs, and present a new family of Petersen-inspired graphs with unbounded cop number, as well as an improved algorithm to determine the cop number of a given graph.

174. A Relaxation of Steinberg's Conjecture

Owen Hill College of William & Mary
Advisor(s): Gexin Yu, College of William and Mary

A graph is $(c_1, c_2, \cdots, c_k)$-*colorable* if the vertex set can be partitioned into k sets $V_1, V_2, \ldots, V_k$, such that for every $i : 1 \leq i \leq k$ the subgraph $G[V_i]$ has maximum degree at most c_i. We show that every planar graph without 4- and 5-cycles is $(1, 1, 0)$-colorable and $(3, 0, 0)$-colorable. This is a relaxation of Steinberg's Conjecture that every planar graph without 4- and 5-cycles are properly 3-colorable (i.e., $(0, 0, 0)$-colorable).

175. Integrated Gene Expression Probabilistic Models for Cancer Staging

Andrew Xia Massachusetts Institute of Technology
Advisor(s): Gil, Alterovitz

The current system for classifying cancer patients' stages has been around for over one hundred years, and with the modern advance in technology, many parts of the system have been outdated. Because the current staging system emphasizes surgical procedures that could be harmful to the patient, there has been a movement to encourage developing a new Taxonomy. In this pilot project, clinical cancer data was looked at and we saw that some important data was missing. It would be logical to construct a system that could recover missing data. A data tree function for the clinical cancer was looked at, which yielded decent but not very accurate results. RNA sequencing data was an alternative also looked at, which could be a cost-efficient system in determining a patient's cancer stage. We found that the accuracy for the data tree function for the clinical data as compared to the TCGA-computed clinical staging data ranged from 90% to 50%. Therefore, there could be some discrepancies with the TCGA-computed staging system and its potential uses. For the RNA sequencing results, we were able to locate some genes that have been proven to increase in frequency as the breast cancer tumor grew, while we also found some other genes did not have previous association with the development.

176. Extensions of Finite Distributive Lattices

Tanya Riston Penn State University Erie, The Behrend College
Advisor(s): Dr. Papiya Bhattacharjee, Penn State University-Erie, The Behrend College

A lattice is a partially ordered set where every pair of elements has a least upper bound and a greatest lower bound. Examples of distributive lattices include, but are not limited to, collection of open sets of a topological space and collection of ideals of a commutative ring. For a given distributive lattice L, the concepts of prime elements, $Spec(L)$, and minimal prime elements, $Min(L)$, of L are of great importance and can be used to understand various lattice-theoretic properties. We will discuss the space of $Min(L)$ for a given finite distributive lattice L. Furthermore, using $Min(L)$ we will define various extensions of lattices, namely, rigid extension, r-extension, and r^b-extension, and results related to them. The ultimate goal is to answer an open question related to the extensions of finite distributive lattices: Is a rigid extension between finite distributive lattices equivalent to the r-extension?

177. Impedance of electrochemical cells

Tianqi Wu Massachusetts Institute of Technology
Advisor(s): Yi Zeng, Massachusetts Institute of Technology

In this study we studied the impedance of electrochemical cells, a characteristic property of such systems, for several one-dimensional and two-dimensional mathematical models, both analytically and numerically. In the 1D models we solved for the impedance, first under a simplifying assumption, and then exactly. We then used finite difference method to solve the 1D model numerically and confirmed the analytical results. Finally we formulated an isotropic 2D model, solved the resulting PDE using finite Hankel transform and Laplace transform, and found an asymptotic result of impedance which closely resembled the results from 1D model. For future research, we may generalize the problem to other physical configurations and fit our mathematical result to experimental data to determine physical quantities such as diffusivity.

178. Tournament and Tournament Solutions

Michelle Dorothy Maiden Meredith College
Melanie Tamar Panosian Muhlenberg College
Ran Ji Wellesley College
Advisor(s): Molly Fenn, North Carolina State University

A tournament on a finite number of alternatives results in a complete, asymmetric directed graph. There are many fields which exhibit applications to tournaments, such as sports, computer science, and political science. Social Choice Theory is a branch of political science which deals with voter preferences measured through pairwise comparisons of elements. These comparisons will produce majority preference relations. These preferences are not always transitive, meaning a cyclic relationship can exist where x beats y, y beats w and w beats x. This cyclic relationship creates an unclear ranking of the alternatives x, y and w in the tournament, symbolizing candidates in an election. This leads us towards methods of picking winners in tournaments or tournament solutions, such as the Heresthetically Stable Set and the Banks Set. We have most closely looked at the Heresthetically Stable Set, which is a subset of the Banks Set, and found which common tournament properties it satisfies. Additionally, we have investigated the relationship between the Heresthetically Stable Set and other tournament solutions, such as the Weak Uncovered Set. Our results have fortified knowledge of the relatively new tournament solution, the Heresthetically Stable Set.

179. The Edge-balance Index Set of Halin Graph of Double Stars

Andrea Monterotti Stonehill College
Advisor(s): Hsin-hao Su, Stonehill College

Let G be a simple graph with vertex set $V(G)$ and edge set $E(G)$. Any edge labeling f induces a partial vertex labeling $f^+ : V(G) \to \{0, 1\}$ depending on whether there are more 0-edges or 1-edges incident with v, and no label is given to $f^+(v)$ otherwise. For each $i \in \{0, 1\}$, let $v_f(i) = \left|\{v \in V(G) : f^+(v) = i\}\right|$ and let $e_f(i) = |\{e \in E(G) : f(e) = i\}|$. An edge-labeling f of G is said to be edge-friendly if $\{|e_f(0) - e_f(1)| \leq 1$. The edge-balance index set of G is defined as $\{|v_f(0) - v_f(1)| :$ the edge labeling f is edge-friendly.$\}$. Because of the definition of the edge-balance index, the calculation of the edge-balance index set depends highly on the structure of a graph. The general approach usually results an arithmetic progression. But, Chopra, Lee and Su discovered in 2010 that the values in an edge-balance index set of a wheel graph do not form an arithmetic progression. A Halin Graph of a Double Star is a graph very similar to a wheel graph except there are two centers inside the outer cycle. We determined the exact values of the edge-balance index sets of Halin graphs of double stars, which do not form an arithmetic progression.

180. Survival Analysis of Olympic Records

Elliott Hollifield University of North Carolina, Asheville
Victoria Trevino Utah Valley University
Adam Zarn Wheaton College
Advisor(s): Ke Wu, California State University Fresno

We use recurrent-events survival analysis techniques and methods to analyze the duration of Olympic records. The Kaplan-Meier estimator is used to perform preliminary tests and recurrent event survivor function estimators proposed by Wang & Chang (1999) and Pena et al. (2001) are used to estimate survival curves. Extensions of the Cox Proportional Hazards model are employed as well as a discrete-time logistic model for repeated events to estimate models and quantify parameter significance. The logistic model was the best fit to the data according to the Akaike Information Criterion (AIC). We discuss, in detail, covariate significance for this model and make predictions of how many records will be set at the 2012 Olympic Games in London

181. The Edge-balance Index Set of Two and Three Level Wheels

Ryan Sullivan Stonehill College
Advisor(s): Hsin-hao Su, Stonehill College

Let G be a simple graph with vertex set $V(G)$ and edge set $E(G)$. Any edge labeling f induces a partial vertex labeling $f^+ : V(G) \to \{0, 1\}$ depending on whether there are more 0-edges or 1-edges incident with v, and no label is given to $f^+(v)$ otherwise. For each $i \in \{0, 1\}$, let $v_f(i) = \left|\{v \in V(G) : f^+(v) = i\}\right|$ and let $e_f(i) =$

$|\{e \in E(G) : f(e) = i\}|$. An edge-labeling f of G is said to be edge-friendly if $\{|e_f(0) - e_f(1)| \leq 1$. The edge-balance index set of G is defined as $\{|v_f(0) - v_f(1)|$: the edge labeling f is edge-friendly.$\}$. Because of the definition of the edge-balance index, the calculation of the edge-balance index set depends highly on the structure of a graph. A wheel graph is formed by a cycle with additional edges connected to a center vertex. Because the wheel graph is the first special graphs whose edge-balance index sets do not form a arithmetic progression, we generalized it into two or three level wheels by adding one or two more layers of cycles with connecting edges. In this paper, we determined the exact values of the edge-balance index sets of two or three level wheels.

182. Flexible and Protective Bio-Inspired Armor Systems

Eduan Martinez-Soto Universidad Metropolitana
Advisor(s): Luis De la Torre, Universidad Metropolitana

The understanding of mechanics of composites plays an important role in the design of protective structures. In this work we specifically focus on biologically inspired scale-armors presented at fishes. The aim of this research is to identify optimal geometrical arrangements that can gain flexibility and protection. These systems are characterized by volume fractions, geometrical parameters, and mechanical properties, among others. To this end, we develop finite elements (FE) based in code and analyze different configurations. In parallel, an analytical model is developed. These approaches shed light on the governing parameters and their role in overall material performance. Next, these finding are compared with the experimental results of 3D printed prototypes. This research will enable a good understanding of the complex structure and help in the future of protective materials at macroscopic level, for example help in the development of more tough and flexible human body armors. The results of these experimental, numerical and analytical methods will be presented.

183. The shortest distance between a point on a box and its opposite: a generalization of the Spider and Fly problem

Stephen Miller Santa Clara University
Advisor(s): Edward Schaefer, Santa Clara University

Given a point (the âspider) on a rectangular box, we would like to find a formula for the minimal distance along the surface to its opposite point (the fly - the reflection of the spider across the center of the box). Without loss of generality, we can assume that the box has dimensions $1 \times a \times b$ with the spider on one of the $1 \times a$ faces (with $a \leq 1$). The shortest path between the points is always a line segment for some planar flattening of the box by cutting along edges. We then partition the $1 \times a$ face into regions, depending on which faces this path traverses. This choice of faces determines an algebraic distance formula in terms of a, b, and suitable coordinates imposed on the face. We then partition the set of points (a,b) by isotopy of the borders of the $1 \times a$ face's regions and a labeling of these regions.

184. Modeling the effects of multiple host species on disease transmission in the Upper Mississippi River

Susan Frankki University of Wisconsin, La Crosse
Advisor(s): Dr. James Peirce, University of Wisconsin-La Crosse

Bithynia tentaculata is an invasive aquatic snail that has had significant effects on the ecosystem in the upper Mississippi River (UMR) since its discovery in 2002. One of the key issues associated with the introduction of this species is that it transmits a number of parasites to migrating birds leading to thousands of waterfowl deaths annually. These parasites can use *B. tentaculata* at two points in their life cycles prior to birds. Although both the snail and its parasites have led to more than 70,000 documented bird deaths over the last 10 years, we still know little about parasite transmission patterns among different snails within the UMR. Because of this, we decided to investigate the role that both *B.tentaculata* and native snail species play in parasite transmission. Field collections revealed different infection rates between invasive and native snails. The rates were incorporated into a system of differential equations used to model disease. Theoretical results demonstrate that parasite infection of additional native hosts can substantially alter the transmission dynamics to waterfowl. The importance of these results for local ecology and conservation strategies will be discussed.

185. A Generalization to Finite Groups of an Inverse Theorem to the Erdős-Heilbronn Problem

Steven Reich University of Pittsburgh
Advisor(s): Dr. Jeffrey Wheeler, University of Pittsburgh

We use elementary number theory and group theory methods prove an implication of a result of Gyula Karolyi regarding the Erdős-Heilbronn problem on restricted set addition in $\mathbb{Z}_p$. We then extend this result to finite (not necessarily abelian) groups using the same methods, which is an original result.

186. Computational Topology and Multi-Tissue Mesh Fidelity In MRI Processing

Michael Trotta College of William & Mary
Advisor(s): Jesse Berwald, College of William & Mary

An important problem in magnetic resonance imaging (MRI) is the efficient acquisition, analysis, and real-time usage of large image data sets. Simplifying these data (often large tetrahedral meshes on the order of Gigabytes or larger) without destroying the geometric or topological fidelity of the mesh's multi-tissue structures is crucial. Chernikov and Chrisochoides implemented an approach from computational geometry utilizing edge contractions to reduce the mesh size under assumptions that maintain geometric fidelity. In this project, we examine the effect of edge contractions on the homologies of individual tissues as a means of detecting topological changes in the tissue representations. We establish efficient and local condition checks that ensure homology-preservation of all tissues in the mesh with the practical goal of augmenting existing algorithms.

187. The VC Dimension of Random Set Systems and Words

Samantha Pinella University of Edinburgh
Advisor(s): Anant Godbole, East Tennessee State University

We say that a random set system, R, shatters a subset, S, of $\{1 \dots n\}$ if for every subset $T \subseteq S$, there exists a set $A \in R$ such that $A \cap S = T$. The VC dimension of R is then defined to be the cardinality of the smallest subset of $\{1 \dots n\}$ that cannot be shattered by R. Inspired by how subsets of $\{1 \dots n\}$ can be represented as words of alphabet size two, so we generalize the concepts of shattered sets and VC dimension to random words of alphabet size q. We generate a system or array of t words each of length n using a uniform probability for each letter. Finally, we present several threshold functions for $t(n)$ to determine the VC dimension of the random word system.

188. Using Populations Projection Matrix Models to Show When the Use of Conspecific Attraction Methods Are Counter-Indicated

Lauren Prince Howard University
Advisor(s): Nina Fefferman, Rutgers University

Conspecific attraction is the "tendency for individuals of a species to settle near one another." Ecologists can artificially attract individuals of a population through social cues, such as song. Although using conspecific attraction as a conservation tool can be beneficial, there are some concerns that need consideration. Population projection matrix models will be used to analyze these concerns in territorial songbirds in order to determine the best conditions for the use of artificial conspecific attraction. The implementation of the models are done through Matlab, where different 3×3 transition matrices and population vectors result in projected population vectors for all age classes seen in the species. The factors concerning artificial conspecific attraction — Allee effect, environmental stochasticity, and philopatry — can all be accounted for by the growth rate, the dominant eigenvalue of the right eigenvector of the transition matrix, of the projected population. The growth rate revealed different instances when the factors affecting artificial conspecific attraction were beneficial or detrimental to future populations. Wildlife managers can apply the models to access whether conspecific attraction as a conservation tool is beneficial to a particular population.

189. Mapping Space and Beyond: Exploration of Partition Functions

Andrew Chang California State Polytechnic University, Pomona
Advisor(s): Dr. Jennifer M. Switkes, California State Polytechnic University, Pomona

The partition function $p_d(n)$ has been a much studied area of number theory and combinatorics. The partition functions $p_1(n)$ and $p_2(n)$, the one- and two-dimensional cases, are well understood. However a grasp of the higher

dimensional partition functions remains elusive. Thus, there is keen interest in an algorithm that can efficiently calculate $p_d(n)$. In this poster, we will establish the combinatorial link among partition functions for different dimensions, and we will deduce a recursion formula for higher dimensions $p_d(n)$ by exploring the connection between double factorial of odd integers and coefficients of the recursion.

190. Static Two-Dimensional Deformation of Kitchen Sponges

Brianna Lynn George Mason University
Mauro Rubio George Mason University
Advisor(s): Daniel Anderson, George Mason University

The shape of elastic physical objects can be modeled by partial differential equations. We describe an approach to determine the elasticity parameter of a sponge under compression from experimental measurements. After solving the partial differential equations, we used a nonlinear optimization technique to determine the elastic parameter.

191. Computer Modeling of the Princeton Micro-Combustion Experiment to Understand Flame Extinction and Re-ignition Patterns

Casey Peters University of Redlands
Advisor(s): Joanna Bieri, University of Redlands

Work is based on a specific experiment that was done at Princeton University in which flames streets were observed while burning methane and air. Flames streets involve the extinction and re-ignition patterns in a mirco-combustor. The mechanisms behind this behavior are not well understood and I sought to better understand these flame streets. Thus far, I have calculated the conditions that are needed to have the dimensionless computer model match the conditions in the experiment as closely as possible. Most recently I have been working on adjusting values that have a high uncertainty such as mixture strength, Damkohler number, and wall temperatures.

192. Omitting Types for AF Algebras as Metric Structures

Alex Sherman University of Maryland, College Park
Kevin Carlson Indiana University, Bloomington
Advisor(s): Ilijas Farah, York University

We approach the study of C* algebras via the continuous model theory of Ben Ya'acov, Berenstein, Henson, and Usvyatsov. Direct limit algebras have long been a central focus of study in the subject of C*-algebras. We especially consider the inductive limits of matrix algebras, collected in the class UHF, and more generally of all finite-dimensional C* algebras, which comprise the class AF. Our results characterize both UHF and AF algebras as those omitting certain types in continuous logic. As an application, we demonstrate that while UHF algebras are isomorphic if elementarily equivalent, there exist non-UHF algebras elementarily equivalent to UHF ones.

193. The Interlace Polynomial of the Wheel Graph

Brandy Thibodeaux University of Louisiana, Lafayette
Itelhomme Fene University of Louisiana, Lafayette
Advisor(s): Christina Eubanks-Turner, University of Louisiana at Lafayette

In this work we study the interlace polynomial of wheel graphs. Interlace polynomials are graph polynomials which give information about the structural properties of graphs. We give explicit formulas for the interlace polynomials of W_n, the wheel graph with n external edges, for certain n. We also give recursive formulas for interlace polynomials of some trees related to wheel graphs. Since for any n the star graph S_n, where $|E(S_n)| = n$ and the butterfly graph B (sometimes called the bowtie graph) are both subgraphs of W_n, we have found recursive formulas for the interlace polynomial of these graphs. We believe these formulas will aid us in computing the interlace polynomial of the wheel graph. Our interest in the wheel graph comes from applications of the wheel graph to radio numbering, which is the assignment of radio station labels to the vertices of a graph.

194. Sorting Permutations with Finite-Depth Stacks

Timothy Goodrich Valparaiso University
Advisor(s): Lara Pudwell, Valparaiso University

In 1968, Donald Knuth showed that a permutation π of length n is sortable in an infinite-depth stack if and only if π avoids the pattern 231; there are $\frac{1}{n+1}\binom{2n}{n}$ such permutations. Twenty-five years later, Julian West extended these ideas to permutations sortable with 2 consecutive stacks. We continue this work by limiting the stack(s) to a finite depth. In particular, we completely characterize permutations sortable through a single finite-depth stack and derive a handy enumeration formula. We also apply our pattern characterization and enumeration techniques to permutations that are sortable after k-passes through a finite-depth stack.

195. Locating the mode of some unimodal independence polynomials

Elizabeth Bailey Houghton College
McCabe Olsen Mercer University
Advisor(s): Patrick Bahls, University of North Carolina Asheville

A graph is said to be *unimodal* if the coefficients of its independence polynomial increase to a mode and then decrease, not necessarily strictly, without increasing again. Our goal is to investigate particular families of unimodal graphs to provide an efficient means of locating the mode of the independence polynomial. In the process of this work, we determine a closed form for the independence polynomial of certain "path-like" graphs, further analyze the behavior of these polynomials and show a certain family of path-like graphs is symmetric and unimodal. Our proofs bulids upon the work of Bahls, Bahls-Salazar, Benhoumani, and Wang-Zhu.

196. New Observations and Data on M&m Sequences

Ivan Espinosa California State University, Fullerton
Advisor(s): Dr. Scott Annin, California State University Fullerton

A mean and median sequence (known as an M&m sequence) begins with any three real numbers, and successive terms are determined in such a way that the nth term satisfies the condition that the mean of the first n terms equals the median of the first n-1 terms. No examples of M&m sequences are known that fail to eventually become stable. Using a C++ program to generate large quantities of M&m sequences we collect data, look for patterns, and make some new observations about these sequences. We also present a few tricks for tackling the conjecture that all M&m sequences stabilize. Finally, we present a few interesting questions about other sequences that are related to M&m sequences.

197. Introduction to $D_8 \times D_8$ and its Subgroup Lattice

Daniel Schilcher University of Wisconsin, Eau Claire
Daniella Ciolino University of Wisconsin, Eau Claire
Advisor(s): Dandrielle Lewis, Univesity of Wisconsin Eau Claire

In 1889, Edouard Goursat formulated a theorem in group theory that provides the subgroup structure of a direct product of finite groups A and B. It does this by relating the isomorphism of a factor group of A and a factor group of B with a corresponding subgroup of the direct product. For our research, we used a recently developed containment relation property between subgroups of a direct product to construct the subgroup lattice of the direct product of the dihedral group of order 8, D_8, with itself. One of our long-term goals is to provide the subgroup lattice of one of the extraspecial groups of order 32. Although we already know what the subgroup lattice is going to be from a construction of the subgroup lattice of $Q \times Q$, where Q is the quaternion group, this construction is interesting because the subgroup structure of $D_8 \times D_8$ is very different. Specifically, $Q \times Q$ contains 133 subgroups and $D_8 \times D_8$ contains 389 subgroups. Thus far, we have determined containment for all of the subgroups and their corresponding subgroup structures. Once this was accomplished, we constructed the subgroup lattice in Geometer's Sketch Pad.

198. Biological Reaction Network Modeling and Simulation with Stochastic Differential Equations

Edgardo Vazquez-Rodriguez Universidad Metropolitana
Advisor(s): Dr. Luis De la Torre, Universidad Metropolitana

The field of synthetic biology has been progressing as biologists and theorists collaborate to engineer new systems that either mimic phenomenon found in nature or demonstrate other useful behaviors. Biochemical reactions are inherently stochastic and this necessitates the use of Monte Carlo simulations before any effort to proceed with experimental implementations. However, there often is a large disconnect between these Monte Carlo simulations and the deterministic models on which the designs and analysis are usually based. In this project, we will examine the spectrum of modeling and simulation techniques between ordinary differential equations (ODEs) and Stochastic simulations, in particular focusing on stochastic differential equations (SDEs) using the Langevin approximation.

199. On Mod(3) Edge-magic Cubic Graphs

Matthew Tardiff Stonehill College
Advisor(s): Hsin-hao Su, Stonehill College

Let G be a (p, q)-graph in which the edges are labeled by $1, 2, \ldots, q$. The vertex sum for a vertex v is the sum of the labels of the incident edges at v. If the vertex sums are constant, $\pmod k$, where $k > 2$, then G is said to be Mod(k)-edge-magic. When $k = p$, the Mod(p)-edge-magic graph is the edge-magic graph which was introduced by Lee, Seah and Tan in 1992. When we consider whether a cubic graph is Mod(3)-edge-magic, an old theorem stated "almost all cubic simple graphs are Mod(3)-edge-magic." So, a conjecture, "all cubic simple graphs are Mod(3)-edge-magic" has been around for more than fifteen years and is still not completely solved. While a power theorem, if a cubic graph is Hamiltonian then it is Mod(3)-edge-magic, takes care of most of cubic graphs, in this paper, we investigate non-Hamiltonian graphs which are Mod(3)-edge-magic.

200. Cytotoxic Effects of Vernonia Amygdalina and Paclitaxel in Extrogen Receptor Positive Breast Cancer Cells

Alvaro Laham Universidad Metropolitana
Advisor(s): Roderick McDowell, Jackson State University

Cancer is best described as a set of diseases in which normal cells escape the control mechanisms that regulate growth and development in humans. There are many types of cancers but we will focus on breast cancer. Breast cancer is the second in cancer related deaths of women in the United States. Why breast cancer occurs is not yet fully understood but there are a variety of contributing factors known. Cancer treatment includes chemotherapy, radiation therapy, hormone therapy and surgery. These treatments may cause undesirable side effects in patients, and therefore, improvements are necessary to better treatment outcomes and life quality. Previous studies have shown that extracts from the Nigerian native edible plant Vernonia amygdalina (VA) possess anti-proliferative effects on cancerous cells with estrogen receptors (ER+). Paclitaxel (TAX) is also very aggressive on cancerous cells but it can also damage healthy cells. The objective of this research is to use Trypan Blue, MTT 3-(4,5-dimethythiazol-2-yl)-2,5-diphenyl tetrazolium bromide and Thymidine Incorporation (3[H]-thymidine) in vitro assays to assess and compare, in detail, the effects of VA and TAX combined and by themselves on MCF-7 breast cancer cells to determine cell proliferation and viability.

201. Spectral asymptotics of Airy's operator under perturbation

Jiaoyang Huang Massachusetts Institute of Technology
Advisor(s): Roman Bezrukavnikov, MIT

We study the eigenvalue problem of perturbed Airy operator $-\triangle + (x + V(x))$ on positive real axis, with Dirichlet boundary condition. Given the asymptotic expansion of $V(x)$ at $+\infty$, we provide asymptotic expansion of the eigenvalues λ_n to certain order. Then we will provide an example to show that in general, merely from the asymptotic expansion of $V(x)$, the asymptotic expansion of λ_n cannot be completely determined.

202. Estimating Prevalence of Sensitive Behaviors with Optional Unrelated-Question Randomized Response Models

Anna Tuck University of North Carolina at Greensboro
Advisor(s): Sat Gupta, University of North Carolina at Greensboro

Obtaining accurate information is essential in all surveys, but can be problematic when subjects face sensitive or incriminating questions. Despite assurances of anonymity, subjects often give untruthful responses, leading to serious response bias. One method of reducing this bias is the Unrelated Question Randomized Response Technique (RRT), in which a predetermined proportion of subjects are randomized to answer an innocuous unrelated question with known prevalence. Subjects are provided a higher level of anonymity because the researcher does not know which question (sensitive or innocuous) any individual answered, although the mean of the sensitive question can be estimated at the aggregate level. We propose a generalization of the Unrelated Question RRT model, which takes into account the fact that a question may be very sensitive for one person, but not at all sensitive for another. Each subject is presented the option of omitting the randomization step if the question is deemed non-sensitive. We simultaneously estimate the Mean Prevalence of a sensitive behavior, as well as the Sensitivity Level of the underlying question. We also show that both estimators are asymptotically normal and unbiased. Computer simulations are used to validate these theoretical results.

203. Generalized Bol-Moufang Identities of Loops and Quasigroups

Lauren Morey The University of Montana
Barbara Hernandez University of Redlands
Alicia Velek York College of Pennsylvania
Advisor(s): Reza Akhtar, Miami University

Most of us are familiar with the notion of a group, which is a set G equipped with a binary operation satisfying the group axioms. A $quasigroup$ is a set G together with a binary operation $*$ that has the property that for all $a \in G$, the maps $L(a) : G \to G$ and $R(a) : G \to G$ defined by $[L(a)](x) = a * x$ and $[R(a)](x) = x * a$, respectively, are bijective. This is known as the Latin Square Property. A quasigroup, unlike a group, does not necessarily contain an inverse, and its elements may not be associative. The $variety\ of\ quasigroups$ consists of $(G, *, \backslash, /)$, where the binary operations $*, \backslash, /$ satisfy the following axioms for all $x, y \in G$: $(x * y)/y = x$, $x\backslash(x * y) = y$, $(x/y) * y = x$, and $y * (y\backslash x) = x$. We are generalizing the notion of Bol-Moufang type (two of its three variables occur once on each side of an identity, the third variable occurs twice on each side, and the ordering of the variables on each side is the same) by considering identities with more variables. Even though a quasigroup does not have as much structure as a group, some unexpected implications can be found from these identities.

204. Novel Characterizations of Knot Complexity

David Hyde University of California, Santa Barbara
Advisor(s): Kenneth Millett, University of California, Santa Barbara

In recent years, the field of knot theory has entered into the spotlight of mathematics. This is in large part due to the fact that, in addition to their role as pure mathematical structures, knots have found numerous applications in the sciences. For example, one may use knot theory to analyze the structures of proteins and to gain greater insight into the mechanisms by which proteins fold or unfold. Key to understanding such applications of knot theory are ways to characterize the complexity of knots. In this work, we analyze graph-theoretic and algebraic properties of "knot fingerprints" in order to develop a systematic characterization of knot complexity. We present ways to use the adjacency matrix of an associated graph as a means of representing knot fingerprints. Furthermore, we draw from the concepts of the Cheeger constant and Menger's theorems and interpret knot fingerprints in the context of a network or flow. With these analyses, we are able to identify quantities that successfully measure knot complexity. We demonstrate the effectiveness of our characterizations by applying them to knots of up to ten crossings as well as select composite knots. Finally, we suggest new avenues of research and potential applications.

205. Inverse Modeling of Dynamical Systems: Multi-Dimensional Extensions of a Stochastic Switching Problem

Blake Chamberlain Susquehanna University
Erik Bates Michigan State University
Rachel Gettinger Saint Vincent College
Advisor(s): Daniel P. Dougherty, Michigan State University

The Buridan's ass paradox is characterized by perpetual indecision between two states, which are never attained. When this problem is formulated as a dynamical system, indecision is modeled by a discrete-state Markov process determined by the system's unknown parameters. Interest lies in estimating these parameters from a limited number of observations. We compare estimation methods and examine how well each can be generalized to multi-dimensional extensions of this system. By quantifying statistics such as mean, variance, frequency, and cumulative power, we construct both method of moments type estimators and likelihood-based estimators. We show, however, why these techniques become intractable in higher dimensions, and thus develop a geometric approach to reveal the parameters underlying the Markov process. We also examine the robustness of this method to the presence of noise.

206. Is Every Invertible Linear Map in the Structure Group of some Algebraic Curvature Tensor?

Lisa Kaylor Westminster College
Advisor(s): Dr. Corey Dunn, California State University, San Bernardino

We study the elements in the structure group of an algebraic curvature tensor R by analyzing Jordan normal forms. Because every matrix has a unique Jordan normal form representation, up to a permutation of the Jordan Blocks, we are able to determine which matrices taking on a specific form will be in the structure group of some algebraic curvature tensor. A method for analyzing these forms is developed and explained.

207. ACTIVE: A Bayesian Approach to Asset Covariance Estimation

Nicholas Marshall Clarkson University
Daniel Robert Helkey Emmanuel College
Robert Paul Hark Montana Tech of the University of Montana
Tejpal Singh Ahluwalia New Jersey Institute of Technology
Advisor(s): Dr. Marcel Blais, Worcester Polytechnic Institute (WPI)

An improved stock return covariance estimation procedure is developed using an implicit Bayesian method known as shrinkage. The application of shrinkage to covariance matrix estimation was first introduced by Ledoit in 2003 to eliminate rank-deficiency problems in the sample covariance matrix. We extend Ledoit's work by incorporating the VIX, a market implied volatility index, into the estimation process and name our strategy ACTIVE, asset covariance through implied volatility estimation. The ACTIVE matrix is well-conditioned and forward-looking by construction. ACTIVE's ability to forecast market volatility makes it more dynamic, allowing it to respond to changing financial regimes. The performance of ACTIVE is evaluated by the use of a mean-variance optimizer and empirical analysis. We show using market data that ACTIVE is a viable alternative to industry standard techniques.

208. Non-Contiguous Pattern Containment in Trees

Alexa Serrato Harvey Mudd College
Connor Scholten Grand Valley State University
Tyler Schrock Troy University
Advisor(s): Lara Pudwell, Valparaiso University

We first define what it means for a binary tree to contain another binary tree in a non-contiguous sense. We then enumerate non-contiguous containments of a j-leaf tree within all i-leaf trees. Our main result is that any two j-leaf trees are both contained within all i-leaf trees the same number of times, regardless of their shapes. Next, we determine a generating function $G(x, y)$ for any path tree t where the coefficient of $x^i y^n$ is the number of trees with i leaves that have n copies of t. Finally, we state which of these results generalize to m-ary trees.

209. Numerical Solution for the Dirichlet problem via Modified Gallerkin Method: Super ellipsoid

Hy Dinh Roger Williams University
Advisor(s): Dr. Yajni Warnapala, Roger Williams University

In this project, we will determine the numerical solution for the Helmholtz equation. How does a surface react towards an incoming wave approaching from various directions? Would it tend to head for the extremes of either absorbing or reflecting everything that comes in contact, or obtain a neutral combinational of the two. This research project focuses on finding the solution for that inquiry and therefore, on determining how a convergent smooth surface depending on its outer shape, in this case the super ellipsoid, responses to different outer waves. The primary purpose is to calculate the possibility of a certain object acquiring the sufficient conditions to either submerge under respectively high water pressure or in outer space; if applicable, this approach can be used for a new efficient design of a portion of a submarine or part of a space craft. The Dirichlet problem is solved through a numerical method, specifically the Gallerkin Method, to obtain accuracy for the Dirichlet condition for the Helmholtz equation.

210. Radio Labeling for Cycle Graphs

Ilia Gonzales-Parham California State University, San Bernardino
Lydia Delgado California State University, San Bernardino
Joel Webster California State University, San Bernardino
Advisor(s): Min Lin-Lo, California State University of San Bernardino

Let G be a connected graph. For any two vertices u and v, let $d(u, v)$ denote the distances between u and v in G. The maximum distance between any pair of vertices is called the $diameter$ of G and denoted by $diam(G)$. A $radio-labeling$ (or multi-level distance labeling) of a connected graph G is a function $f : V(G) \to \{0, 1, 2, 3, \ldots\}$ with the property that $|f(u) - f(v)| \geq diam(G) - d(u, v) + 1$ for every two distinct vertices u and v of G. The $span$ of f is defined as $max_{u,v \epsilon V(G)} \{|f(u) - f(v)|\}$. The $radio\ number$ of G is the minimum span over all radio-labelings of G. In this presentation we will discuss how we found the optimal radio-labeling for even cycle graphs during a 2012 summer research program, which is a part of the NSF PRISM grant DMS-1035120 (*Proactive Recruitment in Introductory Science and Mathematics*).

211. Comparison of Two Models for Fat/Water Separation in Magnetic Resonance Imaging (MRI)

Cody Gruebele California State University, Fullerton
Advisor(s): Angel R. Pineda, California State University, Fullerton

When separating water and fat signals from complex MRI measurements there are a few different models that are commonly used. The models we consider are the non-linear three-point (NL3PT) model, the linear two-point model, and the non-linear two-point (NL2PT) model. The NL3PT model is generally the most accurate but since it has five separate parameters, it requires three complex measurements from the MRI scanner for the model to fit the data. The two-point models only require two complex measurements to fit the data since they both have four parameters, which means a reduction in the amount of time needed to acquire the data. We are studying how well the various models predict the water and fat signals by using numerical techniques to solve the non-linear problems and Monte Carlo methods to asses the uncertainty in the parameters. In MRI scans random errors occur in the measurements and magnetic field. In our work, for the first time, we consider a random distribution of the errors in the magnetic field to evaluate the two point models. We use the data from the NL3PT model using histograms and the mean squared error (MSE) to show how well each model estimates the fat and water signals. We found that the NL2PT model generally has a lower MSE than its linear counterpart.

212. Specializations of generalized Rikuna polynomials

Celeste Cass Bard College
Advisor(s): John Cullinan, Bard College

The generalized Rikuna polynomials are an iterative generalization of Rikuna's generic cyclic polynomials, which themselves generalize Shanks' cubic polynomials. In the associated paper we study Galois properties of the generalized Rikuna polynomials under specialization.

213. Small Figure-Eight Knots, Interesting Unknots, and a Program to Distinguish the Two

Colin Guider Binghamton University
Adelina Kaye California State University, Fullerton
Eric Smith Jacksonville University
Advisor(s): Jennifer McLoud-Mann, The University of Texas at Tyler

Our work investigates finding the minimal number of edges in various lattices to create a figure-eight knot. We modified existing computer programs used to solve the analogous problem for the trefoil. While our research is not complete (computer programs are still running), investigation of initial data has revealed some interesting unknots. In particular, we found unknots that need to be lengthened before they can be reduced to a very small number of edges. Such unknots have been found for the simple cubic lattice but they contain a large number of edges; our unknots are relatively small in length. In order to distinguish knot types from our data in the future, we wrote a computer program which inputs a lattice knot and outputs the colorability of that knot.

214. Mathematical Model of the Effect of Alcohol on Blood Glucose Metabolism

Joseph Bulatowicz New Jersey City University
Eric Ledesma New Jersey City University
Advisor(s): Dr. Zhixiong Chen, New Jersey City University

Many organisms utilize glucose as their main source of energy. Glucose, a simple carbohydrate, is metabolized from the foods organisms consume or is synthesized within the organism. In healthy individuals, the body is able to regulate the amount of glucose present in the bloodstream. However, people with a condition known as diabetes mellitus are unable to successfully carry out proper glucose metabolism. In previous studies, ethanol, or drinking alcohol, caused lower-than-normal blood sugar levels in humans, which is further exacerbated in diabetics. A system of ordinary differential equations was created to include ethanol as a parameter of the blood glucose regulation system.

215. Modeling the Rate of Formation of cAMP in Preformed Signaling Complex of G-Proteins and Adenylyl Cyclase

Paola Martinez University of Houston Downtown
Jungsook Lee Larson University of Houston Downtown
Advisor(s): Dr. Timothy Redl, MAA/University of Houston-Downtown

In reference to cellular signal transduction, it is the accepted doctrine that heterotrimeric G-Protein complexes are activated by the binding of a ligand to a receptor. Exchange of GDP for GTP on alpha subunit of G causes the separation of G from G, and these subunits then diffuse to their respective effector. GTP-G activates the effector, adenylyl Cyclase (AC), which catalyzes the production of the cyclic AMP (cAMP), the second messenger in the cell. However, recent data shows that Inactive G-proteins (GDP-G) exist as a complex with adenylyl cyclase. G-proteins interact with adenylyl cyclase at two distinct sites; the inactive G-proteins are scaffolded at N-terminus of AC while active G-proteins (GTP-G) interact at the catalytic domain of AC. This supports the existence of preformed signaling complex of adenylyl cyclase 5 (AC5) and heterotrimeric G-proteins (G). We hypothesize that the existence of preformed signaling complexes play role in fast activation and inactivation of the signaling pathway and will be mathematically modeled in terms of rate of formation of cAMP.

216. Bounds on the Size of Sound Monotone Switching Networks Accepting Permutation Sets of Directed Trees

Joshua Brakensiek Homeschool High School
Advisor(s): Aaron Potechin, MIT

Given a directed graph G as input with labeled nodes s and t, the ST-connectivity problem asks whether s and t are connected. The memory efficiency of a large class of algorithms solving this problem can be analyzed using sound monotone switching networks. This paper concerns bounds on the size of sound monotone switching networks which solve the directed connectivity problem whenever the input graph G is isomorphic to a given graph H. Previously, tight bounds had been found in the cases that H is a special kind of tree and that H is a collection of disjoint paths from s to t. This paper improves these results to find a nearly tight bound which applies to all directed trees. If we

let n be the number of vertices in the graph and ℓ be the length of the path from s to t in the tree, this paper finds upper and lower bounds B_1 and B_2, respectively, such that $\log(B_1/B_2) = O(\log\log\ell)$. The previous best general bounds satisfied $\log(B_1/B_2) = O(\log\ell)$.

217. New Formulation of a Complex Integral Inverse Problem

Michael Horst Arizona State University
Advisor(s): Rosemary Renaut, Arizona State University

Determining parameters describing the performance of a solid oxide fuel cell requires the solution of a complex integral inverse problem. One formulation suggested in the literature is a direct quadrature approach, based on the real part of the integral equation only. However, better conditioning of the problem can be obtained by using various combinations of the real and imaginary parts of the integral equation. We run simulations of the solution for each of these combinations via the singular value decomposition, truncated singular value decomposition, filtered singular value decomposition, and filtered truncated singular value decomposition, and ultimately find the most accurate to be solving the combined complex setup with the FTSVD.

218. Bound Smoothing using Bordered Euclidean Squared Distance Matrices

Heather Magee University of Central Oklahoma
Advisor(s): Thomas Milligan, University of Central Oklahoma

A distance matrix A which encodes squares of pairwise distances in matrix form is known as a Euclidean Squared Distance Matrix (ESDM). Bordered ESDMs are useful in determining the embedding dimension of points in space. We investigate known methods that use these bordered ESDM's to improve the bounds on unknown distances of four points in three dimensional space (using the tetrangle inequality) and extend these ideas to five points.

219. Determining the Accuracy the of a Quantum Testing Protocol for Werner States

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

The promise of applications to secure communication, improved metrology, and powerful computation technologies motivates us to study quantum states. One such class, called the Werner states, are particularly useful because they have the property that the overall quantum state is unchanged when noise affects all the subsystems in the same way. This motivates the desire for a test to determine whether an unknown state is in fact a Werner state. We worked with Haskell and Mathematica to run computational experiments to determine performance limits of a particular testing protocol.

220. Parameter estimation and network perturbation methods applied to the DREAM7 challenge

Tricity Andrew University of Tulsa
Advisor(s): Stefan Hoops, Virginia Polytechnic Institute and State University

Parameter estimation and network inference are common systems biology problems. Our project used networks in the DREAM7 (Dialogue for Reverse Engineering Assessment and Methods) Challenge, an annual systems biology challenge to increase the understanding of comparative advantages of network inference models. The "Network Topology and Parameter Inference" challenge consisted of two *in silico* models for which dynamic behavior was to be predicted. Our goal was to design optimal experiments to identify model parameters and network links and make model predictions. We used COPASI (COmplex PAthways SImulator) as the major analysis tool and Condor-COPASI (COPASI hosted on a Condor high-throughput computing system) for global sensitivity analysis and parameter confidence estimation. This decreased the coefficients of variation for the parameters with the biggest impact on the predictions and found better estimates. To explore models with different network topologies we developed a series of Python scripts to systematically change COPASI models and used this with COPASI to predict network links.

221. Structure of k-Braid Satellites Within a Type k Torus

Michael Lessley California State Polytechnic University, Pomona
Advisor(s): Rolland Trapp, Cal State San Bernardino

The set of Satellite Knots is one of the three fundamental groups of knots, along with Hyperbolic and Torus Knots. This set is unique in that it contains the set of all composite, or non-prime, knots. In the field of Knot Theory we are mostly concerned with the properties of prime knots, so for my study I focused on the properties of a potential set of prime satellite knots. Specifically we will examine the properties of satellite knots whose companion is a torus of type k and whose braid diagram has an index of k. By deriving braid words from projections of these knots we will examine the structure and properties of these knots and develop a straightforward method for creating knots of this type.

222. The Perfect Parallelepiped Problem

Amy VanHooft The College at Brockport
Benjamin D. Sokolowsky Bucknell University
Rachel M. Volkert University of Northern Iowa
Advisor(s): Cliff Reiter, Lafayette College

A perfect parallelepiped has integer length edges, face diagonals, and body diagonals. We prove the existence of an infinite family of dissimilar perfect parallelepipeds with two of their nonparallel faces being rectangular. We also show that perfect parallelepipeds of this form can be obtained with the angle of the non-rectangular face arbitrarily close to 90. Because of this fact this family has many implications towards the famous open problem concerning the existence of a perfect cuboid. This leads to two conjectures that together would imply no perfect cuboid exists.

223. Are Automatic Algorithms Reliable?

Nick Clancy Illinois Institute of Technology
Caleb Robert Hamilton Illinois Institute of Technology
Advisor(s): Fred J. Hickernell, Illinois Institute of Technology

There are commonly used numerical algorithms that automatically determine the number of steps needed to achieve an approximation answer within a given error tolerance. Often they work well, but sometimes they fail to achieve the desired accuracy. Our work demonstrates the vulnerabilities of quadrature algorithms. Along the way, we defined new relationships among the properties of functions that fool these algorithms. The focus of this study is on the "peakiness" of a function, or how sharp of a spike is missed by the algorithm. This trait also allowed us to compare the algorithms' performances to each other. New algorithms have been proposed that avoid the pitfalls of existing algorithms and have parameters that can be tailored to the user's knowledge of function properties.

224. q-Calculus

Cory Wright Rowan University
Jonathan Lai The University of Texas at Austin
Emily Obudzinski University of Rochester
Advisor(s): Allan C. Peterson, University of Nebraska Lincoln

q-Calculus, or Quantum Calculus, is a subset of a much broader subject, timescale calculus. Its major application is in the field of quantum physics. We will develop this calculus from scratch, deriving some results differently than current research in this field. We will start by motivating definitions for the normal calculus operations: the derivative and integral. Once these are developed, we will find properties of these operators and use them to develop more of our q-calculus. With these important foundations established, we can utilize them to solve q-difference equations. This will be possible by the use of the q-Laplace transform, which we will examine closely. This will lead us to our development of the exponential order of a function, which is the most unique trait of our version of q-Calculus.

225. Towards a Sharper Version of Clifford's Theorem for Graphs

Henry Yelin Emory University
Advisor(s): David Zureick-Brown, Emory University

Connections between degenerations of curves and the chip firing (or sand pile) game have garnered a resurgence of interest. The rank of adivisor on a graph (i.e., a configuration of chips) is a measure of the winnability of the corresponding chip firing game, and in line with the analogy between Riemann surfaces and curves, one finds various theorems—Riemann Roch and Clifford's theorems—which facilitate the computation of the rank of a divisor. One piece of this analogy which is still open is the connection between the sharpness of Clifford's theorem and the geometry (e.g., gonality) of the graph—for instance, classically, Clifford's theorem is sharp if and only if the corresponding Riemann surface is hyper elliptic. We provide evidence for this and related conjectures—restricting to specific families of graphs, we find general theorems for determining winnability and rank of a divisor, and in doing so, we verify the conjecture for these cases. We also present lots of supporting numerical data.

226. Perturbed system of linear differential equations

Ismael Perez San Diego State University
Advisor(s): Peter Salamon, Professor/San Diego State University

Perturbation methods have been traditionally used for finding approximate solutions to otherwise unsolvable physical problems. We perturbed a system of linear differential equations that describe the chemical kinetics of site-specific recombination by the bacteriophage lambda. This is a mechanism that viruses use to insert their genome into the genome of their Escherichia Coli host. We've yet to yield a stable identification of the rate constants when using the Nelder-Mead Algorithm to minimize the sum of square errors between the data and the model. This is due to the fact that one of the steps in the reaction relaxes on a faster time-scale than the time-scale of our observations. If this fast reaction is always in equilibrium, we cannot see the rate constants during this time. In fact however, a weak signal from the fast reaction can be seen in the first few seconds. To focus in on this signal, we perturbed the system to obtain a better identification of the rate constants. Using the Hessian of the sum squared error as a function of the parameters shows this to be a good technique on synthetic data. The low precision possible for real data limits the use of this technique for the original experiments. We've shown that perturbation theory can be used in linear systems.

227. The Kakeya Conjecture and Variations on Besicovitch Sets

Elizabeth O'Reilly University of Pittsburgh
Eleanor Hankins St. Mary's College of Maryland
Advisor(s): Tamás Keleti, Eötvös Loránd University

A Besicovitch set is a compact set in Rn that contains segments of unit length in every direction. Besicovitch discovered there exist Besicovitch sets in the plane with Lebesgue measure zero, implying Besicovitch sets of zero measure exist in higher dimensions as well. The famous Kakeya conjecture states that the Hausdorff dimension of a Besicovitch set in R^n must be n. In 1971, Davies proved this for the 2-dimensional case. In our research, we explore smaller, related problems. We can project a Besicovitch set in R^2 to a set consisting of a line with line segments through each point. Since projection cannot increase Hausdorff dimension, this set must have Hausdorff dimension 2 by Davies' result. Our research focuses on the construction of a curve in 2 dimensions with lines through each point, which has dimension less than 2. In this presentation, we prove the existence and validity of such a construction and prove it has Hausdorff dimension 1.

228. Understanding Wikipedia Editor Lifecycles

Alexandar Bristol University of Massachusetts Amherst
Nathan Edward Leech Macalester College
Guanyu Wang University of Iowa
Mary Katherine Huffman Virginia Polytechnic Institute
Advisor(s): Shilad Sen, Macalester College

Our research studies the health of Wikipedia through several specific questions: What are the work patterns of Wikipedia users? How do users change as they become more experienced? How do user patterns change as Wikipedia becomes older? We study three different measures of work in Wikipedia to demonstrate that editors typically do not

actively continue editing for more than a year. For those who do, a few types of work increasingly dominate their efforts over time. Also, editors who continue to edit for longer amounts of time are those who contributed the most to Wikipedia from the very beginning. This finding supports results from prior research.

229. Properties of a Broken Spline Model

Victoria Miller California State University, Bakersfield
Nehemias Ulloa California State University, Bakersfield
Advisor(s): Eduardo Montoya, California State University, Bakersfield

Researchers often use simple linear regression to model the relationship between two variables because it is a fairly straightforward technique in which the parameters have a clear interpretation. However, there are times when the relationship between the two variables is more complex. This results in incomplete or misapplied analysis because the basic assumptions of parametric regression are violated. When this occurs, non-parametric regression may provide an alternative approach to modeling the data. In this project, we study the broken cubic spline model (which is a special case of non-parametric regression models), and we investigate which model fitting methods provide the better fit for the data. For model fitting, we compare the AIC, AIC_{corr}, BIC, CV, GCV, and RSE criterion. We implement these criteria in the $Penalized\ Spline$, $Myopic$ and $Full\ Search$ algorithms to see how knot selection also influences our decision for the best fit. In order to understand the benefits of each method, a simulation study was performed. The simulation study includes different sample sizes and levels of noise in the data to see if these factors influence the performance of the model fitting criteria.

230. Through the Mathematical Eye: the Shapes of Heavens of Philadelphia

Lisa Chen St. Joseph's University
Tetyana Berezovski St. Joseph's University
Advisor(s): Tetyana Berezovski, Saint Joseph's University

This study focuses on the mathematics of architectural designs. In this project I photographed and analyzed the shapes of various domes in the Philadelphia area. I uploaded the photographed images into dynamic geometry software, called the Geometer's SketchPad and constructed geometric diagrams the represent these images. Conic curves represented the best-fit equations. I applied the mathematics of rigid motion to design and investigate these images. The domes had parabolic, elliptic and onion-shape forms. When working with the conics shaped domes, I also studied algebra of conic sections. The integration of algebra and geometry of conics, along with the golden ratio, help me to appreciate the architecture, and enable me to learn new mathematics.

231. Parameterizing Quaternion Pythagorean Triples

Andrew Herring University of New Mexico
Amy Been University of Nebraska, Lincoln
Advisor(s): Fernando Barrera-Mora, PhD, Universidad Autonoma del Estado de Hidalgo,Mexico

Solutions to the Pythagorean equation $x^2 + y^2 = z^2$ have been completely parameterized over the integers, and more generally over all unique factorization domains. Little is known however about the solutions over non-commutative rings. Throughout this project, we have tried to produce a parameterization of the solutions to the Pythagorean equation in the ring of rational quaternions. To this end, we have adapted a technique of Dickson to produce an infinite family of rational quaternion Pythagorean triples starting from a single such triple. To furnish these "starting triples" we have tried to parameterize the equation $x^2 + y^2 = 1$ for rational quaternions x and y. We show that the existence of such a parameterization is guaranteed by the fact that a certain quadric surface in $\mathbb{A}^8$ has a rational point. The resulting parameterization in five parameters gives infinitely many "starting triples" of the form $(x, y, 1)$ from which we may use our adaptation of Dickson's method to generate (infinitely many) infinite families of rational quaternion Pythagorean triples.

232. Factorization Properties of Congruence Monoids

Joseph Gibson The University of Texas, San Antonio
Arielle Fujiwara Roosevelt University
Daniel Montealegre University of California at Los Angeles
Advisor(s): Dr. Vadim Ponomarenko, San Diego State University

Let $n \in \mathbb{N}$, $\Gamma \subseteq \mathbb{N}$ and define $\Gamma_n = \{\overline{x} \in \mathbb{Z}_n \mid x \in \Gamma\}$ the set of residues of elements of Γ modulo n. If Γ_n is multiplicatively closed we may define the following submonoid of the naturals: $H_{\Gamma_n} = \{x \in \mathbb{N} \mid \overline{x} = \overline{y}, \overline{y} \in \Gamma_n\} \cup \{1\}$ known as a *congruence monoid* (CM). Unlike the naturals, many CMs enjoy the property of non-unique factorization into irreducibles. This opens the door to the study of arithmetic invariants associated with non-unique factorization theory; most important to us will be the concept of *elasticity*. In particular we give a complete characterization of when a given CM has finite elasticity. Throughout we explore the arithmetic properties of H_{Γ_n} in terms of the arithmetic and algebraic properties of Γ_n.

233. Randomized dominating sets in Wireless Sensor Networks

Michelle Tanco Ursinus College
Advisor(s): Akshaye Dhawan, Ursinus College

Wireless Sensor Networks (WSNs) consist of a number of low cost sensors that are equipped with a radio interface. These devices are deployed in large numbers over an area of interest and they monitor the targets in this region and send information to a base station or a gateway node.Domination is a fundamental graph theory problem with applications to routing, fault-tolerance and coverage in Wireless Sensor Networks. Of particular interest are k-tuple dominating sets where each node in the graph is either in the k-dominating set or has at least k neighbors in the set. In this work, we examine the relationship between the domination number of the graph and node connectivity. We also present randomized algorithms that can construct a connected dominating set in a localized manner.

234. Hopf-Cole Type Transformations for a Viscous Burgers Equation

Thomas Deatherage University of Central Arkansas
Brandon Phillip Ashley University of Central Arkansas
Advisor(s): Danny Arrigo, University of Central Arkansas

It is well known that solutions of the linear heat equation can used to generate solutions of Burgers' equation through the Hopf-Cole transformation. Recently, it has been shown that a Hopf-Cole type transformation exists such that solutions of the fast diffusion equation can be used to generate solutions of a viscous Burgers' equation. We show that this result generalizes. We present results showing that there exists large classes of Hopf-Cole type transformations where solution of nonlinear diffusion equations gives rise to solutions of viscous Burgers' equations.

235. The Falling Raindrop in a Non-Uniform Gravitational Field

Ngan Le Montgomery College
Advisor(s): Eugene Li, Montgomery College

A mechanics problem which involves a spherical raindrop gaining mass due to accretion as it falls through a cloud of droplets in a non-uniform gravitational field. This article investigates the motion of very small droplets, those of diameter less than 0.003 inches, which are falling at relatively slow speed, less than 0.188 meters per second. With these conditions, Stoke's Law for air resistance is applicable, since the raindrop is experiencing mostly laminar air flow without turbulent air flow, as the Reynolds number is a very small number less than 1. Using both analytical and numerical methods, we are able to predict the existence of the terminal velocity of a falling raindrop and also the terminal acceleration, in the case of accretion. This mathematical model of falling raindrops proposes a relationship to rocket ship problem which is considered a reversed process.

236. Strings of Special Primes in Arithmetic Progressions

Sarah Peluse The University of Chicago
Keenan Monks Harvard University
Lynnelle Ye Stanford University
Advisor(s): Ken Ono, Emory University

The Green-Tao Theorem, one of the most celebrated theorems in modern number theory, states that there exist arbitrarily long arithmetic progressions of prime numbers. In a related but different direction, a recent theorem of Shiu proves that there exist arbitrarily long strings of consecutive primes that lie in any arithmetic progression that contains infinitely many primes. Using the techniques of Shiu and Maier, we generalize Shiu's Theorem to certain subsets of the primes such as primes of the form $\lfloor \pi n \rfloor$ and some of arithmetic density zero such as primes of the form $\lfloor n \log \log n \rfloor$.

237. Realizable sets of omitted cycle lengths in Hamiltonian graphs

Shannon Fehrenbach University of Wisconsin, Oshkosh
Margaret Perry Wellesley College
Advisor(s): Patrick Bahls, University of North Carolina-Asheville

Bahls, Kutler and Mousley (2012) proved a theorem providing conditions on a Hamiltonian graph which guarantee a large number of cycle lengths in the graph, generalizing the work of Bondy. The theorem admitted the possibility of a class of exceptional cases whose members can be characterized by their cycle spectra. We have discovered the existence of such exceptional graphs and work to characterize them. We prove that any Hamiltonian subgraph of the complete bipartite graph $K_{n/2,n/2}$, $n \geq 6$, with at least $\frac{n^2}{8} + \frac{n}{2} + 1$ edges is a member of the exceptional family of graphs admitted in the theorem. We also discuss other results of our classification of the exceptional class of graphs.

238. Improved High-Order Modulation Maximal Likelihood Detection in MIMO System

Skyler Seto Massachusetts Institute of Technology
Karen Larson University of California at Los Angeles RIPS
Advisor(s): Stacey Beggs, IPAM UCLA

The typical signal is encoded, modulated, multiplexed, transmitted, demultiplexed, demodulated, and finally decoded. This signal path process is typical to wireless communication based broadband systems. Many algorithms have already been introduced to accurately and efficiently carry out the signal path process. Using two existing algorithms (Maximum Likelihood and Minimum Mean Square Error) in the demodulation stage, we were able to develop Simplified Maximum Likelihood Detection algorithms, and tested our algorithms against other existing algorithms by comparing the signal strength and error rate. Our findings on Simplified Maximum Likelihood Detection led us to introduce forward error correction codes in the encoding and decoding stage of the process in order to decrease the error rate. Work is now being done to increase the accuracy of our algorithms using these codes and other methods. Knowledge of the efficiency of these algorithms will be helpful for selecting the appropriate algorithm for telecommunications.

239. Metric-linear characterizations of algebraic structure in finite-dimensional operator spaces

Matthew Gibson Denison University
Advisor(s): Dr. Matthew Neal, Denison University

Recently, Blecher and Neal have given several new characterizations of algebraic structures in terms of their operator space structure (henceforth refered to as the *metric-linear* structure) . In particular, they have given metric-linear characterizations of unital operator spaces, operator systems, and C*-algebras. In this poster session, I will present some new finite dimensional results along these lines. In particular, I will give characterizations of projections, commutivity, nilpotents, closure under multiplication, and other algebraic conditions on matrices and matrix spaces involving the ℓ_1 and ℓ_∞ norm structure of the ambient matrix space. I will also give a new proof that the Shatten class S_1 is not a unital operator space.

240. Growth Patterns of Ethnic Groups in Bexar County with Modified Leslie Models

Judith Arriaza University of the Incarnate Word
Advisor(s): Zhanbo Yang, University of the Incarnate Word

In the previous study, the Leslie model was established to be a mathematical model that was able to predict the population growth of ethnic groups in Bexar County.Even though the Leslie model seemed to give satisfactory results,one of its limitations was that the matrix used in that model was static.The purpose of this study is to improve and modify the Leslie model with a dynamic matrix for better population projections in Bexar County.Modifying the Leslie model with a dynamic matrix seems appropriate for a human population since the birth and survival rates are changing from year to year.The first step toward constructing the dynamic matrix was to find model functions for each of the eighteen age groups in the birth and survival rates.A function template was chosen to model the birth and survival rates.After the modeled functions where gathered they were put in to the matrix.For each of the ethnic groups a Leslie matrix was constructed and multiplied by the initial population vector.Population projections were made until 2020.The results were compared to the censuses and to the static Leslie matrix.In conclusion, having functions for birth and survival rates instead of constant values definitely made a difference.Overall, the dynamic matrix model produced better results.

241. GKZ Systems and Hyperplane Arrangements

Paxton Turner Louisiana State University
Advisor(s): Dr. Jerome William Hoffman, Louisiana State University

The purpose of the project is to study and find relationships between two families of differential equations arising from hyperplane arrangements : GKZ (Gelfand–Kapranov–Zelevinsky) Systems and Gauss–Manin Connections. We begin by covering the fundamentals of both approaches and highlight the basics of D-modules, the machinery used to link the two together. What follows are several investigations: the case of m points in $\mathbb{C}$, an example of two different arrangements which yield isomorphic GKZ systems, with a generalization due to Dr. Chris Bremer of Louisiana State University, and the algorithm for computing Gauss–Manin Connections for m lines in $\mathbb{C}^2$. Furthermore, the algorithm is implemented in a Mathematica notebook which computes the Gauss–Manin Connection Matrix Ω explicitly given an integer input m.

242. Robust Statistical Modeling of Neuronal Intensity Rates

Jenny Chang California State University, Fullerton
Advisor(s): Dr. Sam Behseta, California State University, Fullerton

A popular theory in neuroscience disassociates the primary motor cortex (M1) as an executioner of movements from storing and retaining motor movements. Matsuzaka et al. (2007) conducted a study where M1 neuronal activities of monkeys were recorded in correspondence to hand and digit muscle reactions to two types of visual stimuli: randomly ordered sets and repeated patterns. In this work, we develop a statistical hypothesis testing paradigm based on a nonparametric resampling technique to compare neuronal firing intensity functions obtained from the two experimental conditions. Our approach revolves around resampling neuronal spike trains as an aggregate of time points, or point processes, preserving the spiking nature of each trial recorded during the experimented task. In this context, the null hypothesis reflecting no statistical differences between the neuronal firing rate curves, fitted to the spiking activities of a single motor neuron under the two conditions, is tested nonparametrically. The statistical detection of differences between the firing patterns of M1 neurons gives way to further investigation associated with the role of M1 in executing and planning fully-learned movements.

243. A tractable development for multi-dimensional numbers and geometric algebra

Nathan DiDomenico James Madison University
Keith Thrasher James Madison University
Advisor(s): Debra Warne, James Madison University

In recent years there has been a resurgence of geometric algebra in the sciences. Its ability to express both geometric and physical aspects of problems while using efficient notation has driven its use by physicists, engineers, and computer scientists. Despite geometric algebra's compact and intuitive descriptions of many areas of physical science, it is viewed as having too steep a learning curve for common use. We seek to draw easy-to-follow connections to

current vector analysis in order to foster more widespread use of geometric algebra. We present a novel development of the basic algebra of geometric algebra, using components and basis elements. This development will be a generalization of very recognizable number systems and will employ the use of our eight-dimensional Grassmann hypercomplex numbers. A component representation of numbers and operations provides a way for a novice to more easily wade in the shallow end. This perspective then leads to natural basis elements that in turn allow one to abandon components and dive into a direct, multi-dimensional algebra, which enjoys ease of algebraic manipulation and immediate geometric intuition and interpretation. As an example, we explore our multi-dimensional quaternion expressions to achieve rotations.

244. Nonlocal Models in Diffusion with Applications in Peridynamics

Christine Hoffman University of Minnesota, Morris
Amanda Brucker Cornell College
Trevor Vossberg Illinois Institute ot Technology
Joshua Bracewell New Jersey Institute of Technology
Advisor(s): Petronela Radu, University of Nebraska, Lincoln

This poster presents some nonlocal diffusion models connected with the new theory of peridynamics (introduced by Silling). Peridynamics is an alternative to continuum mechanics that allows us to model phenomena involving material discontinuities. We show connections between classical differential operators and their nonlocal counterparts, obtaining convergence results for the solutions from different points of view. We derive nonlinear diffusion equations in the nonlocal framework of peridynamics, following the ideas of Bobaru and Duangpanya. For the case when the conductivity is time dependent we derive a fundamental solution for the nonlocal problems and prove exponential decay rates by using energy methods and a nonlocal version of the Poincaŕe's inequality. The numerical simulations presented show estimates for the solution in the nonlinear case as well as in the case of time dependent conductivity

245. Newly Irreducible Iterates of Some Families of Some Families of Quadratic Polynomials

Emma Colbert College of the Holy Cross
Patrick E. Hefferman College of the Holy Cross
Sarah Elizabeth Orchard College of the Holy Cross
Advisor(s): Sharon Frechette, College of the Holy Cross

Let K be a number field and for $f(x) \in K[x]$, let $f^n(x)$ denote the n^{th} iterate of $f(x)$. Determining the factorization of $f^n(x)$ into irreducible polynomials has proven to be an important problem. In dynamics, it is a question about the inverse orbit of zero, which has significance in various ways. (For instance, it accumulates at every point of the Julia set of f.) The field of arithmetic dynamics seeks to understand sets such as the inverse orbit of zero from an algebraic perspective; finding factorizations of $f^n(x)$ fits into this scheme. A nontrivial factorization arises from an "unexpected" algebraic relation among elements of the inverse orbit of zero. In this talk, we discuss a two-parameter family of polynomials over a number field, and give conditions under which the $(n+1)^{st}$ iterate is reducible when the n^{th} iterate is irreducible. (We refer to such iterates as *newly reducible*.) In particular, for $n \geq 2$, we show that under certain conditions on γ, there are only finitely many m for which the $(n+1)^{st}$ iterate is newly reducible.

246. Shortest Vectors in Lattices Arising from CM Number Fields

Jacob McNamara Research Science Institute at Massachusetts Institute of Technology
Advisor(s): Dmitry Vaintrob, Massachusetts Institute of Technology

This paper partially addresses the problem of characterizing the lengths of vectors in a family of Euclidean lattices, which arise from any CM number field F. We define a modified quadratic form on these lattices, the *weighted norm*, that contains the standard field trace as a special case. Using this modified quadratic form, we obtain a bound on the field norm of any vector that has a minimal length in any of these lattices, in terms of a basis for $\mathcal{O}_F^\times$, the group of units of the ring of integers of the field F. For any CM number field F, we prove that there exists a finite set of elements of F which allows one to find the set of minimal vectors in every principal ideal of the ring of integers of F. We interpret our result in terms of the asymptotic behavior of a Hilbert modular form, and consider some of the computational implications of our theorem. Additionally, we show how our result can be applied to the specific Craig's Difference Lattice problem, which asks us to find the minimal vectors in lattices arising from cyclotomic number fields.

247. Regularization of an ill-posed inverse problem found in the study of solid oxide fuel cells.

Derek Nasir Arizona State University
Advisor(s): Eric Kostelich, Arizona State University

Characterization of processes in solid oxide fuel cells requires solving an Fredholm integral equation, which we model through numerical quadrature as a linear system (i.e. Ax = b). This problem is ill-posed in nature. In this work we describe the various implementations of regularizing this system and present a method new to this problem which has been found to be useful for solving systems with especially high condition numbers. This method first truncates the "coefficient matrix" A to remove the high-frequency and often error-laden data points before applying the filtering coefficients to the inverse of its singular value decomposition. This is accomplished either by applying Tikhonov Regularization or Truncated Singular Value Decomposition to our modified coefficient matrix. Even though we can't directly solve the system due to the large condition number of A this method guarantees a close approximation which will not be dominated by the noise inherent to the system.

248. Ramsey Numbers and Other Knot Invariants

Maribeth Johnson Hamilton College
Advisor(s): Rolland, Trapp

We make use of a particular linear spatial embedding, the cyclic polytope, in an exploration of bounds on the Ramsey number of knots. Using arc presentations to simplify knotted cycles of this embedding, we examine the relationships between the Ramsey number, bridge number, crossing number, stick number and arc index of knots. In particular we show the Ramsey number is at least as large as the sum of the bridge number and the arc index, and at least as large as the sum of the crossing number and the bridge number plus 2. We also show that for a particular class of torus knots, $T_{p-1,p}$, the difference between the Ramsey number and stick number grows without bound.

249. Graphical Supercharacters

Garcia Luis Pomona College
Advisor(s): Stephan Ramon Garcia, Pomona College

The general study of *supercharacters* was recently initiated by Persi Diaconis and I.M. Isaasc, who provided an axiomatic approach to the *basic characters* developed by C. Andre. We study the supercharacter theory on $(Z/nZ)^d$ induced by the action of the symmetric group S_d. The resulting plots are visually stunning and we explain many of their qualitative properties. In addition, we highlight a possible link to the study of quasicrystals and X-ray crystallography

250. Edge Flames in Narrow Channels: The Effects of Heat Loss and Mixture Strength on the Flow Fields

Kimberly McCarty University of Redlands
Advisor(s): Joanna Bieri, University of Redlands

Studying edge flames in micro-combustors is an important research topic due to its many possible applications. With the ability to be the mere size of a penny, micro-combustors have the potential to be a heat source as well as a future energy source. Thermal expansion is a vital part of modeling edge flames because it links the flame with the flow of the fuel and oxidizer. The thermal expansion code in particular accounts for change in density. Using this code, I have been modeling heat loss in combination with varying mixtures strengths to track the effects they have on the flow field of the channel.

251. Finding the Ideal Geometric Configuration to Optimize Surface Plasmon Generation

Kyle Shaw George Mason University
Dan Weingarten George Mason University
Advisor(s): Igor Griva, George Mason University

Surface Plasmon Resonance (SPR) is a collective oscillation of traveling charge density waves present at the interface of two media (metal-dielectric). We focus on developing an optimization algorithm for finding geometric parameters of the grating nanodevice that provides the most efficient conversion of energy between a Gaussian beam and the

SPR modes. The developed technique will allow controlling electromagnetic fields below the wavelength, which results in applications ranging from computer chip enhancements to more powerful lenses all the way to the extreme case of cloaking at the nano level.

252. Modeling the Limited Immune Reconstitution of HIV-1 Patients on HAART: The Damaged Niche Hypothesis

Leah DeCoste College of the Holy Cross
Advisor(s): David B. Damiano, College of the Holy Cross

In this project we develop a system of ordinary differential equations (ODE) to model and explore the damaged niche hypothesis for the limited immune reconstitution of HIV patients on highly active antiretroviral therapy (HAART). This hypothesis states that the HIV-induced build-up of collagen in lymph nodes causes irreversible damage to lymph node architecture that disrupts cell signals necessary for naive CD4+ T cell survival. We have created a multi-compartment ODE model with CD4+ T cell subsets, CD8+ T cell subsets, and viral compartments for peripheral blood that is consistent with this hypothesis. We are optimizing and validating model parameters with patient data from an ongoing retrospective study at the University of Massachusetts Medical School HIV/AIDS Clinic and with published results in the literature. The UMass cohort consists of 43 patients who have undergone HAART for at least six years and have maintained undetectable viral loads. Although many patients' peripheral blood T cell counts reconstitute in this time period, for some patients this occurs more slowly or appears to plateau before counts reach normal ranges. Our goal is to elucidate the relative impact of lymph damage, thymic impairment, and CD8+ activation on immune reconstitution.

253. Relating Petal Number to Other Knot Invariants

Jesse Freeman Williams College
Samantha Petti Williams College
Advisor(s): Colin Adams, Williams College

It has recently been shown that every knot has a projection with only one crossing. Multiple strands meet at one point and form monogons whose verticies are that central point. Because these monogons can be isotoped to look like the petals on a flower, the aforementioned projection of a knot is known as a petal projection. The minimum number of petals in any petal projection of a knot is called the petal number of the knot. In this research, we investigate petal number and how it is related to other knot invariants.

254. Structure determination from X-ray powder diffraction data at low resolution

Jeremy Baron University at Buffalo
Jennifer Cordaro University at Buffalo
Eric Knauf University at Buffalo
Robert Wesolowski University at Buffalo
Advisor(s): Hongliang Xu, Buffalo State College

Knowledge of the structural arrangement of atoms in solids is necessary to facilitate the study of their properties. The best and most detailed structural information is obtained when the diffraction pattern of a single crystal a few tenths of a millimeter in each dimension is analyzed, but growing high-quality crystals of this size is often difficult, sometimes impossible. However, many crystallization experiments that do not yield single crystals do yield showers of randomly oriented micro-crystals that can be exposed to X-rays simultaneously to produce a powder diffraction pattern. Direct Methods routinely solve crystal structures when single-crystal diffraction data are available at atomic resolution (1.0-1.2Ã…), but fail to determine micro-crystal structures due to reflections overlapping and low-resolution powder diffraction data. By artificially and intelligently extending the measured data to atomic resolution, we have successfully solved structures having low-resolution diffraction data. The newly developed method, Powder Shake-and-Bake, is implemented in a computer program PowSnB. We are going to present new approach, algorithm, strategy and applications. All authors contributed equally to the research project. Research supported by the NSF CSUMS grant 0802994.

255. A Stochastic Dynamic Model for Pea Aphid Aggregations

Benjamin Mayhew Macalester College
Johnny Leonard Paige Macalester College
Advisor(s): Chad Higdon-Topaz, Macalester College

Social biological aggregations are found across the natural world, from bird flocks to fish schools to insect swarms. An ongoing challenge in the mathematical modeling of such groups is to strengthen the connection with biological data by quantifying the rules that individuals follow, including their social interactions with each other. We present and analyze a model for aggregation of the pea aphid, acyrthosiphon pisum. Motivated by data we gather from motion-tracked experiments of aphid groups in a circular arena, we construct a two-state agent-based model of aphids. Insects transition stochastically between a moving and stationary state. Moving aphids follow a correlated random walk. From experimental data, we estimate the state transition probabilities and correlated random walk parameters, and these are well-modeled by rational functions that depend on the distance to each aphid's nearest neighbor. We then compare experimental trials with Monte Carlo simulations of our model and a control model. The model and the data suggest that aphids aggregate socially via a mechanism similar to the classic run-and-tumble model of bacteria.

256. Not Yo' Mama's Incan Gold

Dawn Sturgeon Nevada State College
Lourdes Altamirano Nevada State College
Lewis Miranda Nevada State College
Allysa Starkweather Nevada Sate College
Advisor(s): Dr. Aaron Wong, Nevada State College

Incan Gold is a board game in which players, or âadventurersâ explore an old Incan temple in search of gold. At each step, the players secretly choose if they want to continue exploring deeper into the temple in search of more gold or retreat from the temple with what they have. But disaster can strike at any moment, and if the adventurers travel too far into the temple, they may have to flee for their lives and drop any gold they have collected. We will model a simplified version of this game. Consider a deck of cards labeled $1, 2, 3, \ldots, n$. We will play a game where the goal is to accumulate the most points possible. Each card is worth the value labeled on it, except for the 1 card, which ends the game and causes the player to score zero points. Any time before the 1 card appears, the player can choose to stop and bank their accumulated points. (This is similar to the dice game known as Pig.) Variations of the game can be created by adding more players and changing the number of rounds. We will present the optimal strategies for this game and some of its variants.

257. Invariants of an incidence matrix related to Rota's Basis Conjecture

Adam Zweber Carleton College
Xuyi Guo Stanford University
Advisor(s): Minah Oh, James Madison University

Suppose you are given n bases of an n-dimensional vector space. Additionally suppose that each basis is assigned a particular color: say the first basis is red, the second blue, etc. Then Rota's Basis Conjecture asserts that one can always repartition the multiset union of these bases into n "rainbow bases"—that is, each new basis will contain exactly one vector of each color. This innocent-looking conjecture has been open for over twenty years. In this talk we discuss the eigenvalues and Smith normal form of a particular matrix of ones and zeros which may be useful in solving this problem.

258. The Discovery and Application of Mathematical Concepts in Musical Compositions

Suzanne Crifo College of the Holy Cross
Advisor(s): Shirish Korde, College of the Holy Cross

Mathematics has been an essential component of Western Classical music throughout history. In this project, we developed criteria for assessing the mathematical structure of musical pieces, in particular, fractal-like and group-theoretic structures. We applied these criteria both to assess previous mathematical analyses of texts, including Robert Cogan's analysis of an antiphon by Hildegard von Bingen, one of the earliest surviving pieces western music, and

the Crab Canonâ in Johann Sebastian Bach's Musical Offering. We also analyzed the group structure in twelve-tone compositions and the presence of Fibonacci numbers and the Golden Section in works by both Bela Bartok and Claude Debussy. In addition to analyzing these we have considered chaos and fractals in Gyrgy Ligeti's music and the highly mathematical compositions of Iannis Xenakis, namely Nomos Alpha.

259. Petal Projections, Arc Presentations, and Grid Diagrams of Knots

Benjamin DeMeo Williams College
Advisor(s): Colin Adams, Williams College

A petal projection consists of a non-nesting set of loops emanating from a single central crossing consisting of many overlapping strands, yielding a projection that looks like a daisy. Recent undergraduate research proves that every knot has a petal projection. This poster will define petal projections, arc presentations, and grid diagrams of knots, and explore their relationships in a visually rich format.

260. Gold Glove Winners

James Rader Ohio Northern University
Advisor(s): Ryan Rahrig, Ohio Northern University

There is no single standard measure for quantifying the defensive ability of baseball players and determining who should receive the Rawlings Gold Glove. The most commonly used measure of defense is fielding percentage. Expanding this measure by taking into account other factors which help determine how much impact a player's defensive performance has on the outcome of the game can be used to more accurately pick winners.

261. Differential Geometry: A Video Pedagogy

Nathan Pinsky Harvey Mudd College
Advisor(s): Weiqing Gu, Harvey Mudd College

Mathematics software today is incredibly powerful not only for computation, but also for creating graphics that help mathematicians better understand the structures they work with. As a result, math teachers have been increasingly relying on computer-based tools to help their students visualize mathematics. Many freely-available online courses in mathematics and other sciences have sprung up recently, ranging from those sponsored by institutions of higher education, such as MIT's OpenCourseWare, to independently-generated, YouTube-based programs like Khan Academy. While computer-based teaching methods are becoming common at every level of education, their potential is arguably greatest for geometric visualizations of material, especially for college and graduate level material, where students work with extremely abstract mathematical structures which frequently have a deep geometric interpretation. This in-progress research examines the pedagogies underlying video courses and will generate an introductory video course to differential geometry. It will also aim to question the effectiveness of scaffolding knowledge in a video course, to determine whether early allusions to advanced topics help students comprehend these topics when they eventually encounter them.

262. Great Mathematical Discoveries Elucidated Through Reading and Writing

Elisa Miller Saint Joseph's University
Advisor(s): Dr. Agnes Rash, Saint Joseph's University

The purpose of this project was to compile a number of resources for non-math majors to use in the Great Mathematical Discoveries course. This freshman seminar course involves extensive writing about these discoveries and the people who have made breakthroughs in mathematics, and to relate them to matter that they already have knowledge and an appreciation for. Art, for example, is one area that mathematics can provide a major framework- specifically the work of M.C. Escher, which is heavily influenced by topics including tessellations and impossible constructions. Another area in which math is surprisingly ubiquitous is in nature, as demonstrated by the Fibonacci sequence. The writings of Martin Gardiner illustrate how mathematics is elucidated through clearly written expository articles. This poster will illustrate the resources found that are suitable for this audience.

263. A computational approach to solving a Skyscrapers puzzle

Philip Cooksey California State University, Monterey Bay
William Ian Holt California State University, Monterey Bay
Poema Cavalcanti California State University, Monterey Bay
Clayton Payton California State University, Monterey Bay
Jordan White California State University, Monterey Bay
Advisor(s): Rachel Esselstein, California State University Monterey Bay

We developed a computer application, with the collaboration of computer science and mathematics, which provided empirical evidence for conjectures on a puzzle game called Skyscrapers. Skyscrapers is a Latin square-based game similar to Sudoku. The most notable differences are that the numbers inside the puzzle represent the heights of buildings and the numbers along the edges, border constraints, delineate how many buildings tops can be seen. We know that only certain border constraints will create valid Latin squares. Also some Latin squares have the same border constraints, leading to Skyscraper puzzles with multiple solutions. We designed a computer application to discover the maximum number of Skyscraper solutions for any $n \times n$ board. Further, the program can generate all of the possible Skyscraper puzzles for a given size which helped us discover different empirical properties about the border constraints. We will present the algorithm and some of the data that resulted from the use of the program including results on bounds on the number of solutions for a given row or column and bounds on the number of possible solutions for a board of size $n \times n$.

264. Combinatorial Models for Diagram Algebras

Mike Reeks Macalester College
Advisor(s): Thomas Halverson, Macalester College

A Gelfand model for an algebra $\mathbf{A}$ is a matrix representation of $\mathbf{A}$ that contains each irreducible representation of $\mathbf{A}$ exactly once. This project develops a method to explicitly construct Gelfand models for a large class of diagram algebras which includes the Brauer, Temperley-Lieb, Motzkin, and partition algebras. This method utilizes signed conjugation to define an action of the algebra on its vertically symmetric diagrams. This is based on a similar model construction for the symmetric group, in which $\mathbf{S_n}$ acts on its involutions via the signed conjugation defined by the Saxl weight on a permutation. We lift this construction to general diagram algebras using a Jones basic construction, and explicity describe the representation for each algebra.

265. Skyscrapers: A 3-Dimensional Game on Latin Squares

Poema Cavalcanti California State University, Monterey Bay
Clayton Payton California State University, Monterey Bay
Philip Cooksey California State University, Monterey Bay
William Holt California State University, Monterey Bay
Jordan White California State University, Monterey Bay
Advisor(s): Dr. Rachel Esselstein, California State University of Monterey Bay

Skyscrapers is a Latin square based puzzle game similar to Sudoku. In Skyscrapers, however, instead of the clues being pre-solved cells, the clues are border conditions which constrain the solutions for a row or column. All boards of order 3 have a valid solution, meaning every possible set of border conditions yields a unique solution to the Latin square. However, for board of order 4 or greater, there may be 1 or more solutions. Some of the results we present are 1) an upper bound for the number of solutions to general boards of orders 4, 5, and 6, 2) the minimal border conditions necessary to yield a unique solution to a board of order n, 3) conditions guaranteeing a unique solution, and 4) the number of solutions to a row/column of order n given a pair of border conditions (a, b) such that $1 \leq a \leq b \leq n$ without loss of generality Some open problems which we seek to address are 1) whether or not there exists a board and set of border conditions which yield an odd number of solutions, 2) how can we describe the relationship between Stirling numbers of the 1^{st} kind and the number of solutions to a row/column, and 3) given an $n \times n$ board with a set of border conditions, how can we predict the number of solutions.

266. Discrete Morse Theory and Homology

Brian Green Ursinus College
Alex Onderdonk Immaculata University
Michael Agiorgousis Ursinus College
Advisor(s): Nicholas Scoville, Ursinus College

We develop a theory of homological equivalence of discrete Morse functions. We define the homological sequence associated to a discrete Morse function on any finite simplicial complex. This sequence is shown to satisfy specified desirable properties. These properties allow us to show that homological sequences may be viewed as lattice walks satisfying certain parameters. We count the number of discrete Morse functions up to homological equivalence on any collapsible 2-dimensional simplex by constructing discrete Morse functions satisfying certain properties.

267. Can CFA franc promote the trade between the WAEMU (West African Economic and Monetary Union) and its trading partners?

Kodjo Houssou University of Minnesota
Advisor(s): Terry Roe, University of Minnesota

This paper discuss briefly the implications of the peg exchange rate CFA-Euro on the trade in West African Economic and Monetary Union (WAEMU) based on the framework of SHANE-ROE-SOMWAPU, optimal control and the real business cycle theories. Hence, the study aims to show by econometrical estimation under the international market clearance condition, the effect of the exchange rate on the trade in WAEMU. It analyzes deeply the dynamic propagation mechanism of the rate of change of the exchange rate on the exportation volume, consumption, and foreign interest rate. Definitely, the exchange rate seems to be an important macroeconomics variable affecting the trade between WAEMU and its trading partners such the European Union, USA, China, etc. We find that the depreciation of the exchange rate will be effective if the real value of the exportation and the consumption is greater than one percent increase of the foreign interest rate. The results indicate also that under the peg exchange regime system with Euro, the exportation demand in WAEMU is an exponential function of the foreign interest rate, the import prices, and the consumption.

268. Infinite families of infinite families of congruences for k-regular partitions

Rowland Carlson Wake Forest University
Advisor(s): John Webb, Wake Forest University

Let $k \in \{10, 15, 20\}$, and let $b_k(n)$ denote the number k-regular partitions of n. We prove for half of all primes p and any $t \geq 1$ that there exists $p-1$ arithmetic progressions modulo p^{2t} such that $b_k(n)$ is a multiple of 5 for each n in one of these progressions.

269. A VBA algorithm to more efficiently apply a pricing rate algorithm to a live data field for the purpose of negotiating a contract proposal

Seth Cohen Roosevelt University
Advisor(s): Melanie Pivarski, Roosevelt University

A contract is given as input to a pricing tool that reads it and extracts the values of different fee rates. The contract contains the amount paid for each fee, and the tool must use that and a rate algorithm to calculate the actual fee rate. My tool was written to replace an existing tool which accomplished the same task, except the time it took was proportional to the size of the contract. My version of the tool ensures that calculations happen nearly in real time, regardless of the size, so that a contract with 100000 items can be renegotiated in the same that a contract of 100 items could. A contract proposal is comprised of 100-1000s of items, each a single line which is broken down into 50 different fee rates that must be applied to each item. Fee rates are dependent on each other, so to adjust a single fee rate, every fee rate must be updated to maintain dependencies. Once this is accomplished, the proposal is mirrored onto another spreadsheet, where all values are calculated from base costs, rather than hard coded values. The fields that can be manipulated are each individual fee rate and rates for individual items, which are quantity and cost/unit or hour. All adjustments are reflected into the mirrored sheet to recalculate the contract with the newly applied rates.

270. Stochastic Models of an Antibiotic-Resistant Nosocomial Infection

Alexandra Signoriello Ursinus College
Pamela Kirkpatrick Messiah College
Nicole Fiorentino Muhlenberg College
Jayant Velagala Ursinus College
Advisor(s): Mohammed Yahdi, Ursinus College

Approximately 10% of U.S. hospital patients acquire a clinically significant nosocomial infection. These infections have been linked to increased mortality and costs. About one-third of infections contracted in intensive care units (ICU) are caused by Vancomycin-resistant enterococci (VRE). This project emphasizes the use and comparison of stochastic modeling approaches to derive and analyze models for VRE infections in an ICU. Stochastic models can be more realistic for a dynamical system with small population size, uncertainty in parameters, and variability in transitions. Modeling procedures include Discrete-time Markov chains, Continuous time Markov chains, and stochastic differential equations. The models account for randomness and simulate transitions between the five population states in an ICU. Computer techniques created simulations to visualize and compare the models. The ultimate goal of this project is to provide an understanding of the VRE dynamic and to determine the most efficient and economically favorable strategies to control VRE.

271. Random Error Models in Quantum Error Correction

Charles Pasternak Montgomery Blair High School
Advisor(s): Matthew Coudron, Massachusetts Institute of Technology

We examine the performance of quantum error correcting codes subjected to random Haar distribution transformations of weight t. Rather than requiring correction of all errors, we require some high probability that a random error is corrected. We find that, for any integer i and arbitrarily high probability $p < 1$, there are codes which perfectly correct errors up to weight t and can correct errors up to weight $t + i$ with probability at least p. We also find an analog to the quantum Hamming bound for the new error model. Lastly, we prove that codes generated from classical Reed-Muller codes can correct errors of weight up to $3d/4$ with a probability approaching 1 as the length of the code increases, whereas they can only correct up to weight $d/2$ perfectly.

272. Digraph Sources and Digraphs of Reduced Rings

Alex Schulte University of St. Thomas
Advisor(s): Michael Axtell, University of St. Thomas

The directed graph of a commutative ring is a graphical representation of its additive and multiplicative structure. Using the directed edge relationship $(a, b) \to (a+b, a\cdot b)$ one can create a directed graph for every commutative ring. This paper focuses on the structure of the sources in directed graphs of commutative rings, with special concentration in the finite case. It will also examine directed graphs of reduced rings.

273. Extrapolation Techniques Using Physiologically Based Pharmacokinetic (PBPK) Modeling

Charles Wilson Middlebury College
Lider Steven Leon Montclair State University
Lauren Joann Beesley University of Kansas
Advisor(s): Dr. Marina Evans, Environmental Protection Agency

Physiologically based pharmacokinetic (PBPK) models are used in applications of risk assessment and extrapolation. New extrapolation methods and techniques are often developed using chemicals that have sufficient data (e.g. a data rich situation) to evaluate the model output. A PBPK model for lindane was generated and optimized over time-course data for Wistar rats when considering an oral dosage. Optimized values in rats, such as partition coefficients for blood and skin (P_{blood} = 1.725 and P_{skin} = 26.22) were then extrapolated to adult humans, and the model was fit to the time-course data for humans. Also, an *in vitro* model for absorption of lindane through the skin was developed, which included a follicular compartment. Optimized parameters from this model, such as the uptake rate into the follicular compartment from the media reservoir (10.12 $hr^{-1}cm^{-2}$) were extrapolated to an *in vivo* study. Acceptable ranges for $K_{media:skin}$ *in vivo* were then explored using optimized *in vitro* values and literature values. Our results provide not only methods to model lindane, but also an example of extrapolation methodology.

274. Is QMAC secure?

Natalia Poniatowska Benedictine University
Advisor(s): Ellen Ziliak, Benedictine University

In this presentation we will study how Quasigroups are used in Cryptography; in particular we will look at its use in a widely studied and used cryptographic tool, Message Authentication Code, or MAC. In this presentation we discuss a type of a MAC, called QMAC, which uses quasigroups, introduced by Meyer in 2006, however no proof of security was provided. We will present several attacks that we analyzed to help determine the security of this scheme. From these attacks we have discovered a property of quasigroups called depth that could be used to classify which quasigroups are less secure for this scheme.

275. Modeling the Dynamics Between Yeast and Bacteria

Carol Wu Skidmore College
Advisor(s): Rachel Roe-Dale, Skidmore College

Thrush, an oral yeast infection, is typically caused by an overgrowth of the yeast species candida albicans. When antibiotics kill off bacteria that normally compete with yeast cells for nutrients, the yeast cells function as opportunistic pathogens and rapidly multiply, thus leading to infection. We model these population dynamics using a system of differential equations and analyze the stability of these growth models. We simulate treatment using a pulse-condition model and examine how certain parameter combinations influence the treatment outcome.

276. Fast Approximation Algorithms for Spectral Clustering

Juan Ramirez Instituto Tecnológico Autónomo de México
Advisor(s): Stacey Beggs, Institute for Pure and Applied Mathematics

The employee-attrition problem consists of separating the individuals that are likely to quit from those that are not. In this project, we approached this problem using the spectral clustering algorithm. Spectral clustering is a well-known method for separating individuals into similar points according to their characteristics. This method relies on solving an eigenvector problem, which may become computationally expensive for large datasets. To overcome this constraint, we studied several approximations to the spectral clustering algorithm which aim to reduce running time while maintaining the classification structure. We compared these algorithms in terms of running time and accuracy. We also researched improvements to the algorithms; we provide evidence that these improvements are worthwhile. The exact spectral algorithm was used to solve the attrition problem on a large dataset, and the results were compared with the approximations.

277. Amalgamatic Curvature and Absolute Umbilical Hypersurfaces

Lucy Odom California State University, Fullerton
Charles Conley California State University, Fullerton
Rebecca Etnyre California State University, Fullerton
Brady Gardener California State University, Fullerton
Advisor(s): Bogdan D. Suceava, California State University, Fullerton

We review the concept of curvature on hypersurfaces, then introduce a new curvature invariant called amalgamatic curvature. Then, our work will move to explore its geometric interpretation by proving an inequality relating this new invariant to the absolute mean curvature of the hypersurface. This exploration will result in obtaining a new class of geometric objects: the absolutely umbilical hypersurfaces. We illustrate this class through examples.

278. Using Pebble Game Algorithms to Find Non-Generic Embeddings of a Framework

James Farre The University of Texas at Austin
Advisor(s): Jessica Sidman, Mount Holyoke College

The study of frameworks provides a mathematically rigorous way to approach problems concerning the rigidity of structures coming from engineering and the natural sciences. While the problem of characterizing the graphs of generic minimally rigid bar-and-body frameworks was first solved by Tay in 1984 for all dimensions, a non-generic embedding of a framework whose combinatorial structure satisfies the conditions of Tay's theorem may actually be

flexible. We use the existing infrastructure of a class of algorithms called pebble games in order to study non-generic embeddings of frameworks. Our analysis is based on a proof of Tay's Theorem given by White and Whiteley in 1987.

279. Modelling Cancer Stem Cell and Non-Stem Cancer Cell Population Growth

Amanda Thompson North Carolina State University
Justina Cline Coe College
Karina Cisneros Dominican University/Illinois Institute of Technology
Brian Barker University of Rochester
Sarah Bober Worcester Polytechnic Institute
Advisor(s): Suzanne Weekes, Worcester Polytechnic Institute

The Cancer Stem Cell Hypothesis states that there are two types of cancer cells: cancer stem cells and non-stem cancer cells. Stem cells have unlimited proliferation capacity and can initiate and drive tumor growth. These cells can give rise to mortal non-stem cancer cells with unknown, but limited, proliferation potential m. In this project, we developed several new models in order to conduct mathematical and numerical investigations of the dynamics of the interactions between these two populations. First, we built linear multi-compartment ODE models, found their analytic and steady-state solutions, and performed sensitivity analyses. The sizes of the stem and non-stem populations were compared to see the effect of accounting for generational age. A 2-compartment model capturing the multi-component results was also built. Next, a nonlinear model took into account competition for resources by using proliferation rates that decline as the cell population rises. Lastly, we developed a system of 1D PDEs for the non-stem generations where they diffuse and experience population pressure; stem cells act as point sources. We wrote a finite volume method to numerically solve the PDE.

280. A Rigidity Theorem for Hypersurfaces

Rebecca Etnyre California State University, Fullerton
Brady Gardener California State University, Fullerton
Charles Conley California State University, Fullerton
Lucy Odom California State University, Fullerton
Advisor(s): Bogdan D. Suceava, California State University, Fullerton

The spread of a matrix has been introduced by Mirsky in 1956. The classical theory provides an upper bound for the spread of the shape operator in terms of the second fundamental form of a hypersurface in the Euclidean space. In the present work, we are extending our understanding of the phenomenon by proving a lower bound, inspired from an idea developed recently by X.-Q. Chang. We obtain a new rigidity theorem for hypersurfaces, by estimating the spread of the shape operator of a hypersurface lying in the n+1-dimensional real space.

281. Tchoukaillon; a single player Mancala game

Benjamin Sebuufu Gordon College
Advisor(s): Dr. Anthony Tongen, James Madison University

Many interesting results on two-player sowing games, such as Mancala, have been discovered via brute-force computational analysis; but, a mathematical analysis of these games has proved to be difficult for primarily two reasons. First, the types of permissible moves, while small, produce a great variety of different board states. Second, the competing strategies between the two players depend on a (not fully understood) balance between short-term gains and the, ultimate, long-term gain of winning the game. In order to better understand these Mancala type games, we restrict our attention to certain single-player sowing games in which the types of permissible moves are limited and the number of strategies for a single player is small. We present results on two such restricted single-player games: Tchoukaillon and Tchoukaillon-with-wrapping. In Tchoukaillon, we prove that the sequence of bins played exhibits a certain regularity. In Tchoukaillon-with-wrapping we prove an interesting 'negative' result, that there are no winning Tchoukaillon-with-wrapping boards with an equal number of stones in each bin.

282. Analysis of the estimation of inverse problems for solid oxide fuel cells

Caleb Johnson Arizona State University
Advisor(s): Dr. Eric Kostelich, Arizona State University

We consider an inverse problem arising in the polarization processes occurring in solid oxide fuel cells. Two different methods have been proposed: a convolutional method and a quadrature method. Here we provide a complete analysis of the quadrature method which leads to two equivalent systems for the desired signal. As a part of this analysis we look into the model error due to the approximation of the improper semi-infinite integral. Fully understanding the error arising from the original measurements, each piece of the model and their relative effect on the model error is sufficient evidence to test the validity of the model. Our results enable us to determine the minimal sampling required to control the sampling error to less than the quadrature error for certain expected functions, and encourage combining the two systems and creating a system which is not as ill-posed as the two individual systems.

283. A New Probability-Based Characteristic in Finite Group Theory

Danny Orton California State University, Fullerton
Daniel Lenders California State University, Fullerton
Advisor(s): Scott Annin, California State University Fullerton

Given a finite group G, the probability that two randomly chosen elements of G commute has long been viewed in the literature as a natural measure of the degree of commutativity enjoyed by the group. Many variants on this probabilistic question have arisen in the literature recently, and our research introduces yet another such variation that provides somewhat different information. With the help of the software program Groups, Algorithms, and Programming (GAP), we have discovered patterns leading to new results about our variant that we will present in this presentation. Furthermore, in our presentation we will describe our variation of the commutativity question, examine data provided by GAP for such familiar finite groups as cyclic, dihedral, and symmetric groups, and describe the general results we have obtained. Some of these results are at odds with the analogous ones known for the commutativity measure described above, thereby adding further interest to our investigation.

284. The Prevalence of the Cutoff Phenomenon in Markov Chains

Cassandra DePietro Fairfield University
Lauren Bruchansky Fairfield University
Advisor(s): Mark Demers, Fairfield University

Markov chains are popular models from probability which describe random, memory-less processes that transition between states according to certain probabilities. In this study, we focus on mixing Markov chains with a finite state space; such systems are known to converge to equilibrium at an exponential rate. A Markov chain is said to exhibit a cutoff phenomenon if the convergence to equilibrium is initially delayed before converging rapidly to its equilibrium distribution. We explore the prevalence of the cutoff phenomenon in both large deterministic and large random matrices by manipulating their size and sparseness, using MATLAB to model their behavior. We find that random sparse matrices do tend to exhibit cutoff and that the cutoff in deterministic matrices becomes more pronounced as the probability of long jumps shrinks. These findings increase our understanding of finite-time behavior in this type of probability model, as opposed to the usual focus on asymptotic behavior.

285. Incorporating All Positional Voting Methods

David Lingenbrink Harvey Mudd College
Sam Gutekunst Harvey Mudd College
Advisor(s): Michael Orrison, Harvey Mudd College

In an n candidate election, a positional voting method assigns s_i points to the ith ranked candidate, where $1 = s_1 \geq s_2 \geq \ldots \geq s_{n-1} \geq s_n = 0$. There is often debate over which values of s_i should be chosen to best reflect voter preferences, and so we study two methods that attempt to take into account all positional voting methods. The first method computes the average number of points given to each candidate by integrating over all possible values of s_i, and we show that this method is equivalent to the Borda Count (where $s_i = \frac{n-i}{n-1}$.) The second method declares the winner of the election to be the candidate who wins the largest proportion of all possible values of $s_2, \ldots, s_{n-1}$.

This method, however, fails many well-established criteria for evaluating voting systems. In particular, it fails the consistency criterion, which is satisfied by all individual positional voting methods.

286. On Weak Chromatic Polynomials of Mixed Graphs

Joseph Crawford Morehouse College
Jean-Louis Taina Amherst College
Daniel Blado California Institute of Technology
Advisor(s): Matthias Beck, San Francisco State University

Modeling of metabolic pathways in biology and process management in operating systems are applications of mixed graphs. A *mixed graph* is a graph with directed edges, called arcs, and undirected edges. The *weak (resp. strong) chromatic polynomial* of a mixed graph is a counting function that counts proper k-colorings, that is, assigning colors to vertices such that colors are different on vertices connected by an edge, while colors have to obey the $\leq$ (resp. $<$) relation along an arc. We find a contraction-deletion analogue for mixed graphs in which the weak chromatic polynomial of any mixed graph can be reduced to a linear combination of weak chromatic polynomials of simpler mixed graphs, such as trees. Following closely previous work on reciprocity theorems for other types of chromatic polynomials, we also find a reciprocity theorem for weak chromatic polynomials using partially ordered sets and order polynomials.

287. Trapping Brownian Particles Using Circular and Noncircular Traps

Trevor Steil Michigan State University
Advisor(s): Dr. Jeffrey Schenker, Michigan State University

Being able to calculate the proportion of Brownian particles from a release sample caught in a trap up to time t could have wide applications to fields such as entomology. For circular traps, there is an integral formula involving Bessel functions giving the expected proportion of Brownian particles caught when released at a fixed radius from the trap. This formula can be used when circular traps are investigated, but it does not directly offer information when a noncircular trap is used. However, given the proportion of movers caught in a noncircular trap at time t, the parameters for the formula describing the expected proportion caught in a circular trap can be optimized to give a unique effective trap radius for the noncircular trap at the given time. Numerical evidence suggests that this effective trap radius stabilizes over long time scales and is related to the conformal maps which map the exterior of the unit disc in the complex plane to the exterior of the trap used.

288. Computing the Chromatic Polynomials of the Six Signed Petersen Graphs

Erika Meza Loyola Marymount University
Bryan Nevarez City University of New York, Queens College
Alana Shine Pomona College
Advisor(s): Matthias Beck, San Francisco State University

Graphs are a collection of vertices and edges that connect some vertices to others. Signed graphs are graphs with edges assigned positive or negative labels and may contain loops. Signed graphs have been useful in understanding phenomena that occur in our society, such as interactions within a group of individuals or the representation of biological networks which allow for further analysis of the relationships that exist in nature. Our work addresses open questions regarding proper colorings of signed graphs, in which the vertices are assigned colors based on rules according to the edge connections and edge labels. We explore the number of proper colorings of these graphs by computing their corresponding chromatic polynomials. In particular, we investigate the six distinct signed Petersen graphs studied by Thomas Zaslavsky and prove his conjecture that they have distinct chromatic polynomials.

289. Effects of Momentum Trading on Asset Prices

Neeraj Vijay George Mason University
Advisor(s): Dr. Harbir Lamba, George Mason University

Geometric Brownian motion is a standard model used for asset pricing. We amend this model by introducing market participants with momentum trading strategies. Let $r(t)$ be the log-price and consider an agent i who bought the

asset at time ω. Then the agent will sell when

$$\left[\max_{\omega \le s \le t} r(s)\right] - r(t) = d_i$$

for some threshold value $d_i > 0$. Similarly an agent j who sold the asset at time τ will change position and buy when

$$r(t) - \left[\min_{\tau \le s \le t} r(s)\right] = d_j.$$

When the changes in agent position are fed back into the price, cascades of buying and selling result in large and sudden price moves that are similar to those that occur in real financial markets. The model can be described as a stochastic dynamical system on the positive real line. A variation of the model that requires buyers and sellers to be matched is then used to simulate illiquid markets such as housing.

290. The Effect of Graph Operations in Lights Out on the Nullspace of the Neighborhood Matrix

Laura Ballard Houghton College
Advisor(s): Darin Stephenson, Hope College

Based on a puzzle created by Tiger Electronics, "Lights Out" can be formulated as a problem in graph theory and linear algebra. A graph begins with vertices that are either on or off, and the edges determine which other vertices are affected when just one vertex is turned on or off. The objective of Lights Out is to turn off all of the lights, in which case a graph has been "won." In our research, we worked with generalized Lights Out puzzles in which each light is in one of several states, of which one is designated as "off." Our approach to the Lights Out problem has not only been the investigation of winnable states of graphs, but has also led to the investigation of the null space of the neighborhood matrices of those graphs, and how the null space changes when a graph is altered. We proved results about how the null space dimension changes when specific graphs are joined at a single vertex or when certain subgraphs are removed. It is our hope that these results lead to a more complete understanding of how the null space (and hence, the number of winnable states) changes as graphs are built up from paths and cycles, or as subgraphs are removed.

291. Ranking Rankings: a Comparison of the Predictive Power of Sports Ranking Methods

Peter Elliott University of California at Los Angeles
Daniel Michael Barrow Pitzer College
Ian Spencer Drayer University of California at Los Angeles
Garren Robert Joseph Gaut University of California at Los Angeles
Advisor(s): Braxton Osting, UCLA

In our meritocratic society, the concept of rank is paramount. Consumers seek the best product, search engines recommend the most relevant document, and sports fans demand to know the standing of their favorite sports team! The need for rankings in various contexts had led to the development of many different ranking algorithms. In this poster, we consider several existing statistical ranking methods and, using a variety of sports data, analyze the differences in the predictive power between rankings. More specifically, we use k-fold cross validation methods to evaluate the predictive accuracy of the Least Squares, Least Absolute Deviation, Least Maximum Deviation, Random Walker, ELO, Microsoft TrueSkill, Ratings Percentage Index, and Winning Percentage ranking methods. Using the non-parametric Friedman test, we find that the null hypothesis, that all rankings have equivalent predictive power, can be rejected for all datasets considered, i.e., the predictive accuracy among the ranking methods is not the same. Finally, using the post-hoc Nemenyi test, we conclude that the least squares ranking method has statistically significant increased predictive power.

292. A Lower Bound on The Fineness of the Smooth Concordance Group

Joshua Tobin Columbia University
Advisor(s): Jen Hom, Columbia University

The knot Floer complex and the concordance invariant ϵ can be used to define a filtration on the subgroup of the smooth concordance group generated by topologically slice knots. We construct an infinite family of topologically slice knots in the indexing set of this filtration that is order isomorphic to $\mathbb{N} \times \mathbb{N}$

293. Arithmatical Functions On Gaussian Integers

Thomas Steinberger Ohio Northern University
Advisor(s): Mohammad Zaki, Ohio Northern University

We are exploring the ring of arithmetical functions, A, on Gaussian Integers. We define and investigate the valuations of A and prove their behavior under convolution and sum of arithmetical functions. Our main result is the completeness of the matrix space induced by the valuation on A.

294. A Partial Ordering of Knots

Arazelle Mendoza Christopher Newport University
Tara Sargent Clarke University
John Shrontz The University of Alabama, Huntsville
Advisor(s): Paul Drube, Valparaiso University

Knot theory is the study of the different ways to embed a circle in three-dimensional space. Our research concerns how knots behave under crossing changes. In particular, we investigate a partial ordering of alternating knots. A similar ordering was originally introduced by Kouki Taniyama in the paper "Partial Order of Knots". We amend Taniyama's partial ordering and present theorems about the structure of our ordering for more complicated knots. Our approach is largely graph theoretic, as we translate each knot diagram into one of two planar graphs by checkerboard coloring the plane. Of particular interest are the class of knots known as pretzel knots, as well as knots that have only one direct minor in the partial ordering.

295. Modeling the Attendance at Open Air Events

Grant Innerst Shippensburg University
Advisor(s): Benjamin Galluzzo, Shippensburg University

Culture, local customs, and community are constantly on display at street fairs across the country (and world!). These fairs are very important to the town they are held in for many reasons, including money and tourism. A common practice of fair organizing committees is to tout their attendance numbers as a way to prove their festival's popularity and attract more vendors, but are these counts accurate? This project examines this question by using accessible technology and a combination of mathematical tools ranging from arithmetic to advanced calculus to develop mathematical models for determining the number of people at open air events. This project is also being used to introduce a real world topic to the high school classroom. The poster presentation will cover the motivation for the research, data collection techniques, the mathematical processes used to create the models, and the approach used to bring this problem into the high school classroom.

296. Mathematical study on the effect of catheter on the peristaltic transport of a viscous fluid

Artem Hulko Univerisity of South Carolina Upstate
Advisor(s): Muhammad Hameed, USC Upstate

In this work we investigate the peristaltic transport of viscous Newtonian fluid in a vertical annulus with influence of endoscope and heat transfer. One dimensional mathematical model is developed and governing equations are derived using long wave-length and low Reynold's number approximations. Analytical solutions are obtained for velocity and pressure rise per wave length. Additional physical effects such as the influence of heat transfer and magnetic field are also taken into account. We prove in this work that existing solutions (Mekheimer & Elmaboud 2007) of this problem are flawed and here we present correct analytical solutions.

297. Knot Parameterizations

Rebecca Fiorillo Ramapo College of New Jersey
Geena Nicole Cockcroft Ramapo College of New Jersey
Advisor(s): Dr. Donovan McFeron, Ramapo College of New Jersey

In our research, we have found lower bounds for minimum degree parameterizations using rational functions for the six-crossing and seven-crossing knots. We have shown that the smallest degree rational function that can parameterize all of the six-crossing and seven-crossing knots has degree (2/4), and we have made progress toward finding explicit parameterizations of these knots. These parameterizations serve as a way to characterize and express each knot.

298. Searching for Trees with the Same Chromatic Symmetric Function

Keeler Russell University of Kansas
Advisor(s): Dr. Jeremy Martin, University of Kansas

All graphs have an associated invariant called the chromatic symmetric function (CSF). In 1995, Richard Stanley introduced the CSF as a symmetric function generalization of the chromatic polynomial. In general, it is possible for a pair of nonisomorphic graphs to have the same CSF. On the other hand, whether a pair of nonisomorphic trees can have the same CSF is an open question; computations by Li-Yang Tan have determined that no such pair exists among trees with 23 or fewer vertices. We have developed a program to search for nonisomorphic trees with the same CSF. The size of the problem increases superexponentially with the number of vertices. Consequently, the program uses combinatorial algorithms, such as iterating over all subsets of a fixed size, to increase time and space efficiency. So far, we have verified Tan's results up to 21 vertices, and we anticipate exceeding 23 vertices using both algorithmic and hardware improvements.

299. Rainbow Coloring and Optimization

Kristen Heaney La Salle University
Advisor(s): Janet Fierson, La Salle University

Rainbow connectedness is a concept in chromatic graph theory introduced in 2008 by Chartrand et al. The rainbow connection number of a connected graph G is the minimum number of colors required to color the edges of G such that every pair of vertices is connected by a rainbow path, a path with no two edges assigned the same color. The strong rainbow connection number requires a rainbow shortest path between every pair of vertices. This topic is motivated by the issue of secure transfer of information. A thorough investigation of rainbow and strong rainbow connection numbers within the families of cycles, wheels, and other similarly constructed graphs was conducted. These graphs include helm, web, and various ladder graphs. This work reveals similarities and differences among various families of graphs with respect to rainbow connectedness. Although some conclusions may be surprising at first glance, they can be proven concisely. The focus is not only on the rainbow connection numbers themselves, but also on optimal coloring strategies. In addition, building on the rainbow connection number of a graph, a new concept is presented that introduces an additional level of optimization. General results for this new metric are provided, as well as results for specific families of graphs.

300. Expressing the k-Rank Difference Functions for Multipartitions as Modular Forms

Anthony Lazzaro Oregon State University
Zoe Ellery Jansen Wellesley College
Advisor(s): Holly Swisher, Oregon State University

Partition theory, an area of combinatorics and number theory, is deeply linked to the theory of modular forms. In 2008, Ahlgren and Treneer, amongst others, showed that rank difference functions for single partitions can be classified as either identically zero functions, weakly holomorphic modular forms, or "mock" objects. Using the arsenal of tools provided by complex analysis, we attempt to classify k-coefficient multipartitions in a similar manner. Ultimately, we relate restricted k-rank generating functions and k-rank difference functions to weakly holomorphic modular forms, as well as to identically zero functions.

301. Lusternik-Schnirelmann Category for Cell Complexes

Seth Aaronson Ursinus College
Advisor(s): Nicholas Scoville, Ursinus College

The discrete version of Morse theory due to Robin Forman is a powerful tool utilized in the study of topology, combinatorics, and mathematics involving the overlap of these fields. Inspired by the success of discrete Morse theory, we take the first steps in defining a discrete version of the Lusternik-Schnirelmann category suitable for cell complexes. This invariant is based on collapsibility as opposed to contractibility. We prove some basic results of this theory, showing where it agrees and differs from that of the smooth case. Our work culminates in a discrete version of the Lusternik-Schnirelmann theorem relating the number of critical points of a discrete Morse function to its discrete category.

302. Elliptic Curves with Full 2-Torsion and Maximal Adelic Galois Representations

Sarah Trebat-Leder Princeton University
David Corwin Princeton University
Advisor(s): David Zureick-Brown, Emory University

In 1972, Serre showed that the adelic Galois representation associated to a non-CM elliptic curve over a number field has open image in $GL_2(\hat{Z})$. In his thesis, Greicius develops necessary and sufficient criteria for determining when this representation is actually surjective and exhibits such an example. However, verifying these criteria turns out to be difficult in practice; Greicius describes tests for them that apply only to semistable elliptic curves over a specific class of cubic number fields. In this paper, we extend Greicius' methods in several directions. First, we consider the analogous problem for elliptic curves with full 2-torsion. Following Greicius, we obtain necessary and sufficient conditions for the associated adelic representation to be maximal and also develop a battery of computationally effective tests that can be used to verify these conditions. We are able to use our tests to construct an infinite family of curves over $Q(\alpha)$ with maximal image, where α is the real root of $x^3 + x + 1$. Next, we extend Greicius' tests to more general settings, such as non-semistable elliptic curves over arbitrary cubic number fields. Finally, we give a general discussion concerning such problems for arbitrary torsion subgroups.

303. Statistical Regression Model for Soccer Recruiting

Alyssa Hoff Siena Heights University
Advisor(s): Jeff Kallenbach, Siena Heights University

There are multiple types of recruiting software available to soccer coaches. These programs allow coaches to organize, manage and analyze data associated with the soccer recruiting process. However, these programs cannot tell a coach whether or not a player is right for the schools existing program. The software programs do not provide coaches with an actual meaningful numerical rating of a player. The purpose of the project is to develop a statistical regression model that will calculate a numerical rating of a player which will allow coaches to more accurately recruit female soccer players for their specific programs. The model will, hopefully, make accurate and useful predictions about recruits in order to determine if the recruit is an appropriate fit with the school's soccer program. Furthermore, the project will investigate if a statistical regression model for women's soccer recruiting is a more beneficial and efficient tool to use than the software programs already in use by today's soccer coaches.

304. Deriving and Analyzing the Box-Counting Zeta Functions of Cantor-Like Sets

Lindsay Kohorn California State Polytechnic University, Pomona
Advisor(s): John Rock, California State Polytechnic University, Pomona

Box-counting zeta functions of Cantor-like subsets of R can be found by analyzing their respective box-counting fractal strings given by their box-counting function. This box-counting function is defined to be the minimum number of closed intervals of a given size required to cover the set. In this case, the fractal strings studied were defined by scaling ratios of 1/3, 1/5, 1/7, and 1/9 on the interval [0,1]. Each of these ratios defines one fractal string. By analyzing these fractal strings, one can see that there are specific relationships between the scaling ratios, the accumulation points of the set, and the box-counting function. Using all of this information, the box-counting zeta function can be found. The dimension of the fractal string has been proven to be the upper box dimension of the fractal string. The fractal string also allows for the application of Moran's equation, thus allowing the complex dimensions of each fractal string to be found. These complex dimensions consist of a unique real part, in this case the box-counting dimension, and an infinite number of imaginary parts. In another case, an interval of length L gives a very interesting result: the Riemann-zeta function appears in its box-counting zeta function.

305. Statistical Analysis to Validate the Dark Sky Laws

Geoffrey Schuette Sul Ross State University
Advisor(s): David Martin, Sul Ross State University

We will attempt to use statistical analysis to validate the Dark Sky Laws of the region around McDonald Observatory-Fort Davis, Texas. Data reduction methods are used to find the flux under the curves of the natural lines, oxygen and nitrogen, and man-made lines, sodium and mercury. Interpretations of the the results of data reduction are given and explored.

306. Graph Pebbling

Mark Schrecengost Grove City College
Advisor(s): Airat Bekmetjev, Hope College

The pebbling problem arises from a game in graph theory. Pebbles are configured on the vertices of a graph G, and a pebbling move consists of removing 2 pebbles from any vertex and adding 1 to an adjacent vertex. A configuration is said to be *solvable* if, given any starting configuration, at least one pebble can be moved to any vertex through a finite sequence of pebbling moves. The smallest number of pebbles that guarantees solvability of any configuration on G is called *pebbling number* of G. The *pebbling threshold* of a family of graphs is a function $g(n)$ such that any configuration with $t << g(n)$ is almost always not solvable and with $t >> g(n)$ is almost always solvable, where $t = t(n)$ is the number of pebbles and n is the number of vertices of a graph. We examined the pebbling threshold of diameter two graphs and estimates for the pebbling number of graphs of fixed diameter.

307. What do math and LEGOs have in common?

Carrie Winterer St. Mary's College of Maryland
Isabel Guadarrama Bryn Mawr College
Samantha Sprague Marist College
Emmanuel Daring Williams College
Advisor(s): Dr. Casey Douglas, St. Mary's College of Maryland

Standard optimization strategies combined with discrete mathematics and number theory allow us to show that the smallest number of unit squares needed to enclose A units of area is $P(A) = 2\left\lceil 2\sqrt{A} \right\rceil + 4$. This question lends itself to interesting generalizations that include using different brick-shapes, imposing various weighting constraints, and the formulation of a "LEGO^{TM} double bubble" problem comparable to the one solved by Dr. Frank Morgan.

308. Linear Dependence and Hermitian Geometric Realizations of Canonical Algebraic Curvature Tensors

Daniel Diroff Michigan State University
Advisor(s): Corey Dunn, California State University San Bernardino

We bring the geometric nature of curvature tensors into the linear algebraic setting by studying inner product spaces equipped with an algebraic curvature tensor. Any point on a smooth Riemannian manifold gives rises to such a space in a canonical way with the tangent space equipped with restricted metric and Riemann curvature tensor. By studying the algebraic properties of these spaces, valuable geometric insight may be gained. It is known every algebraic curvature tensor can be written as a linear combination of canonical algebraic curvature tensors built from self-adjoint or skew-adjoint endomorphisms. We study the linear dependence of such canonical tensors with emphasis on the skew-adjoint setting. We then study the criteria for these tensors to be geometrically realizable on a Hermitian manifold.

309. Continua of Central Configurations with a Negative Mass in the n-body problem

Spencer Sasarita University of Arizona
Julian Hachmeister University of Hawaii at Hilo
Advisor(s): Roberto Pelayo, University of Hawaii - Hilo

The number of equivalence classes of central configurations of $n \leq 4$ bodies of positive mass is known to be finite, but it remains to be shown if this is true for $n \geq 5$. By allowing one mass to be negative, Gareth Roberts constructed a continuum of inequivalent planar central configurations of $n = 5$ bodies. We reinterpret Roberts' example and generalize the construction of his continuum to produce a family of continua of central configurations, each with a single negative mass. These new continua exist in even dimensional spaces $\mathbb{R}^k$ for $k \geq 4$.

310. Simplex Polytope Numbers: Duoprisms and Expansion

Eric Fairchild Grove City College
Robin Mabe Grove City College
Emma Polaski Grove City College
Advisor(s): Michael A. Jackson, Grove City College

Polytope numbers are sequences of nonnegative integers constructed geometrically from convex, uniform polytopes. The simplex numbers are easily found and can be used to find sequences of both duoprisms and expanded simplices. A duoprism is a polytope resulting from the product of two polytopes, each of dimension two or higher. An expanded polytope is the polytope resulting from separating a simplex at each $d-1$ dimensional facet and joining it together with new $d-1$ dimensional facets. Using methods outlined by H.K. Kim, we explored simplified methods for determining the duoprism and expanded polytope numbers as linear combinations of simplex numbers.

311. A Clustering Approach to Image Compression

Nathan Blyler Gettysburg College
Advisor(s): Jung-Jin Lee, Mount Holyoke College

We combine the K-means clustering algorithm with distance metrics weighted in accordance to the human visual system to improve on the lossy data compression technique used in JPEG images. In particular, we try to improve the chroma subsampling method used in JPEG images. Instead of combining chroma values of pixels based on proximity, we cluster based on likeness in color. We successfully lessen the color bleeding that regular downsampling causes, and improve JPEG compression of images with sharp contrast with comparable amounts of compression.

312. Betti Tables of Reducible Algebraic Curves

David Bruce University of Michigan
Ben Perez St. Olaf College
Evan D. Nash University of Nebraska, Lincoln
Advisor(s): Pete Vermeire, Central Michigan University

We study the Betti tables of reducible algebraic curves, focusing our attention on connected *line arrangements*, curves comprised of intersecting linear components. We provide a general formula for the quadratic strand of the Betti table for any line arrangement satisfying mild hypotheses. Building upon this result we give explicit formulas for the entries of the Betti tables for all curves of arithmetic genus zero or one. Finally, we give explicit formulas for the Betti numbers for a large class of curves of higher genus, as well as prove some general results on how the Betti numbers change when the line arrangements are modified.

313. A Paradoxical Decomposition of the Real Number Line

Shelley Kandola St. Lawrence University
Advisor(s): Sam Vandervelde, St. Lawrence University

In 1924, Banach and Tarski demonstrated that two arbitrary point sets with nonempty interiors in Euclidean n-space for $n \geq 1$ are equivalent to each other using a countable decomposition. It is also well known that it is impossible to replicate the Banach-Tarski paradox (i.e., using finitely many subsets) for $\mathbb{R}$ using rigid motions. In this poster, we propose a free group similar to the one used in proving the Banach-Tarski paradox whose generators are not solely rigid motions, but the maps $x \mapsto x+1$ and $x \mapsto x^3$. Using the free group on these generators, we are able to partition the real number line into a disjoint union of subsets that can be transformed via these maps and then reassembled into two identical copies of the original line. The result is a paradoxical finite decomposition of the real number line.

314. Moduli Spaces of 1–4-Dimensional Complex Associative Algebras

Andrew Boyd University of Wisconsin, Eau Claire
Andrew Meinel University of Wisconsin, Eau Claire
Advisor(s): Michael Penkava, University of Wisconsin - Eau Claire

Algebras are very familiar objects. Most people know about polynomial algebras, the integers, and the rational, real, and complex numbers, which are all examples of algebras. Shifting the point of view from considering algebras

as sets of rules to thinking of them as objects in a certain space changes the type of questions that we can ask about them. The new point of view is that an associative algebra is a codifferential, which is a special type of coderivation. Two algebras are isomorphic if their codifferentials are equivalent. The set of equivalence classes of codifferentials on a fixed vector space V is the moduli space of algebra structures on V. We can also study curves in this moduli space, which are families of algebras. A family passing through a particular algebra gives a deformation of that algebra. We have recently constructed the moduli space of 1–4-dimensional non nilpotent complex associative algebras, which contains 506 types of algebras, of which 11 are actually families of algebras. Currently, we are in the process of studying all the deformations of these algebras, which determines how the moduli space is glued together from the algebras.

315. Mixing in the Keller-Segel Partial Differential Equation Model for Chemotaxis

Nate Bean Harvey Mudd College
Advisor(s): Chad Higdon-Topaz, Macalester College

The classic Keller-Segel partial differential equation model of chemotaxis describes organisms that both diffuse and move with directed velocity up gradients of a chemical field produced by the organisms themselves. This model is well-known to form spike profiles in a one-dimensional domain, and to blow up in a two-dimensional domain depending on the initial data. Motivated by swimming bacteria, we introduce a modification of the Keller-Segel equations in which the diffusion of organisms and of the chemical signal depends on the population density of the organisms. This model reflects the mixing effect that bacterial motion has on the surrounding medium. For a one-dimensional geometry, we locate spike solutions as homoclinic orbits in a phase-plane formulation of the steady-state problem. For a two-dimensional radially-symmetric geometry, we show via numerical simulations that the mixing effect is sufficient to prevent blow-up.

316. Geometry of Singular Surfaces: The Cylinder

Sarah Dittmer Florida Southern College
Advisor(s): Dr. Nate Stambaugh, Florida Southern College

The concept of a triangle is well-studied over a Riemannian Manifold, where curvature is spread over the surface, and on singular surfaces with isolated cone points. We focus on other singular surfaces, like the surface of a cylinder, where singular points are not isolated. We use the notion of a triangle to discuss local curvature along the singular curves of an otherwise piecewise Euclidean surface. In an effort to develop a generalization of the Gauss-Bonnet Theorem, we find the relation between the interior angles of the triangle and the concentrated curvature of the surface.

317. Co-Circular Central Configurations of Four Vortices

Alexander Gutierrez Arizona State University
Jonathon Gomez Brigham Young University, Hawaii
Jesse Robert University of Hawaii at Hilo
Advisor(s): John Little, College of the Holy Cross

The Newtonian n-body problem is a well-studied question in celestial mechanics with many practical applications. Of particular interest is the study of *central configurations* in which each mass accelerates towards the center of mass at a rate proportional to its displacement from the center of mass and where the proportion of the displacement is the same for each mass. Central configurations can be used to find periodic solutions to the n-body problem. One interesting variant of the n-body problem is the study of the central configurations of *Helmholtz vortices*, whirlpools on an infinite horizontal surface consisting of a perfect fluid. A configuration in both the n-body and n-vortex problem is central if and only if it satisfies the Albouy-Chenciner (AC) equations. We use the AC equations to study the central configurations of four vortices from the point of view of algebraic geometry. In a recent paper Cors and Roberts completely characterize the central configurations of four bodies when all four lie on the same circle. We replicate these results *mutatis mutandis* for the four-vortex problem and conjecture that there do not exist co-circular central configurations of four vortices that have two vorticities of each sign.

318. Efficient Approaches to Identifying Lagrangian Coherent Structures in Analytical and Modelled Flow Data

James Upton Arizona State University
Advisor(s): Wenbo Tang, Arizona State University

A common technique for identifying patterns in fluid flow is the identification of Lagrangian Coherent Structures (LCS). In a particular flow, LCS are the boundaries of regions containing similar flow patterns. One of the most widely used techniques to identify LCS is the computation of Finite-Time Lyapunov Exponents (FTLE). We implemented a variety of methods to compute FTLE for several different fluid flows. We developed adaptive unstructured meshes for both Cartesian and spherical coordinates and applied them to analytical and model data. Specifically for weather data on a spherical coordinate, we computed FTLE on an isentropic surface in the atmosphere in order to identify patterns in the flow of ozone. We then verified our results by comparing them to measured potential vorticity, an indicator for the pattern of ozone concentration in the atmosphere.

319. On the Splitting of MO(2) over the Steenrod Algebra

Maurice Shih Laramie Senior High School
Advisor(s): John Ullman, Massachusetts Institute of Technology

We study the problem of whether the cohomology of the Thom spectrum, MO(2) can be split as a module over the Steenrod algebra by considering various finite-dimensional subalgebras, denoted as $A(n)$. In order to solve this problem, we attempt to find a disjoint splitting, based on a minimal generating set over a polynomial ring. First, we solve the hit problem over the cohomology of MO(2) in order to find a minimal generating set. Second, we use a basis for various finite-dimensional subalgebras and find a splitting. The cohomology of MO(2) is constructed by multiplying the symmetric algebra on two generators by ω, the Thom class of the universal two-dimensional vector bundle. Topologically, this corresponds to adding a common point at infinity to all the fibers of the vector bundle. The motivation for this problem is to better understand the real unoriented bordism spectrum MO. In this project, a splitting is first constructed for each of the $A(0)$ and $A(1)$ cases. Next, for $A(2)$ and $A(3)$ we conjecture that a splitting is not possible. From this result, we predict that MO(2) does not split over the Steenrod algebra.

320. The Price is Strategy

Christian Heilman Nevada State College
Advisor(s): Aaron Wong, Nevada State College

The title of my poster will be The Price is Strategy, for the game-show The Price is Right. My concentration will be on the wheel portion of the game-show. From word-of-mouth I have heard that adults (from my parents' generation) assume to know how to beat the game based off experience. The goal of this project is to discover the optimal strategy of contestant 1's turn of spinning. What is the optimal number to reach, when to re-spin, and when to stop so that contestant 1 is in the best position possible when ending their turn. I want to discover the ultimate strategy, given any first spin, on how to react to that spin. This project will incorporate probability/statistics in achieving the answer by developing a layout of outcomes with probabilities. Comparing staying at one number versus another number and the consequences of any choice made. Every single variable will be looked at, much different than a board game being analyzed. Also, I will include the probability of winning the bonuses if contestant 1 gets a 100 as their turn total (bonuses: if 100 is achieved on turn, then bonus spin, if on the bonus spin contestant 1 rolls a 100, they get $10,000 extra or if they roll the 5 or 15 next to the 100 they get $5,000).

321. On the c-strong Chromatic Number of t-intersecting Hypergraphs

Ping Ngai Chung Massachusetts Institute of Technology
Advisor(s): Joseph Gallian, University of Minnesota Duluth

For a fixed $c \geq 2$, a *c-strong coloring* of the hypergraph G is a vertex coloring such that each edge e of G covers vertices with at least $\min\{c, |e|\}$ distinct colors. A hypergraph is *t-intersecting* if the intersection of any two of its edges contains at least t vertices. This paper addresses the question: what is the minimum number of colors which suffices to c-strong color any t-intersecting hypergraph? We first show that the number of colors required to c-strong color a graph of size n is $O(\sqrt{n})$. Then we prove that we can use finitely many colors to 3-strong color any 2-intersecting hypergraphs. Finally, we show that $2c - 1$ colors are enough to c-strong color any shifted

$(c-1)$-intersecting hypergraphs, and $2c-2$ colors are enough to c-strong color any shifted t-intersecting hypergraphs for $t \geq c$, both chromatic numbers are optimal and match the conjectures that the shifted condition can be removed.

322. Mathematical Modeling and Numerical Solution of Cell Growth

Zihuan Liu University of Massachusetts Boston
Wenke Sun University of Massachusetts Boston
Advisor(s): Xiaodi Wang, Western Connecticut State University

Biologists are interested in the effects of diffusivity and Chemotaxis on the competition of several species for a limited resource. Diffusivity of cells is also called motility in some engineering literature. Chemotaxis is the oriented movement of cells in response to the concentration gradient of chemical substances in their environment. To illustrate the general idea involved, consider a species of cells which responds chemotactically to a chemical which attracts the cells. Let u(x, t) and v(x, t) be the concentration of the chemical and density of cells, respectively. The chemical is assumed to be diffusive with diffusion coefficient = D_1; The cells are assumed both diffusive and chemotactic with diffusion coefficient = D_2; The Chemotaxis flux of cells is assumed to have the form $\vec{J}_{chemo} = \chi v \phi'(u) \nabla u$, where χ is a nonnegative constant, called Chemotaxis coefficient; $(u) > 0$, and ∇u is the gradient of u with respect to the spatial variable. The purpose of my research is to solve the PDE equation and to show some property of flux. For example, what is the direction of flux? Find the solution for case of single species model and two-species competition model.

323. A Generating-Function Approach for Reciprocity Formulae of Dedekind-like Sums

Jordan Clark Morehouse College
Stefan Klajbor University of Puerto Rico, Rio Piedras
Advisor(s): Matthias Beck, San Francisco State University

Apostol sums and HWZ sums are generalizations of Dedekind sums, important finite arithmetic sums introduced by Dedekind in the 1880's with applications in various fields of mathematics and computer science. These sums satisfy numerous reciprocity laws that have been the object of much research. We introduce and prove an identity which serves as a generalization of Apostol and Rademacher reciprocity for the case of Apostol sums with three variables. We do this by showing how it is implied by the HWZ reciprocity and also show how Apostol and Rademacher follow as special cases.

324. A Data Mining Toolbox for Twitter

Brian McGue Davidson College
Advisor(s): Tim Chartier

Twitter has over 500 million users worldwide posting tweets of 140 or less characters. With hundreds of millions of tweets appearing on this social network daily, what tools can be developed to mine information from this rich and ever-enlarging dataset? For example, Lady Gaga and the Twitter accounts have over 30 million and 14 million Twitter followers, respectively. If each of these accounts posted a tweet, which is most likely to be retweeted? If you have a topic for which you want to search, how can you take a large number of tweets and quickly gain a perspective on the topics being tweeted and possibly refine your search? Further, how might one mine tweets from a sporting event? This work developed tools for data mining Twitter related to these issues.

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