# The Seventeenth Annual Nebraska Conference for Undergraduate Women in Mathematics

## January 23 - January 25, 2015

# POSTER ABSTRACTS

## Posters by Undergraduate Students

**Emily Alfs, Doane College**
[A-1][1] *Fun!-Damentals of The Number Game 31-derful*

Similar to Sudoku, 31-derful is a game where the player tries to place values into certain positions to win the game. 31-derful is also similar to magic squares in that to win the game, the rows and columns must all sum to the same value. To win 31-derful, the player must place cards from a standard deck of cards into a five by five grid with each row and column summing to 31. Cards are worth their face value except for face cards, which are all worth ten and aces are worth eleven. We started on a two by two grid, and limited the deck to one suit to recreate having one suit less than the size of the grid. We modified the sum rule to having the rows and columns sum to the same value. One unique solution exists in the case of the two by two grid. Research was then scaled up to the three by three case using two suits. We found that there are 358 unique solutions (up to symmetry). Each grid falls into one of five distinct categories. Algorithms were generated that can construct any winning three by three grid.

**Mikasa Barnes, University of Central Oklahoma**
[B-1] *On the Painting of Caterpillar Continua*

Caterpillar continua are trees with certain restrictions. Caterpillar continua can be partitioned into classes based upon the number of non-cut points and the number of points of order greater than or equal to 3 possessed by each continuum in the class. In fact, a class $C(m, j)$ of caterpillar continua is defined to be those caterpillars with m non-cut points and with $j$ points of order greater than or equal to 3. Given one of the caterpillars from a class $C(m, j)$, we will count the number of non-isomorphic ways to color non-cut points of $C(m, j)$ any one of k colors.

**Iris Bennett, Grinnell College**
[A-2] *Inference for the Correlation Coefficient in a Bivariate Normal Model Under Type II Censoring*

Suppose a sample of n bivariate Normal random variates $(X, Y)$ is subjected to Type II censoring on one variate so only p observations are made - the p smallest values of $X$ (single censoring) or middle p values of $X$ (symmetric censoring), where p is predetermined. The sampling distribution of the sample correlation coefficient, r, is mathematically intractable. An arcsine transformation, Fisher's Z, is often used to make inference on $\rho$, the population correlation, for full samples because it converges rapidly to a Normal distribution. We demonstrate that use of Fisher's Z transformation leads to systematic errors in percentile estimation of the sampling distribution under Type II censoring, creating confidence intervals with coverage probabilities far from nominal. We propose modifications based on experimental conditions to Fisher's Z and show that these modifications lead to greatly improved estimates of sampling distribution percentiles and closer to nominal confidence interval coverage rates.

**Abbey Benzine, Coe College**
[B-2] *Optimizing Medical Image Reconstruction*

With the advent of higher resolution cameras and faster computer processors, digital images have become more commonplace. This prevalence can be observed in the exponential increase of images shared on personal electronic devices and social networks. In addition to personal use, the domains of academia and industry have gained from the expansion of digital imaging. In our research, we focus on imaging in health care–in particular, CT scanning. The medical field relies on CT scans to create visual representations of the body through noninvasive means. These images are acquired through x-ray data; however, the observed data are not an exact representation of the patient?s anatomy. These data require computational methods to reconstruct the original image. We need an efficient computational method that can reconstruct a high quality image while minimizing patient exposure to radiation. We will discuss various methods for optimizing this reconstruction of the original image from the data we are able to collect.

[1] [A-1] means poster #1 in Poster Session A on Saturday. [B-1] means poster #1 in Poster Session B on Sunday.

**Rose Berns-Zieve, Hamilton College**
[A-3] *Groups with Context-Free Co-Word Problem and Embeddings into Thompson's Group V*

We describe a generalized Thompson group $V_{(G,\theta)}$ for each finite group $G$ with homomorphism $\theta$: $G \to G$. Our group is constructed using the *cloning map* concept introduced by Witzel and Zaremsky. We prove that $V_{(G,\theta)}$ is co$\mathcal{CF}$ for any homomorphism $\theta$ and finite group $G$ by constructing a pushdown automaton and showing that the co-word problem of $V_{(G,\theta)}$ is the cyclic shift of the language our automaton accepts. Lehnert conjectures that a group has context-free co-word problem exactly if it is a finitely generated subgroup of $V$. The groups $V_{(G,\theta)}$ where $\theta$ is not the identity homomorphism do not appear to have obvious embeddings into $V$.

**Kate Causey, Furman University**
**Hayden Rudd, Furman University**
[A-4] *What are We Waiting For? Statistical Analysis in Disney's Animal Kingdom*

In May of 2014, three professors and 12 students from the Furman University Mathematics Department traveled to the "happiest place on earth" for a three week intensive course studying applied mathematics in Walt Disney World. This poster presents statistical throughput analysis of two popular rides in Animal Kingdom, Expedition Everest and Kali River Rapids. Our analysis explores wait times of single rider lines and examines capacity issues.

**Cassandra Chan, Furman University**
[B-3] *Exploring The Colley Ranking Method with An Application to The National Football League (NFL)*

The current NFL ranking system, along with most ranking systems used in other sports, is based solely on the win-loss ratio of their teams. In comparison, the Colley ranking method takes into consideration not only the win-loss ratio, but also a strength of schedule factor. We considered that the inclusion of this factor would give the system more fairness and efficiency. We tried to explore a convenient way to incorporate the Colley ranking method into the NFL schedule and generalize to other scenarios. The approaches we took involve eigenvalues and eigenvectors, adjacency matrices and minimal polynomials, matrix inverses, and elements of graph theory. So far, we have not yet found a desirable result for our purpose, but the ideas presented here provide a valuable basis for further exploration.

**Taylor Chott, Colorado School of Mines**
[B-4] *Bayesian Modeling on Small Spatial Lattices*

Bayesian hierarchical spatial models are widely used to model phenomenon recorded as lattice data. They are a flexible way to incorporate prior knowledge and uncertainty into estimating distributions for the response. Furthermore, the Bayesian technique allows for the use of Monte-Carlo methods for sampling from a conditional prior distribution. We present a case study of such an approach applied to aggregated melanoma data at the state level in the United States and at the county level in California. The results suggest that on small lattices, an informative prior must be applied to guarantee convergence. We demonstrate how a model comparison metric, DIC, is sensitive to the choice of prior, how confounding can easily be mistaken for significance, and conclude that subject-matter knowledge must be applied to appropriately specify the model.

**Gabriella Clemente, The City College of New York (CCNY)**
[A-5] *Graphs with Minimal Well-Covered Dimension*

Let $G$ be a graph and $sc(G)$ be the number of simplicial cliques of $G$. The well-covered space of $G$ is the vector space of all functions on $V(G)$ that 'make' $G$ well-covered, and the dimension of this space is the well-covered dimension of $G$, denoted by $wcdim(G)$. In 2005, Brown and Nowakowski proved that (1) $wcdim(G) \geq sc(G)$, and that (2) $wcdim(G) = sc(G)$ if $G$ is a chordal graph. We generalize (2) and obtain a family of graphs with minimal well-covered dimension that contains chordal graphs. We also prove that for any Sierpinski gasket graph, $S_n$ with $n \geq 2$, $wcdim(S_n) = sc(S_n)$.

**Casandra Conigliaro, Alverno College**
[A-6] *Geometric Concrete Modeling of Axiomatic Systems*

With even the smallest of patterns, there exists mathematical thinking. Axiomatic systems help to illustrate such patterns in mathematical language. My presentation includes creating 2D and 3D geometric concrete models, both computer generated and with physical concrete models, such as a bracelet. I will also discuss generating an axiomatic system from a pattern, more specifically a bathroom tile pattern. In addition, it will be shown that patterns can be used to illustrate the independence of axioms in a system.

**Amanda Croan, Park University**
[B-5] *Constructing a Nice Basis for the Global Weyl Module for the Map Algera of Sl2*

In 2004, Feigin and Loktev proved that the global Weyl modules for the map algebra $\mathfrak{sl}_2 \otimes A$ are isomorphic to symmetric tensors of the fundamental module for $\mathfrak{sl}_2$ tensored with $A$. In symbols $W_A(k) \cong S^k(V(1) \otimes A)$. We build upon this theorem to construct a basis for $S^k(V(1) \otimes A)$ which, via the isomorphism, gives a particularly nice basis for the global Weyl modules for the map algebra $\mathfrak{sl}_2 \otimes A$.

**FranChell Davidson, Texas Southern University**
[B-6] *On The Solution of* $X_{n+1} = f(x_n)/x_{n-1}$

In this paper we examine the solutions of the equation (1) $x_{n+1} = f(x_n)/x_{n-1}$ for various functions f. While equation (1) has been studied by several authors, no one has considered (1) for specific functions. This work will fill that void and focus on the qualitative behavior of solutions of (1) boundedness, periodicity, and oscillation of solutions are considered.

**Aleyah Dawkins, James Madison University**
[A-7] *Realizations of Secondary Polytopes*

Polytopes have been investigated since Euclid and have enjoyed a significant renaissance in the last half-century. Triangulations of polytopes generate a plethora of beautiful structures and have many applications within and beyond pure mathematics. One object associated to the triangulations of polytopes is the secondary polytope. My objective is to provide some first results and further questions on secondary polytopes.

**Mandi Dean, Berry College**
[B-7] *Enriching Geometry Curriculum with 3D Printing*

3D printers are affordable, powerful teaching tools that can be used to teach difficult mathematical topics such as cross-sections, symmetry, volume, and properties of 3D solids in an interactive and engaging environment. In this presentation, I will share my experiences of teaching geometry concepts to elementary and middle school students using 3D printers and 3D design software. My research team has found that creativity in math, spatial reasoning skills and connections to real world applications–areas which are difficult to address through traditional lessons–can be featured in geometry curricula through 3D printing. The presentation includes a variety of lesson plan ideas for incorporating 3D printers in the classroom as well as teacher feedback and student samples from the 3D printing lessons I have conducted.

**Janae Dixon, California State University, Fresno**
[B-8] *Grim: A Graph Game*

The game Grim is a subtraction game played on a graph. A move consists of deleting an available vertex (one that has not been already deleted), together with any vertices that become isolated as a product of this move. As usual, the last player to make a move wins. Some was already known about Grim played on certain families of graphs (certain paths, cycles, and gears, and complete bipartite graphs and grids). Not surprisingly, the analysis of the game gets really complex when the number of vertices grows, even for very simple graphs, such as even paths. We focused on two problems: Large graphs: What happens when Grim is played on graphs with many vertices. Randomized playing: What happens when Grim is played randomly (no strategy, or just using a 'local' strategy) on a given graph.

**Ailaura Donahoe, Penn State University**
[A-8] *Modeling the Interaction Between the Cardiovascular System and Inflammatory Response*

The more quickly a patient begins to mobilize after surgery, the shorter their recovery time is. However, postoperative patients are prone to syncope, or fainting. This is due to inflammation lowering blood pressure and their hearts inability to readjust it to normal levels. To better understand this phenomenon, three models were developed to predict blood pressure, heart rate, and the inflammatory response. The models were formulated as systems of differential equations that were solved using MATLAB. They were then tested using blood pressure and heart rate data measured from a healthy subject who was given a dose of endotoxin to stimulate an inflammatory response. The ultimate goal of the project is to combine the models for heart rate and blood pressure in the cardiovascular system and the model of the inflammatory response, in order to achieve a better grasp of why patients faint after surgery and to shorten recovery time by expediting mobility.

**Stephanie Dorough, University of Montevallo**
[A-9] *Connectivity Properties of Topological Spaces*

My presentation concerns connectivity in topological spaces. A space is connected provided it cannot be expressed as a disjoint union of two nonempty open sets. A stronger property is path connectivity. Examples are given of path connected analytic function spaces, as well as spaces which are connected but not path connected. An interesting property related to connected spaces is that of an explosion point. It is possible for a connected topological space to have an explosion point which, when removed, results in a completely disconnected space (a space in which the only connected subsets are one-point sets). The Cantor Teepee is an example of such a space.

**Elizabeth Eason, Grinnell College**
[B-9] *Orthogonal Polynomials and Characteristic Polynomials: Coming full circle with cyclic graphs*

Each graph has its own associated family of orthogonal polynomials. This summer, I discovered that for the cyclic graphs, these families of polynomials are nested within each other. Through studying the recurrence relation used to derive the orthogonal polynomials, I created and proved an explicit formula to find any orthogonal polynomial for any cyclic graph. After finding that the characteristic polynomials for cyclic graphs are quite similar to the orthogonal polynomial of the same degree, I then used my formula to prove the orthogonal polynomials and characteristic polynomials of cyclic graphs are related in an unexpected way.

**Marquesha Foreman, Texas Southern University**
[A-10] *On the Solutions of* $x_(n+1) = (f(x_n))/x_(n-1)$ *Where* $f$ *is Piecewise Linear*

Our goal in this paper is to examine the long-term behavior of solutions of the following difference equation $x_{n+1} = (f(x_n))/x_{n-1}$ , where f is piecewise linear, and the initial values $x_{-1}$ and $x_0$ are non-zero real numbers. We examine the boundedness, periodicity, and the existence of oscillatory solutions.

**Remi Fuhriman, Brigham Young University**
[B-10] *Wavelet Analysis and their Implication for the Art World*

The temptation to take what belonged to another was too strong for many during World War II. Art became the currency of war and the practice of Kunstschutz resulted in the looting of over 600,000 works of art. Many of those pieces will never be seen again, but those that have been recovered face charges of forgery. Determining the authenticity as well as the original artist provides art historians with meaningful and valuable information regarding a work's history and influence. Surprisingly, the field of Applied Mathematics provides many tools that can be used to assist in the conclusive authentication of such works of art. Particularly, wavelets have shown remarkable success in this effort by performing numerous hierarchical edge detections at various levels of resolution to analyze paintbrush strokes to identify the style of the artist. Different wavelets have been designed to analyze specific criteria  some focus on texture, others topography, and even style and fluency.

**Ara Han, University of Central Oklahoma**
[B-11] *The Effect of Platelets on the Degradation of Blood Clots*

Fibrinolysis, the degradation of blood clots, is initiated by tissue-type plasminogen activator (tPA). However, tPA is inhibited by a molecule called PAI-1, which is secreted by platelets. The presence of both PAI-1 and platelets affects how easy the clot is to degrade. Thus, we use mathematics to study how the configuration of platelets and the presence of PAI-1 affects the degradation of clots. We investigate how the distribution of platelets and PAI-1 affects the degradation rate by using a stochastic model to count the fibers in a blood clot as time progresses.

**Melanie Harrison, Lewis University**
**Elizabeth Langland, Lewis University**
[A-11] *Permutations in Abstract Algebra*

We will look at the various aspects of permutations and how they are used in the study of Abstract Algebra. One such aspect is the structure of an $r$-cycle, and how to create a disjoint cycle from this notation; this can also be seen graphically. Furthermore, we will look at how to formulate the conjugate of $\alpha$ by $\beta$, to create $\beta\alpha\beta^{-1}$. We also explore the inverse and transpositions of a given permutation. We will look at another application, dihedral groups. A dihedral group is $2n$ elements and fulfill the equation $bab = a^{-1}$, with element $a$ being of order $n$ and element $b$ being of order 2.

**Jessica Hauschild, Kansas Wesleyan University**
[A-12]*On the Levi Graph of Point-Line Configurations*

Given a certain point-line configuration C one may construct its Levi graph (AKA incidence graph), Levi(C), by connecting point-vertices with line-vertices if and only if they are incident in C. In this work we assume C to be a $(v_r, b_k)$ configuration, and we investigate the vector space of vertex weightings of Levi(C) that are constant on all maximal independent sets of the graph, and prove that its dimension, known as the well-covered dimension of Levi(C), is always equal to 0, as long as $r > 2$.

**Samantha Hemleben, Wofford College**
[B-12]*Modeling a Tethered Puck*

In this talk I will discuss the project that I worked on while at Oregon State University participating in their REU. Together with two engineers we modeled a puck in Matlab, that is floating on an air hockey table, while it is tethered after it has been launched. Our model takes into account the offset of the tether and the starting point of the puck in relation to the launcher. I also assisted with the building of the launcher on the air hockey table. Once the physical launcher and model of the system were completed we recorded data and compared them. This allowed us to study them and create comparison videos of the pucks movement.

**Kownoon Her, Colorado School of Mines**
[A-13]*Periodical Cicadas and Prime Numbers*

Periodical cicadas are renowned for having unique prime-numbered life cycles of 13 and 17 years. In this project, several simulations were performed to model the survivability of cicadas with unique life cycles ranging from a 10 year cycle to a 20 year cycle. In the simulations, a carrying capacity underground and a co-emergence proportion aboveground were implemented to model competition for available resources. The results showed that from competition, prime-numbered cycles were more likely to outlast nonprime-numbered cycles due to the lack of co-emergence years that prime-numbered cycles shared with other cycles.

**Su-Ji Hong, California Lutheran University**
[B-13]*Applying Queuing Theory to a Queuing System*

Queuing theory uses flow balance equations derived from steady states to determine the probability of each state, the number of customers in the system. I modeled the queuing system at the Centrum caf on California Lutheran University campus assuming that the arrival and service rates follow an exponential distribution. The queue system at the register followed $M/M/1/FCFS/\infty/\infty$ : the arrival and service times are independent, there is one server, it has a first come first serve queue discipline, infinitely many people can be in the queue, and there are infinitely many people from which customers are drawn. I figured out the arrival rate, $\lambda$, and service rate, $\mu$. I computed the waiting time and compared it to the data. I simplified the model at the kitchen to $M/M/1/FCFS/\infty/\infty$. Then I connected them using the fact that $\lambda$ depends on $\mu$ of the register. After calculating the probability of each steady state, I calculated the queue time at the register and the kitchen.

**Sarah Jackson, Texas Tech University**
[A-14]*Exploration of The Iteration of Complex Functions*

Rational functions, including logarithmic and rational functions, are iterated using Newton's method. Interesting symmetries and patterns of convergence to specific roots are observed. Fixed points are classified as attracting or repelling. The basins of attraction exhibit interesting geometric properties for different values of specified parameters. These properties are verified for some special cases of the parameters.

**Michelle Johnson, St. Catherine University**
[B-14]*Combinatorics in the Sinha Spectral Sequence: Geometry of Knots in Higher Dimensions*

Generalizing classical knot theory to higher dimensions, we consider the space of knots $R^n$, for $n \geq 4$. Although all knots in higher dimensions can be untied, this space has interesting topology. We study motions of families of knots moving through the ambient space. Our main goal is to find an explicit example of a homology cycle. The Sinha spectral sequence transforms this difficult geometric question into a more accessible combinatorial question. We wrote a computer program to address this combinatorial question, and we found that while an explicit example of a cycle in the particular section of the Sinha spectral sequence we were exploring is possible to find, such a cycle would be too complicated to provide insight into the geometry of the space of knots.

**Akina Khan, St. Olaf College**
[A-15]*On Subgroups of Semi-direct Products*

In 1889, Goursat published a paper that established a correspondence between subgroups of a direct product $A \times B$ and triples of the form $(A_1/A_2, B_1/B_2, \sigma)$ where $A_2/A1 \leq A, B_2/B1 \leq B$, and $\sigma : A1/A2 \to B1/B2$ is an isomorphism. About a hundred years later in 1991, Usenko published a paper that established a correspondence between subgroups of a semi-direct product $A \circ \varphi B$, where $\varphi : B \to AutA$, and triples of the form $(L, R, \theta)$ where $L \leq A, R \leq B$, and $\theta : R \to A$ is a derivation (or crossed homomorphism) with special properties. While Goursat's theorem has been used many times to investigate subgroups of direct products, Usenko's theorem has not, probably due to the computational complexity of finding the special derivations. In our paper, we find ways of reducing the computational complexity under certain conditions (e.g. when one of A is abelian), and use Usenkos theorem to determine the subgroups of certain metacyclic p-groups.

**Dana Lacey, North Central College**
[A-16]*Bathtub and Unimodal Hazard Flexibility Classification of Parametric Lifetime Distributions*

There are a number of bathtub and unimodal hazard shape parametric lifetime distributions available in literature. Therefore, it is important to classify these distributions based on their hazard flexibility to facilitate their use in applications. For this purpose we use the Total Time on Test (TTT) transform plot with two different criterion: I) measure the slope at the inflection point on the scaled TTT transform curve; II) measure the slope at selected points from the constant hazard line on the scaled TTT transform curve. We confine our research to classify the flexibility of Weibull extensions and generalizations and also select one-shape parameter lifetime distributions to exemplify the two criterion process.

**Elizabeth Langland, Lewis University**
see **Melanie Harrison**

**Grace Lim, California State Polytechnic University, Pomona**
[B-15]*Persistent Random Walk of Microorganisms in a Porous Medium*

Microorganisms such as bacteria and algae typically live in complex porous environments like soil and biological tissue. It is challenging to characterize accurately the movement of microorganisms under these conditions for their motion is neither completely random nor fully deterministic. For our project, we develop a persistent random walk model for the motion of swimming cells in an idealized lattice-like porous medium. The walk is described by a Markov chain in phase space, tracking both position and velocity. Physical parameters, including the overall geometry, bulk flow, and scattering laws, are incorporated into the memory-dependent transition amplitudes. Based on this simplified model, we analyze the drift and diffusion of the microorganisms through the medium. From the fundamental matrix of the Markov chain, we numerically compute first passage time in MATLAB for square and honeycomb lattices to determine the effects of lattice structure on microbial transport.

**Lucia Magos, Creighton University**
[A-17]*Low Regularity Mild Solutions to The MHD Equation*

Here, we consider the incompressible magneto-Hydronynamical (MHD) equation. The MHD equations govern the dynamics of the velocity and magnetic fields in electrically conducting fluids such as plasmas, reflect the conservation of momentum, are induction equations, and specify the conservation of mass. In this paper, we prove the local existence of a unique short-time solution to the MHD equations with known data in the Sobolev space $H^{s,p}(\mathbb{R}^n)$.

**Connie Maluwelmeng, Iowa State University**
[B-16]*Modeling and Optimization of Solar Tower Power Plants*

The purpose of this project was to create a basic structure for a graphical interface. Previously, the research team had created a working software that optimized solar tower power plants based on several parameters such as location, solar tower configuration, time of day, number and position of heliostats (mirrors that reflect sunlight into the central receiver located on the tower), and many others. A problem arose when the team realized that most people would not know what most of the parameter labels were. Thus, this project created. A graphical user interface creates a way for users to easily interact with digital copies of their existing or in-design solar tower power plants.

**Aurora Marks, California State University, Sacramento**
[A-18] *Modeling the Sea Floor Using Tension Spline Curve Radial Basis Functions*

A map of the seafloor off the coast of California is constructed by interpolating bathymetric data with radial basis functions under tension (RBFTs). Open source tools were used to calculate and render the sea floor images. Data used in this study were acquired, processed, archived, and distributed by the Seafloor Mapping Lab of California State University Monterey Bay.

**Talin Masihimirzakhanian, California State Polytechnic University, Pomona**
[B-17]*A Locally Adaptive RBF-FD Method*

Conventional Radial Basis Function (RBF) methods for numerically solving partial differential equations use global approximations resulting in dense matrices that grow in size if data refinement occurs. The Radial Basis Function – Finite Difference (RBF-FD) approach is a local approximation method that utilizes nearest neighbor data and yields a sparse implementation. Unfortunately RBF-FD differentiation matrices have fixed stencils and the approximations can lose accuracy under refinement. In this paper we propose using local approximations with locally adaptive stencils that take advantage of the features of both global and local approximations. In this approach the stencil sizes stay fixed where the solution is smooth but grow in size only where refinement is needed. The advantage of this method is that it is computationally efficient and stable much like the RBF-FD method but offers comparable accuracy to global approximations with significantly lower computational cost.

**Lorena Maxwell, Rose-Hulman Institute of Technology**
[A-19]*Using Machine Translation to Extend Text Classification*

In order to place advertisements relevant to the content of the web pages on which they appear, text classification (TC) has to be utilized. However, this process is burdened by the fact that a person has to observe a web page and manually label it to create training data for the machine. Because there are millions of pages, categorizing them is both time consuming and expensive, especially when it needs to be done over tens of languages. My team approaches this problem by automating the process of text classification for foreign-language articles by using machine translated (MT) texts to train a classifier. We experiment with English, Spanish, Russian, and French articles from Wikipedia, using English as the source language and the others as target languages. We compare the MT model to the native model and investigate the benefits and limitations of machine translation.

**Jordan Michela, University of Central Oklahoma**
[B-18]*Saving Lives One Ambulance Trip at a Time*

In emergency situations, a person may lean towards calling 911 for an ambulance. From the scene of the accident, the victims are rushed to a hospital where their injuries can be taken care of. When you have multiple hospitals in the area, which one would be best to send the patient to? Problems could result from having a shortage in doctors, a delay, no rooms available, or even no one specializing in that specific injury. So how do you come up with the best solution without worsening the condition of the patient? We model the problem mathematically and test the solutions generated by simple heuristics against those from more advanced alternatives.

**Erica Musgrave, Saint Mary's College of California**
[A-20]*Catalan Numbers Modulo* $2^\alpha$

Catalan numbers, defined by the explicit formula $C_n = 1/1 + n\ C_{2n}^n$, have been studied since the eighteenth century due to their frequent appearance in various fields from set theory to combinatorics. For example, $C_n$ counts the number of permutations of $\{1, 2, \ldots, n\}$ that avoid a three-term increasing subsequence. However, there are few results about the properties of Catalan numbers modulo prime powers. In particular, this project examines the number of residues obtained by viewing Catalan numbers modulo powers of 2. For example, it is known that no Catalan number is equivalent to 3 modulo 4. Can other residues that do not occur for higher powers of 2 be characterized? As these higher powers of two are analyzed, it can be seen experimentally that more and more residues are not attained. Through our research we believe as $\alpha$ gets large, the proportion of residues modulo $2^\alpha$ attained by some Catalan number is between 0.125 and 0.27.

**Brittany Myers, University of Central Oklahoma**
**Alanna Riederer, University of Central Oklahoma**
[B-19]*A Mathematical Model of Circadian Rhythms in Drosophila*

Periodically occurring events can be expressed by a system of differential equations. Circadian rhythms, daily rhythmic activity cycles, are an example of such an event. Experimental observations coupled with previous modeling efforts have explained much of the behavior of Drosophila circadian rhythms, but questions remain. We develop a more comprehensive model which accounts for two different Drosophila genes (PER and TIM), in an effort to create a more accurate biological description. We hypothesized that our biologically-motivated model will better model the observed circadian rhythms.

**Danna Naser, Texas Tech University**
[A-21]*Evaluating The Impact of Climate Change on Dynamics of House Insurance Claims*

Insurance companies are highly affected by adverse climate change. Indeed, the year 2013 brought a record amount of claims and losses due to weather related damages, which in the USA and Canada alone cost the insurance industry more than 3 billion dollars. The objective of this paper is to provide a statistical data-driven insight on the (non)linear relationship between weather-related house insurance claims and atmospheric variables and to predict future claim dynamics accounting for changes in extreme precipitation. In this paper we propose to employ a flexible Generalized Autoregressive Moving Average (GARMA) model for count time series of insurance claims, develop a new method to compare tails of the observed and projected extreme precipitation and evaluate its impact on number of claims in the GARMA framework. We illustrate our approach by studying house insurance dynamics in three Canadian cities.

**Alyssa Newman, Hobart and William Smith Colleges**
[B-20]*All Work No Play, Is It Worth It?*

We are interested in seeing how important friendships are for college students and whether they can enjoy friendships while maintaining good academic performances. Assuming the topology of college friendships fits into a Watts Strogatz network, we studied relationships between socialization and academic work using a series of computer simulations. We studied to which extend friendships help students handle the stressful college environment and attempted to find an optimal time allocation between academic work and maintaining these crucial friendships. Base assumptions from Sociology and Phycology research are used to fairly generate these networks and scenarios. We found that for students to enjoy their college life, it is very important to have close friends that can assist in a time of need. We also found that doing well in academics is also rewarding and spending more time on academics can improve your overall happiness.

**Maisie Newman, Washington College**
[A-22]*Knot Colorings and Dimer Graphs*

A knot is a circle embedded into three-dimensional space. We can investigate properties of knots with invariants: specific quantities assigned to knots that are the same for isotopic knots. In 1956, Fox defined n-Fox coloring of knot diagrams as a way to get new invariants. Now, we have a new method to color knot diagrams called face coloring. We know we can get data about face coloring knots via matrix theory in the same way that we could for Fox coloring. The methods we are particularly interested in are using the determinant and Smith Normal Form of a face coloring matrix in order to determine how many nontrivial n-face colorings there are for any n. When a knot is alternating, there is a way to build a graph from a knot's face coloring matrix and use a visual approach to find the same data. The goal of our project is to get data about the knot's corresponding matrix directly from the graph. We would also like to find a way to relate the graphs data directly to the structure of the knot.

**Sujee Park, Colorado School of Mines**
[B-21]*Modeling Malaria*

Mathematical biologists have spent over a century modeling malaria. With many different assumptions and approaches, this disease has proved to be complicated to fit into a mathematical model. This research project uses insights and approaches from the most well-known malaria models. Our goal in creating a model was to balance realistic biologic assumptions with the limitations arising from simulations done in Matlab. We use a simplistic approach, similar to the Ross Model of 1911. From this starting point we developed two models. The first introduces vital dynamics (natural births and deaths), and the second introduces temporary immunity. Using constant parameters and initial conditions across the two models, we were able to find differences in the two approaches. Additionally, we consider how the spread of the disease changes with preventative measures versus medical treatment. Simulating these changes can give insight into which practices can keep this disease at an endemic state.

**Anisha Pathak, University of Southern California**
**Kira Soderstrom, University of Southern California**
[A-23]*A Data Analytic Approach to Epileptic Seizure Prediction*

We will present the methods that we investigated and developed with the aim of contributing to a more efficient seizure forecasting system for epilepsy patients. The research area dealing with using intercranial electroencephalography (EEG) recordings to predict imminent seizures (preictal brain activity) is very active. In particular, the American Epilepsy Society sponsored a data science challenge (https://www.kaggle.com/c/seizure-prediction) in which a team of USC undergraduates participated this past fall. We will discuss the process of developing and implementing our algorithms. We will also give a brief survey of the mathematics and statistics that was involved.

**Alex Peterson, Berry College**
[B-22]*Uniquely Bipancyclic Graphs*

A bipartite graph on n vertices, n even, is called uniquely bipancyclic (UBPC) if it contains precisely one cycle of length $2m$ for every $2 \leq m \leq n/2$. In this note, using computer programs, we show that if $32 \leq n \leq 56$, and $n \neq 44$, then there are no UBPC graphs of order n. We also show the six non-isomorphic UBPC graphs of order 44. This improves the recent results on UBPC graphs of order at most 30.

**Ariel Pignatelli, SUNY New Paltz**
[A-24]*Real and complex dynamics for symbolic sequences of logistic maps*

The behavior of orbits for iterated logistic maps has been widely studied since the dawn of discrete dynamics as a research field. Existing results refer not only to the family of real quadratic polynomials, but also to the context of complex maps $f(z) = z^2 + c$. However, little is known about orbit behavior if the map evolves along with the iterations. We investigate how the theory changes if the dynamical scheme involves two functions, $f_0$ and $f_1$, iterated according to a prescribed binary sequence of 0s and 1s. In particular, we observe the effects of the structure of the symbolic sequence (periodicity, complexity, etc) on the complexity of the resulting system and (visually) on the topological structure of its Julia set. This direction is of potential interest to a variety of applications (including genetic and neural coding), since it investigates how an occasional or a reoccurring error in a replication or learning algorithm may affect the outcome.

**Hannah Prawzinsky, Northern Arizona University**
**Emily White, Northern Arizona University**
[B-23]*On Prime Vertex Labelings*

A prime vertex labeling is an injective assignment of the labels $\{1, 2, ..., n\}$ to the vertices of a simple connected graph on n vertices such that any two adjacent vertices have relatively prime labels. We will present background information, known results, and some open questions associated with prime vertex labelings. No prior knowledge of graph theory is needed.

**Sarah Renfro, Sam Houston State University**
[B-24]*Simplified Pseudo-Kauffman Polynomial: An Invariant for Pure Pseudoknots*

In mathematics, a knot is an embedding of a circle in 3-dimensional Euclidean space. However, the study of knots is primarily on 2-dimensional representations of knots, called knot diagrams. Two knot diagrams are equivalent if they are related by a finite sequence of Reidemeister moves. Pseudoknot diagrams, conventionally called pseudodiagrams, are generalizations of knot diagrams where, at a crossing, the over and under strands may be undetermined. Crossings where the over strand is unknown are called precrossings. Two pseudoknot diagrams are defined to be equivalent if they are related by a finite sequence of Reidemeister moves and pseudo-Reidemeister moves. Equivalent pseudoknot diagrams are said to be diagrams of the same pseudoknot. In my presentation, I will introduce an invariant for pure pseudoknots inspired by the Kauffman Polynomial and characterize the polynomial for families of pure pseudoknots. A pseudoknot is said to be pure if there exists a diagram of the pseudoknot with only precrossings.

**Alanna Riederer, University of Central Oklahoma**
see **Brittany Myers**

**Colleen Robichaux, Louisiana State University**
[A-25] *K-Knuth Equivalence for Increasing Tableaux*

A K-theoretic analogue of RSK insertion and Knuth equivalence relations was first introduced in 2006. The resulting K-Knuth equivalence relations on words and increasing tableaux on [n] has prompted investigation into the equivalence classes of tableaux arising from these relations. Of particular interest are the tableaux that are unique in their class, which we refer to as unique rectification targets (URTs). We give several new families of URTs and a bound on the length of intermediate words connecting two K-Knuth equivalent words.

**Gabriela Rodriguez, Universidad Metropolitana**
[A-26]*Hydrothermal Synthesis of MoS2 Catalyst Applying EDTA Acid in the HDS of Petrochemicals*

The metal dichalcogenide catalyst MoS2 has been a standard material employed in the petrochemical industry for hydrodesulfurization process. The new TMS generation has to be strong and selective enough to disassociate the sulfur and other pollutants from the liquid transportation fuels. In order to create this kind of catalysts two different protocols (Wet Chemistry and Reflux) were designed and followed. MoS2 had to be "promote" by adding Co(NO3)2 and Ni(NO3)2 to enhance the catalytic activity. EDTA acid was also added to impregnate solutions containing the Ni (or Co) and Mo precursors. This catalyst was submitted to X-Ray diffraction (XRD) and High resolution Transmission electron microscopy (HRTEM) for characterization of the phases presented. Also catalytic activity was measured in the Hydrodesulfurization of dibenzothiophene (HDS of DBT) reaction.

**Hayden Rudd, Furman University**
see **Kate Causey**

**Wendy Rummerfield, University of Redlands**
[B-25] *Touch-based Continuous Authentication*

Smartphone continuous authentication seeks to add a layer of defense beyond existing entry-point authentication systems. Most pre-existing research focuses on data gathered from the touch screen itself, such as the characteristics of tapping and swiping. However, the focus of this project discovering novel features from different sources, specifically, the device's motion sensors. I hypothesized that a person's heartbeat could be detected using the smartphone's built-in accelerometer, which could be utilized as a method to differentiate between users. After collecting data from an app created last year, I analyzed the data using an algorithm I wrote in Matlab to detect peaks in the acceleration signal that could correspond to heart beat. The algorithm also creates a feature vector to hold calculated statistics which will be used to create a template in order to compare different users.

**Megan Schill, University of California, Merced**
[A-27] *Modeling the Diffusion of Prion Aggregates in Budding Yeast*

Prions are misfolded proteins which self-propagate by converting native proteins to the aggregation-prone prion form. These prions cause fatal neurodegenerative diseases, collectively termed Transmissible Spongiform Encephalopathies. The devastating nature of these diseases has focused researchers on identifying prion propagation and transmission mechanisms. The prion transmission mechanism during cell division is not yet understood; our aim is to examine how an analogous process occurs in model organisms. In Saccharomyces cerevisiae the protein Sup35 adopts multiple prion conformations. Recent fluorescence and mathematical modeling studies have shown that differences in strain transmissibility depend primarily on aggregate size and not strain specific conformation. Based on prior experimental and modeling results, we quantify differences in diffusion between two prion strains, develop a diffusion model for transmission in budding yeast, and estimate the diffusion coefficient for Sup35 and prion aggregates.

**Kira Soderstrom, University of Southern California**
see **Anisha Pathak**

**Kimberly Stubbs, University of North Carolina at Asheville**
[B-26] *Dynamics of Co-Orbital Moons Near Collision*

This project is about celestial mechanics and dynamical systems. Specifically, the goal is to explore the techniques used in modern celestial mechanics to analyze near-collision dynamics and chaos. The model we're working with is a 3-body co-orbital system. Josep Cors and Glen Hall wrote a paper on 3-body co-orbital systems and determined when the moons will pass each other and/or change orbits. They were only interested in these two occurrences, and so they left out the dynamics of near-collision. We're interested in finding out what happens near collision of the two moons and have done the necessary change of variables to allow analysis of the dynamics and chaos. We'll look into the dynamics and what they mean for the entire system.

**Kristina Sundy, University of Central Oklahoma**
[A-28]*Determining the Optimal Placement of the Quarantine Specialist in the Board Game Pandemic*

In the board game Pandemic, players work cooperatively to treat and cure the global outbreak of four diseases. Each player has a unique role in the team and the optimal utilization of these roles is essential to success in the game. One possible role is that of the Quarantine Specialist. This player has the ability to prevent the spread of disease in the area of the board in which their player token is located. This research uses the technique of Integer Programming to find the optimal position on the board for the Quarantine Specialist for a given turn of the game. Constraints that need to be taken into account include the distance that the player can move in a single turn. As an objective, we minimize the expected number of new disease cases over the current round of the game. Extensive testing has verified the positive impact this technique has on the outcome of the game.

**Mariel Supina, The George Washington University**
[B-27] *The Power of Quantum Computing Algorithms*

Algorithms based on the properties of quantum physics can facilitate enormous computations that would be unthinkable on a classical computer. Analysis of quantum algorithms involves several areas of mathematics and computer science, including linear algebra, complex analysis, and computational complexity theory. Our goal is to analyze three famous quantum algorithms: the Deutsch-Jozsa algorithm, Grover's search algorithm, and Shor's factoring algorithm. Using techniques of algorithm analysis, we can calculate the time complexity of each quantum algorithm and compare it with the time complexity of its corresponding classical algorithm. Quantum algorithms are probabilistic, and from these comparisons, it will be clear that they run much faster than their classical counterparts. If a quantum computer that can harness the power of these algorithms is built, it will have a revolutionary impact on computing and our world.

**Christy Vaughn, Duke University**
[A-29]*Redistricting and the Will of the People*

In the 2012 election for the US House of Representatives, only four of North Carolina's thirteen congressional districts elected a democrat, despite a majority democratic vote. This raises the question of whether gerrymandering, the process of drawing districts to favor a political party, was employed. This study explores election outcomes under different choices of district boundaries. We represent North Carolina as a graph of voting tabulation districts. A districting is a division of this graph into thirteen connected subgraphs. We define a probability distribution on districtings that favors more compact districts with close to an equal population in each district. To sample from this distribution, we employ the Metropolis-Hastings algorithm in which samples are taken from a Markov Chain on the graph. After sampling, election data from the 2012 US House of Representatives election is used to determine how many representatives would have been elected for each party under the different districtings.

**Andrea Vazquez, Universidad Metropolitana**
[B-28]*A Comparison of Automated and Human Observations of Freezing Drizzle*

Freezing drizzle can lead to significant engine damage if not properly detected. While contract weather observers identify freezing drizzle using only visual observations,it is unclear how accurate they are when collecting that data. Automated Surface Observing Systems (ASOS) have B. F. Goodrich Ice Detectors that identify freezing rain, and NCAR scientists have developed an algorithm to identify freezing drizzle using said sensor. This resarch evaluates data that was collected visually and compares it to the data collected by automated sensors in order to assess the accuracy of manual measurements. The data chosen was from the years 2000 to 2009 for four ASOS stations using Goodrich Ice Detectors. The median annual hours were calculated for each site and compared against the results Cortinas et al,found. This study duplicated his technique, converting local time of the observation to Normalized Solar Time (NST). The results presented are a comparison of the automated measurements and the manual observations.

**Sarah Verros, Colorado School of Mines**
[A-30]*Long-term Crime Forecasting and Setting Crime Reduction Targets*

This project investigated methods of forecasting crime rates for use by the Los Angeles Police Department (LAPD) along time scales of months to years. The forecasting method currently used by the LAPD is a constant annual percentage decrease, which does not account for seasonality or other long-term trends within city-wide crime data and inhibits accurate performance evaluations. We developed several models to capture crime trends and forecast crime rates, such as long-term and seasonal decomposition and an annual distributional method. The accuracy of these methods were compared to real crime data and assessed using cumulative percentage error, mean squared error, and other statistics. After testing the developed methods, we determined that our annual distributional method was more accurate at crime forecasting than the method currently used.

**Racheal Ward, University of Montevallo**
[B-29]*Item Response Theory: Ability Estimates*

I will discuss the assumptions of Item Response Theory (IRT) and Classical Test Theory (CTT). I will compare the differences of Item Response Theory and Classical Test Theory in the areas of ability estimates and measurement error. I will also examine the results of a comparison of a assessment exam for a general education class.

**Emily White, Northern Arizona University**
see **Hannah Prawzinsky**

**Lauren White, California State University, Northridge**
[A-31]*The Igusa zeta Function of A Quadratic Form over The p-adic Integers*

Let $f(x_1, ldots, x_n)$ be a quadratic form over the $p$-adic integers, $\mathbf{Z}_p$, and $N_i(f)$ be the number of zeroes of $f$ modulo $p^i$. The Poincare series, $P(t) = sumlimits_{I \geq 0} fracN_i(f)p^{in}t^i$, is a power series that organizes zero counts. From the Poincare series one obtains the Igusa zeta function using the relation $Z(s) = p^s - (p^s - 1)P(p^{-s})$. For $s$ in the complex right half-plane, the Igusa zeta function is defined as $Z(s) = intlimits_{\mathbf{Z}_p^n} |f(x_1, x_2, ldots, x_n)|_p^s dx_1 ldots dx_n$, where $|cdot|_p$ is the $p$-adic absolute value and $dx_1 ldots dx_n$ is a volume element. We calculate the Poincare series and the Igusa Zeta function for an arbitrary quadratic form over the $p$-adic integers, $p$ an odd prime. After determining the number of zeroes modulo $p$ using generating functions, we use Hensel lifting to recursively calculate the Poincare series of $f$. This recursion stabilizes so that we may express $P(t)$ as a rational function.

**Rose Winter, St. Catherine University**
[A-32]*Fighting Fires on Random Threshold Graphs*

We constructed a random threshold graph by randomly assigning each vertex $v$ a weight $w(v) \in [0, 1]$, and adding an edge between vertices $u$ and $v$ if and only if $w(u) + w(v) > 1$. On this graph we played the firefighter game, modeling the spread of some condition, represented by fire, on a system represented by the graph. The objective was to save as many vertices as possible through the optimal placement of a limited supply of resources (firefighters). We proved a winning strategy for firefighter on random threshold graphs and found the probability distribution of the maximum number of saved vertices.

**Chunyi Zhao, Bowdoin College**
[B-30]*Social Network Analysis in a Bayesian Way*

This research aims to reveal the social topology of current Bowdoin student body by applying Bayesian statistic analysis on student dining information. With spatial-temporal data provided by the college, the research uses information of dining time and location. The core interest is to understand the parameters that shape the fundamental structure of a social network and therefore to see how individuals are clustered and connected in such network. Under Bayesian analysis, the likelihood is based on the concept of a Hidden Markov Model, where social clusters are unidentifiable stages only implied by individual IDs. Implementing Markov Chain Monte Carlo with the likelihood and proper priors leads to a thorough description of the posterior distribution, the probability of parameter given data, which accurately illustrates the social network's key parameters. The end goal is to map individuals according to their social clusters on a map and show potential clustering variations.