The Nineteenth Annual Nebraska Conference for Undergraduate Women in Mathematics

February 3 – 5, 2017

TALK AND POSTER ABSTRACTS

PLENARY TALKS

Dr. Ami Radunskaya
Professor of Mathematics
Pomona College, Claremont, CA
From music to mathematics to medicine: one woman's journey

I have always been fascinated by the relationship between pattern, prediction, order and disorder. Mathematics is the perfect language to describe the evolution of patterns, and music is a great way to listen to them. My first career as a musician led to a new career in mathematics, as I pursued patterns and prediction through the study of dynamical systems and ergodic theory. In more recent years, I have discovered that mathematical descriptions of physical processes can be used to address problems in medicine, such as understanding how cancer evolves, or developing treatment strategies. In this talk I will describe my own journey from musician to mathematician to modeler, highlighting this path with mathematical examples.

Dr. Brooke Shipley
Professor and Head of the Department of Mathematics, Statistics, and Computer Science
University of Illinois at Chicago
A Lincoln - Chicago round trip via algebraic topology

I will start in my hometown of Lincoln and then describe my education, my research in algebraic topology, my experiences with women in science programs, and my experience leading the department of mathematics at the University of Illinois at Chicago.

Talks by Undergraduate Students

Andrea Allen, Oberlin College
Chronology of Epidemics in Aggregated Temporal Networks

Epidemic propagation on temporal human contact networks is a developing area in network science. Typical approaches involve slicing time into snapshots aggregated over a time period. Given the adjacency matrices A & B for two snapshots of the same underlying network, it is difficult to tell to what extent an epidemic spreading process will obey the chronology of the network if the two snapshots are aggregated into one fixed network, A+B. The solution to a system of equations modeling a diffusion process on the adjacency matrix for a network can be found using the matrix exponential. The product of the matrix exponential for two noncommuting matrices yields an expression in terms of the aggregate A+B with an error term involving the commutator, AB-BA. We derive analytical measures to quantify the significance of the error term, and compare with measures of error from simulated epidemics on both temporal and aggregated versions of the network.

Stephanie Allen, State University of New York at Geneseo
Ye Ye, University of California, Los Angeles
Change-point Detection Methods for Body-Worn Video

Body-worn video (BWV) cameras are increasingly utilized by police departments to provide a record of police-public interactions. However, BWV deployment produces terabytes of data per week, necessitating the development of effective computational methods to identify changes in video. We present a novel two-stage framework for video change-point detection. First, we employ state-of-the-art machine learning methods including convolutional neural networks and support vector machines for scene classification. We then develop and compare change-point detection algorithms utilizing mean squared-error minimization, forecasting methods, hidden Markov models, and maximum likelihood estimation to identify noteworthy changes. We test our framework on detection of vehicle exits and entrances in a BWV data set provided by the Los Angeles Police Department and achieve over 90% recall and nearly 70% precision – demonstrating robustness to rapid scene changes, extreme luminance differences, and frequent camera occlusions.

Qingci An, University of Illinois at Urbana-Champaign
Knowledge Spaces: The Mathematics Behind Assessment and Learning

Knowledge spaces are mathematical objects that can be used to identify the knowledge state of students and that have been used in assessment and learning systems like ALEKS. In our project, we build a simple knowledge space and run simulations based on real-world data to investigate the knowledge state of an "average" student, a student at a given percentile, a class of students, and students from different years.

Bethany Baker, Coe College
Minimal Packings of Double Hexagon Tiles on Pseudo-Rectangular Boards

A packing is a tiling of a board such that there are no overlapping tiles and another tile cannot be placed. We examine minimal packings of double hexagon tiles on pseudo-rectangular boards and establish the smallest number of double hexagon tiles needed for a minimal packing of nearly all finite boards.

Caroline Bang, St. Cloud State University
A Class of Gnomons

A *gnomon* G is a geometric object that, when added to an object F, creates a new object that is similar to F. Rectangles with square gnomons, *golden rectangles*, are mathematically pleasing, giving rise to the fascinating golden number. This research looks at two generalizations of the golden rectangle - both in n-dimensions and in two dimensions as gnomon to n-gons whose side lengths are in geometric progression. As one moves into higher dimensions, we get more fascinating numbers. In two dimensions, we were able to fully classify isosceles gnomons to n-gons whose side lengths are in geometric progression.

Rachel Barnett, Rutgers University-New Brunswick
Rose Johnson-Leiva, Quest University Canada
Cutting up a Higher Dimensional Donut: 3-Torus Graph Embeddings

The study of combinatorial graph embeddings is a central focus of topological graph theory. One technique of determining the surfaces onto which a given combinatorial graph embeds is called Edmonds' Permutation Technique. This technique associates a cyclic ordering of the edges incident to each vertex in a combinatorial graph (called a rotation scheme) with a 2-cell embedding of the graph into a compact and orientable surface. When the genus (the "number of holes") of the surface is 1, we obtain a 2-torus embedding of the graph. Motivated by our desire to generalize Edmonds' method as a way to embed combinatorial graphs in higher-dimensional spaces (such as the 3-torus, a cube with opposite faces identified), we proposed a definition of a 3-cell graph embedding and subsequently discovered characteristics of such embeddings. Our talk will showcase our major result, namely that a combinatorial structure we have dubbed "the double cube graph" has a unique 3-torus embedding, up to automorphism.

Tasha Boland, Villanova University
Shantel Silva, Villanova University
New Metrics of Economic Inequality

The Gini coefficient is a well known metric used to study economic inequality in a population. We study a new metric proposed by Volpert and Jantzen (2012) to measure income inequality: a metric that considers both the low and high ends of the income spectrum, leading to two separate indices. Using Monte Carlo methods, we compare these indices to other metrics of economic inequality. By looking at the metrics applied to current data, we draw conclusions about the accuracy of these metrics and what they tell us about how inequality has changed over time.

Isabelle Butterfield, Seattle University
Comparisons Between Mathematical Models and Experiments of Waves on Deep Water

We have written MATLAB codes that solve a variety of partial differential equations (PDEs) that model the evolution of wave trains on deep water. We use these codes to compare the PDE predictions with data from physical experiments conducted by Diane Henderson at Penn State University. We use the cubic nonlinear Schrodinger (NLS) equation and a number of its generalizations including the Dysthe and viscous Dysthe systems as our base models. The codes solve these PDEs using operator splitting methods, and plot the predictions against the experimental data. Additional MATLAB codes compare the difference between each prediction and the experimental data to determine which PDE is best predicting the experimental behavior. In examining the first two sets of experimental data, we have found that the viscous Dysthe system does the best job modeling the experimental data in comparison to our selected generalizations of NLS, optimized over their free parameters.

Natalie Canuteson, William Jewell College
Calculating the Expected Number of Monochromatic Components in Graphs

Let G be a graph with n vertices, and let the probability of each vertex being colored one of r colors be $\frac{1}{r}$. A *monochromatic component* in G is a connected region of vertices that share the same color of maximal size. I will give formulas for the expected number of monochromatic components for trees, complete graphs, and cycles for an arbitrary number of colors, as well as formulas for wheels, certain broken wheels, and complete k-partite graphs using two colors.

Jacquelyn Combellick, Metropolitan State University of Denver
A Complete Eigensolution of the Multiple-Urn Ehrenfest Model

Originally developed to model diffusion, the Ehrenfest urn model can potentially be applied to many real-world situations, such as expected hitting times with respect to population migration. While the standard 2-urn model is fairly well understood, few studies have focused on models with more than 2 urns. In the multiple-urn model examined here, M balls are distributed amongst d containers, or "urns." At discrete time steps, a ball is selected at random and transferred to a different urn, with each of these urns having equal probability of receiving the ball. Although the premise is simple, examining the behavior of this system over time can be difficult, as this involves taking powers of large transition matrices. Here, a complete eigensolution of the multiple-urn Ehrenfest model is presented. This provides a means of diagonalizing the transition matrices and raising them to larger powers with comparative ease, making the model much more feasible as a tool for analyzing real-world situations.

Sarah Cooney, Saint Joseph's University
Maria Macaulay, St. Olaf College
Strong Accessibility: Forging a Link Between Accessible and Large Sets

A D-diffsequence is a sequence of positive integers where $x_i - x_{i-1} \in D$ for all $i \in [2, k]$. Then $\Delta(D, k; r)$ is the least positive integer where when $[1, \Delta(D, k; r)]$ is colored with r colors there is a monotone k-term D-diffsequence. D is called r-accessible if $\Delta(D, k; r) < \infty$ for all k and accessible if it's r-accessible for all $r \geq 1$. Largeness is defined equivalently for arithmetic progressions. Large and accessible sets have been found to have vastly different properties. Here we define and explore strong accessibility, a concept between accessibility and largeness. We call a D-diffsequence whose first three terms are in arithmetic progression a β-sequence. Then $\beta(D, k; r)$ and strong accessibility are equivalent to $\Delta(D, k; r)$ and accessibility. We will present results on strong accessibility on the sets $T = \{2^i \mid i \geq 0\}$, the Fibonacci Numbers, $\mathbb{Z}^+$, and $V_m = \{x \in \mathbb{Z}^+ \mid m \nmid x\}$.

Surabhi Desai, University of St Andrews
Snaking in Systems with Non-Orientable Manifolds

The Swift-Hohenberg equation

$$u_t = -(1 + \partial_x^2)^2 u - \mu u + \nu u^2 - u^3, \qquad x \in \mathbb{R}$$

is an example of a pattern-forming dynamical system. Previous work, which focused on localised roll patterns in the Swift-Hohenberg equation, involved the study of orientable invariant manifolds. Here we will look at more general systems which exhibit localised rolls with non-orientable invariant manifolds; more specifically, we investigate the effect this has on the characteristic snaking behaviour of the bifurcation diagrams and on the types of solutions produced. In this presentation, I will discuss the results obtained when considering the non-orientable case and, more generally, when looking at twisted manifolds.

Desiree Domini, Pacific Lutheran University
Devon Johnson, Pacific Lutheran University
Divisibility by Powers of 2 in Pascal's Triangle

A famous theorem of Kummer connects Pascal's Triangle to base-p arithmetic where p is prime. When $p = 2$, we utilize this result to determine the possible forms for the base-2 representations of the row numbers in Pascal's Triangle where no entries are divisible by a fixed power of 2. We then use our description to provide formulas for these row numbers, n, and use our formulas to describe the base-2^m representations of such n. Furthermore, we characterize all of the possible base-2^m representations of such row numbers. In doing so, we also introduce new connections between some interesting integer sequences and Pascal's Triangle.

Franciska Domokos, California State University, Sacramento
Jacobi-Type Triple Sums with an Explicit Evaluation Modulo Small Powers of Primes

Let p be an odd prime and $\chi_1, \cdots, \chi_s$ be mod p^m Dirichlet characters. We look at the sum of the form

$$J_s = \sum_{\substack{x_1=1 \\ A_1 x_1^{k_1} + \cdots + A_s x_s^{k_s} \equiv B \bmod p^m}}^{p^m} \cdots \sum_{x_s=1}^{p^m} \chi_1(x_1) \cdots \chi_s(x_s)$$

where B is an integer, $p \nmid A_1 \cdots A_s$ and the integers t and n are defined by

$$p^n \mid\mid B \text{ and } t = \max_i\{t_i\} \text{ where } p^{t_i} \mid\mid k_i,\ i = 1, \cdots, s.$$

This sum was previously evaluated by Alsulmi, Pigno, & Pinner when $2t + n + 2 \leq m$. In this project, we looked at a smaller range of m where $t + n + 1 < m \leq 2t + n + 2$ and used the Cochrane-Zheng Reduction Method and power detecting character sums to explicitly evaluate J_2 and J_3. We are exploring using these methods to evaluate J_s within this smaller range of m.

Alisa Ediger, Tabor College
Jennifer Moon, Grand Valley State University
Lyndsey Wong, University of La Verne
Expansions on "A Game of Edge Removal on Graphs"

A Game of Edge Removal on Graphs (Gallant et al.) is revisited and expanded upon in the context of the original game and variations on the game. Variations include a game of vertex removal and a game of mixed removal. These games are analyzed to reveal patterns and properties of graphs. Furthermore, the resulting nim-sequences of games are explored, including charts of graph classes and their associated nim-value.

Camille Felton, University of Wisconsin-Platteville
A Radically Simple State Sum Invariant for Complex n-manifolds

A statistical mechanical model is defined on an oriented compact n-manifold equipped with a vertex ordered triangulation. State variables are located on edges and the analog of Boltzmann weights are assigned to top dimensional simplexes according to the Ansatz $\prod f(\lambda(xy))^{\epsilon_{xy}}$ where f is a complex valued function on the edge states. The powers ϵ_{xy} depend only on the position of the edge within the ordered simplex and the combinatorial orientation of the simplex relative to the ambient orientation. Conditions are determined for which the resulting partition function is invariant under Pachner moves, thereby determining an invariant of PL manifolds. Instances of such invariants can differentiate between S^3, $S^2 \times S^1$ and the lens space $L(5, 2)$. This work was supported by NSF Grant DMS#1262877.

Melissa Flynn, University of Mississippi
Dual Hamiltonian Graph Classes

A graph is Hamiltonian if there is a cycle containing every vertex. This cycle is a cycle with maximum possible size. A connected graph is Dual Hamiltonian if there is a bond with largest possible size $|E| - |V| + 2$, where $|E|$ is the total number of edges and $|V|$ is the total number of vertices. We will present results on the largest bond problem for several classes of 3-connected graphs such as the planar graphs, the complete bipartite graphs, the generalized Petersen Graphs, and a few cases of the hypercube as part of an undergraduate senior thesis research project.

Selina Foster, Westminster College
Hexagonal Mosaic Knots

In their 2008 paper, Quantum Knots and Mosaics, Lomonaco and Kauffman introduce mosaic knots on square tilings of the plane. This paper generalizes the tiles, terms, and theorems from square tilings to hexagonal tilings. Additionally, we develop further constructions with properties unique to hexagonal mosaic knots, including minimal hextile number and algebraic saturation diagrams.

Myra Garlid, University of Minnesota Duluth
Sarah Stark, University of Minnesota Duluth
Quasi-Crowns

Our goal is to survey a few questions related to partially ordered sets, specifically crowns and quasi-crowns.Trotter defined a specific poset, called a crown, in 1974. In 2014, Garcia and Silva defined a layered crown by gluing two identical crowns together, one atop the other. We consider gluing two nonidentical crowns atop each other and explore the properties of the resulting quasi-crown.

Catherine Godfrey, University of Houston
A Voting Method for Multiple Candidates

In elections with two candidates it is common to use majority rule, a voting method in which the candidate who receives the most votes wins. Elections with three or more candidates are substantially more complicated, and it has been proven that there are no voting methods satisfying all the fairness conditions that one would like to impose. Consequently, in elections with multiple candidates, different voting methods are used depending on which fairness criteria are most relevant in a given situation. In this talk we introduce a new voting method for elections with multiple candidates in which the winner is determined by minimizing collected voter unhappiness. We consider several properties of this new voting method and examine situations for which this method is appropriate.

Marcela Gutierrez, Northern Arizona University
Courtney Schmitt, Northern Arizona University
Infinite Trees of Primitive Pythagorean Quadruples

A primitive Pythagorean triple is a 3-tuple of natural numbers sharing no nontrivial common factors that satisfies the Pythagorean Theorem. Hall (1970) and Price (2008) found distinct perfect infinite ternary trees whose vertex sets are precisely all primitive Pythagorean triples. This talk will present progress toward the construction of an infinite tree whose vertex set consists of all primitive Pythagorean quadruples - i.e; 4-tuples (a, b, c, d) of natural numbers sharing no nontrivial common factors that satisfy $a^2 + b^2 + c^2 = d^2$.

Shana Havenridge, Doane University
Modeling the BZ Reaction with Ordinary Differential Equations

This research demonstrates the kinetics of the Belousov-Zhabotinskii (BZ) reaction in a closed vessel in the presence of a ferroin indicator. By analyzing the underlying chemical kinetics of the important compounds in this ten step reaction, a 4×4 system of nonlinear ordinary differential equations is created. The system is then nondimensionalized and reduced into a system with less parameters. The system is then solved numerically using initial concentrations and rate constants. Finally, the model is compared with experimental results by analyzing the reaction oscillations in the phase plane. Based off of methods in Casey Gray's analysis of the BZ reaction, the purpose of this research is to identify if different reaction recipes yield the same set of system parameter values.

Michelle Haver, Ohio Northern University
Kathleen Lee, Whittier College
Classification of numerical sequences originating from recursive polynomial sequences

In this talk, we classify the asymptotic behavior of sequences which can be generated from polynomials which satisfy the recurrence relation:

$$\begin{cases} M_n(x,y) = xM_{n-1}(x,y) + yM_{n-2}(x,y) \quad n \geq 2 \\ M_0 = a \\ M_1 = bx + cy + d \end{cases}$$

We classify and discuss subtle behaviors on the boundary such as periodicity and convergence to a constant, as well as the behavior inside the triangle. Moreover, we present a finite sum expression for M_n, which can be used to generate sequences that we interpret combinatorically. One example is

$$\sum_{k=0}^{\lfloor \frac{n+1}{2} \rfloor} \left[\binom{n-k}{k} + (w-1)\binom{n-k-1}{k} \right] w^k (w-1)^k = w^n \tag{1}$$

Finally, we explain how the first derivative of M_n with respect to y under certain conditions generates sequences that are typically found by convolution of two numerical sequences.

Heather Heier, Kansas State University
Modulus of Spanning Trees and Epidemic Spreading

Modern mathematical treatments of epidemics involve building a realistic contact network to model the interactions of individuals. In these networks, individuals within the population are modeled as point nodes in space, with edges connecting two nodes if the two associated individuals have regular contact with each other. The disease is assumed to spread only through contact, and thus only along edges in the network. In an epidemic breakout, wherein every node becomes infected, it is possible to trace a unique path of the infection back from each node to the initially infected source. Mathematically, this observation gives rise to a rooted spanning tree on the graph.

The p-modulus is a very general tool for analyzing networks. When applied to a spanning tree, it appears to give a measure of how influential a given node is with respect to the tree pathways. We explore the interconnection between modulus and epidemic spreading.

Tiffany Jann, University of California, Berkeley
Reverse Engineering Functional Brain Networks from fMRI Data Using Probabilistic Boolean Networks

The brain functions by communicating information across regions, so to characterize neurological disorders and eventually propose systematic approaches to diagnosis, we study the brain as a system and consider both its structure and dynamics. We proposed a pipeline to reverse engineer static and dynamic functional brain networks from fMRI data. Using probabilistic Boolean networks (PBNs) as our mathematical framework, our pipeline iterates through several steps. Using fMRI data generated from in silico networks, we validated steps 1-2. In step 1, reverse engineering static functional brain network from fMRI data, we applied 44 reverse engineering methods and proposed a way to combine top-performing methods such that the result outperformed any individual method. In step 2, Booleanizing fMRI data, we proposed a metric to benchmark and rank discretization methods. In step 3, inferring dynamical models, our preliminary studies supported results from step 2. Future work will focus on validating dynamic models.

Devon Johnson, Pacific Lutheran University
see **Desiree Domini**

Rose Johnson-Leiva, Quest University Canada
see **Rachel Barnett**

Mackenzie Jones, University of Akron
Simulating Chlorophyll Concentration and Forecasting Algae Blooms

In Wisconsin, the lakes tend to get a lot of phosphorus run-off from farms, so the lakes are polluted and have bad algae blooms in the summer. To help them understand and prevent the blooms, I worked on mathematical models for forecasting algae population and finding the conditions under which blooming occurs. The forecasting model uses Monte Carlo simulations on an ordinary differential equation to predict how long after a large flushing event it takes for the lake to turn green and smelly from excess biomass if there's no rain. The blooming condition was found by solving a parabolic partial differential equation that describes algae growth and movement. This model was solved both analytically and numerically using pseudo-spectral methods. These models can take proposed solutions to fix the lakes and test their effectiveness before expensive policy plans are put into place.

Brianna Kozemzak, Saint Mary's College, Notre Dame
A Mathematical Model for Copper Homeostasis in Pseudomonas aeruginosa

Copper is a necessary cofactor in many biochemical reactions, but it becomes toxic to cells when present in high levels. We constructed a compartmental model for copper homeostasis using a system of ODEs that describes the changes in amounts of cuproproteins in P. aeruginosa, a bacterium responsible for thousands of healthcare acquired infections in the U.S. annually. A complete model of this system could aid in the development of new antibiotics that target cuproproteins. We performed a systematic comparison of combinations of global and local parameter estimation algorithms to approximate kinetic parameters and protein concentrations in our model. We were able to sufficiently fit the model to data by invoking up-regulation of certain proteins. There is evidence that some parameters are highly interdependent, but measurement of some protein levels could address this issue. These results will help our collaborators design experiments that produce the most crucial information for expanding our current model.

Courtney Kunselman, United States Air Force Academy
Approximating Roots of Polynomials by Modifying an Ancient Diophantine Technique

Theon's Ladder is an ancient technique that was used to approximate irrational numbers with rational numbers. In this talk, we will be examining modifications to this technique which allow the ladder to approximate the roots of polynomial functions.

Kathleen Lee, Whittier College
see **Michelle Haver**

Aixin Li, Denison University
The Monty Hall Problem Classical and Quantum

In the classical standard scheme, the player maximizes the chance of winning at 2/3rd by choosing the fixed strategy of always switching after the first reveal. Information and uncertainty are technical terms that describe any process that can be used to analyze the selection of one or more objects from a set of objects. Suppose we have a device that can produce 3 symbols, A, B, or C. As we wait for the next symbol, we are uncertain as to which symbol it will produce. Once a symbol appears and we see it, our uncertainty decreases; that is, we have received some information. In this case, information is a decrease in uncertainty. This notion of information is formalized and deepened in the theory of Shannon information. We show how information can be used to analyze both the classical and quantum versions of the Monty Hall game by using the quantum circuit. We have developed the quantum circuit to analyze the Monty Hall game in quantum and classical ways.

Sichen Li, Pennsylvania State University
ODE and PDE Models for Traffic Flow

We study differential-equation models simulating cars traveling along a road. We first simulate the situation from a microcosmic aspect using an ordinary differential equation (ODE) model, and then we simulate the situation using a macroscopic partial differential equation (PDE) model. In the ODE model, we look at the pattern of movement of individual cars by defining a speed function and thus generating an ODE model describing the behaviors. We simulate the basic case and cases with extra conditions, including traffic light, road block, etc. In the PDE models, the density is the unknown variable, and we use the conservation law to predict changes of density along the road with time. We explore connections between the two models through numerical computation. We use numerical methods such as Runge-Kutta solver for ODE and Lax-Friedrichs and Godunov methods for the conservation law. The results show conformity between the two methods and are indicative of real life situations.

Maria Macaulay, St. Olaf College
see **Sarah Cooney**

Alexandria Medeck, Northern Arizona University
A Game of Chance Inspired by Othello

Inspired by the board game Othello, consider a one-player game of chance on a 4 by 8 board where the new twist on the game includes choosing your color disk, white or black, and the objective is to get four disks of the chosen color in a line. The more lines you complete, the more “money” you win. Consider a mathematical generalization, representing the game board by an r by c matrix, $r \leq c$. Each entry in the matrix is an independent Bernoulli random variable (*i.e.*, either 1 or 0 with probability p and $1 - p$ respectively). The result is a random matrix. Associated with each possible matrix outcome is a score based on the number of completed vertical and diagonal lines of r ones in the matrix. My research is focused on determining the probability distribution of the score as a function of r and c. I will present results concerning the probability structure of the game.

Jennifer Moon, Grand Valley State University
see **Alisa Ediger**

Samantha Moore, University of Northern Colorado
Predicting Network Connectivity Based on Neural Connections

Many networks in the brain exhibit internally-generated dynamics (patterned activity that does not reflect changes in external stimuli, but rather is generated intrinsically by the network itself). The source of this internally-generated activity is not well understood, but explanations range from single-cell properties, such as intrinsically oscillatory neurons, to network-level properties such as complex network connectivity. Past models and explanations of such behaviors have involved a variety of complex ingredients making the models mathematically intractable. We will focus on a new minimal model with simple threshold-linear neurons and two-valued synapses whose dynamics are driven solely by an underlying directed connectivity graph. This model is simple enough to be mathematically tractable, and yet captures the full variety of internally-generated behaviors. Through this model, we isolate the role that connectivity plays to address the question of how neural connectivity shapes network dynamics.

Angelique Morvant, Texas A&M University
Extensions of the Link Smoothing Game

The Parity Link Smoothing Game was introduced by Henrich and Johnson in the paper The Link Smoothing Game (2013). In this game, players take turns smoothing the precrossings of a link shadow diagram of a knot, resulting in a final diagram with some number of disjoint links. One player's goal is to resolve the shadow into an even number of components, and the other player's goal is to resolve it into an odd number. We investigate whether or not the Parity Link Smoothing Game is balanced (meaning that both players have an equal number of winning outcomes) and determine which player has a winning strategy on a given diagram. In addition, we explore the possibility of creating a balanced game for more than two players.

Sara Myers, University of Scranton
A Graph-Theoretic Approach to Predicting the NFL Playoff Results

Every year, people across the country will hedge their bets on which NFL team will win the Super Bowl, often using less-than-perfect methods. Can we use mathematics to increase the accuracy of predictions? In this project, we create directed graphs to represent game results from the first 12 weeks of the NFL season. Then, we build a matrix representation of the graphs and apply the Floyd-Warshall algorithm to the matrix to determine the path length from each vertex to each other vertex; taking the mean gives us the average path length. Time permitting, we will also look at the size of the subset for each team containing those teams to whom they have an edge. This integrated approach allows us to account for both strength of schedule through considering the path length and strength relative to the rest of the field through considering subset size when trying to mathematically predict the results of the NFL Playoffs.

Shriya Nagpal, Trinity College
Domination In the Hierarchical Product and Vizing's Conjecture

Given a graph G, a set $S \subseteq V(G)$ is a dominating set of G if every vertex of G is either in S or adjacent to a vertex in S. The domination number of G, denoted $\gamma(G)$, is the minimum cardinality of a dominating set of G. Vizing conjectured in 1968 that $\gamma(G \Box H) \geq \gamma(G)\gamma(H)$ where $G \Box H$ represents the Cartesian product of G and H. In 1995, Hartnell et al. identify a class of graphs, called Type χ graphs, for which the conjecture is true. We identify another class of graphs for which the conjecture holds. We also study domination in the hierarchical product $G \sqcap H$, which is a generalization of the Cartesian product, and give lower bounds on $\gamma(G \sqcap H)$ that show a trend to Vizing's conjecture.

Sarah Petersen, Hope College
Modeling Pioneer Plant Populations in the Monteverde Cloud Forest

The pioneer plants that colonize forest canopy gaps require high light conditions for germination and eventual reproduction. The light environment, which changes rapidly as a gap ages, is dependent on the initial size of the gap. To persist and take advantage of new gaps, a pioneer plant must have a large presence in the seed bank and grow rapidly. We investigate questions related to gap formation dynamics and gap-size dependent plant demography within the context of over thirty years of field data from the cloud forest of Monteverde, Costa Rica. The resulting empirical models will be used to understand the spatial interactions between forest gap dynamics, avian dispersal of seeds, and plant demography. We will discuss some of the initial gap size - demography relationships that we have found, as well as a method for estimating the distribution of canopy gaps of a particular size across the whole forest given the occurrences of gaps along a transect, a generalization of Buffon's needle problem.

Karen Reed, Mount Holyoke College
The Discrete Exponential Function Modulo Prime Powers and Other Related Problems

In my research, I explore the Discrete Self-Power Map $x- > x^x$, and the generalized Discrete Exponential Function. These functions prove useful for various cryptological applications, including Digital Signature Schemes (DSS). This research will count the number of collisions of the self-power map for p=2, as well as the number of fixed points of the generalized DEF, modulo powers of a prime, for a specific range of values. That is to say, we will count the pairs (a,h) such that a^a is congruent to $h^h \mod (p^e)$ when p=2 and $1 \leq a, h \leq p^e(p-1)$, and count solutions for x such that $g^{[f(x)]}$ is congruent to $x \mod (p^e)$ when $1 \leq x \leq p^e(p-1)$. In addition, we will discuss a more difficult problem concerning an alteration of the self-power map and its collisions. Because we are working with primes and their powers, several p-adic methods have proved useful, including p-adic interpolation, Hensel's Lemma, and the Chinese Remainder Theorem.

Anna Schenfisch, University of Wyoming
Turan numbers of vertex-disjoint cliques in r-partite graphs

For two graphs G and H, the Turn number $ex(G, H)$ is the maximum number of edges in a subgraph of G that contains no copy of H. In 2009, Chen, Li, and Tu determined the Turn numbers $ex(K_{m,n}, kK_2)$ for all $k \geq 1$. In this talk, we will show how we determined the Turn numbers $ex(K_{a_1,\ldots a_r}, kK_r)$ for all $r \geq 3$ and $k \geq 1$.

Courtney Schmitt, Northern Arizona University
see **Marcela Gutierrez**

Shantel Silva, Villanova University
see **Tasha Boland**

Kallie Simpson, Slippery Rock University
Analyzing Underlying Structures of Pedagogical Methods

Flipped teaching is gaining popularity as a new teaching pedagogy and it is imperative that we have information from quantitative analysis to better understand the advantages/disadvantages of flipped teaching. Flipped learning is defined by flippedlearning.org to be a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, learning environment.... The work presented here is a continuation of previous research in which we increased the sample size to overcome limitations. The purpose of our study is to perform statistical, and more specifically, cluster analysis on the final grades from students that took Statistics 1, taught in both classroom settings by one professor at SRU, to identify clusters that might give insight into the pedagogies. The data collection took place from 2013 to 2016. This project focuses on Hierarchical and K-Means Clustering through the use of R software.

Rebecca Sorsen, University of Nebraska-Lincoln
Splitting Numbers of 10-Crossing Links

The splitting number of a link, L, is the minimum number of between-component crossing changes required to produce a completely split link. All splitting numbers of links with nine or fewer crossing were known prior to this research, so we were interested in links with 10 crossings. We explored five different methods, each increasingly more difficult than the last, to uncover the splitting numbers of all 287 10-crossing links.

Sarah Stark, University of Minnesota Duluth
see **Myra Garlid**

Jessica Steidle, State University of New York at Geneseo
Modelling a Freeform Surface for Illuminating Mark Rothko's Green on Blue

Lighting conditions are a major concern in the art world. Poor lighting can distract viewers, alter the emotional impact of art, and even cause permanent damage. The proposed solution is to illuminate a painting with an optical system designed to create a uniform spatial distribution of light. Freeform optics have more degrees of freedom and so can be used to solve complicated lighting problems such as this, but are challenging to design and manufacture. The optical design software LightTools can generate a point cloud representation of the required freeform surface assuming a point source. Zernike, Chebyshev, and Legendre polynomials, as well as monomials, were used to create a variety of polynomial representations of this surface in MATLAB. These representations were then evaluated by the quality of their fit to the point cloud as well as by the resulting spatial distributions of light. This will ideally lead to the manufacturing and testing of this system for use in The University of Arizona Museum of Art.

Meghan Stuart, University of Tennessee
Ballast Cleaning Scheduling Optimization

CSX Corporation is one of the nation's leading railway transportation suppliers. Since track is one of the most valuable assets at railway industries, a large part of CSX annual expenses results from track upkeep and repair work, including track-ballast cleaning. Having clean ballast prevents damage to ties, supports and holds the ties in place, facilitates water drainage, and reduces vegetation around railways. Ballast cleaner's routes are normally scheduled manually due to frequent changes in the planned route with constraints such as geography, weather, types of track, cleaner speed, cleaner working hours, repair work on portions of track, and union furlough activity. In this presentation, we describe an algorithm to schedule optimized ballast-cleaner routes, completing all high priority jobs in minimum time. The algorithm is based on a modified version of a traveling salesman solution algorithm that takes as input a list of jobs with priorities, regions with curfew, and other relevant scheduling data, and outputs a near-optimal route for the following year. The algorithm is configurable and dynamic to change as conditions and constraints are altered.

Kaitlin Tademy, Sam Houston State University
A New Polynomial Invariant for Unoriented Links

The Jones Polynomial is a Laurent polynomial invariant that distinguishes knots and links of various orientations. However, links of the same components with different orientations have different Jones Polynomials. I will be discussing a new polynomial invariant my collaborators and I have created to alleviate this problem. We call this polynomial the U-Polynomial. I will also discuss some properties of the U-Polynomial, using established properties of the Jones Polynomial as a basis.

Libby Taylor, Georgia Institute of Technology
Kasteleyn Cokernels and Perfect Matchings on a Planar Bipartite Graph

The Kasteleyn cokernel of a planar bipartite graph is a quotient group consisting of integer linear combinations of its vertices modulo its signed bipartite adjacency matrix. In this result, we describe the relationship between the Kasteleyn cokernel of a graph and its set of perfect matchings. In a special subclass of planar bipartite graphs introduced by Kenyon, Propp, and Wilson, we present an elegant algorithm producing a bijection between these two objects.

Lillian Webster, Grinnell College
Small Graphs with Generalized Quaternion Automorphism Group

For a finite group G, the value $\alpha(G)$ denotes the minimum number of vertices of a graph Γ such that Aut $\Gamma \cong G$. Given an integer m, $e(G, m)$ denotes the minimum number of edges of a graph Γ on m vertices such that Aut $\Gamma \cong G$. We investigated edge minimal graphs with automorphism group isomorphic to the generalized quaternion group Q_{2^n}. It has been previously shown that $e(Q_{2^n}, \alpha(Q_{2^n}) = 2^{n+2}$ for $n \geq 4$ and $e(Q_8, \alpha(Q_8)) = 44$. In our research, we determined the value of $e(Q_{2^n}, m)$ for $m = \alpha(Q_{2^n}) + k$ where $k \leq 3$. In the special case of $n = 3$, we also determined the value of $e(Q_8, \alpha(Q_8) + 4)$.

Carrie Wintle, University of South Dakota
Mathematical Modeling in Cheerleading

We provide a mathematical model for one of the most complex cheerleading stunts, the back tuck basket toss. The mathematical model starts by analyzing a two-link figure with a joint at the hips. Each link has a specified length, coupled with an individual mass. The model assumes that the mass of each link is centrally located as a single point and that the head and feet remain stationary. The entire figure will rotate about a center of mass. Maple was utilized to do the calculations and visualize the mathematical model, depicting the movement through time. The model is expanded by adding more links and joints that resemble a realistic human body, while analyzing a real basket toss to make the model as accurate as possible.

Jenna Wise, Youngstown State University
Determining Developer Debugging Behavior from Eye Gazes

Eye tracking equipment is being used to understand how software developers work by providing further insight into what a developer is looking at in source code. Eye trackers have become a popular biometric tool for researchers studying program comprehension. We analyzed an existing eye tracking dataset using TraMineR, an open source R package. The goal is to determine common eye gaze patterns among the different participants and learn about the debugging behavior of experts vs. novices. TraMineR is used for mining, describing and visualizing sequences of states or events, and more generally discrete sequence data. In this talk, we present the results and implications of our analysis and the mathematical details of the routines used in our analysis.

Lyndsey Wong, University of La Verne
see **Alisa Ediger**

Ana Wright, Willamette University
Renjun Zhu, University of California, Berkeley
Mixing Times for the Generalized Rook's Walk

Our work focuses on using path coupling, a powerful probabilistic tool, to find bounds on the mixing times of a class of Markov chains. The mixing time of a Markov chain measures the rate of convergence to its stationary distribution. This mixing time is of interest for sampling and simulations of random processes. The Markov chains we are investigating are restrictions on the random rook's walk on a d dimensional chessboard, which can also be considered random walks on the Cartesian powers of certain groups of circulant graphs. We prove bounds on the mixing times of these Markov chains, extending and generalizing previous results for the unrestricted case of the rook's walk.

Ye Ye, University of California, Los Angeles
see **Stephanie Allen**

Renjun Zhu, University of California, Berkeley
see **Ana Wright**

Posters by Undergraduate Students
Session A

Izabel Aguiar, Colorado School of Mines
Jacqueline Feuerborn, Colorado School of Mines
The Mathematics of Gossip

In this project we develop a numerical model to investigate the spread of rumours, lies, and gossip throughout a community using a susceptible-infected-recovered (SIR) dynamical system. We employ the model to study parameter dependence and system properties using computational methods for differential equations.

Cherlyse Alexander-Reid, College at Brockport, State University of New York
How Much Cream Cheese Can One Have on a Bagel

If we cut the bagel with a knife revolving about the circular axis of the bagel we divide it into two intertwined Mobius like surfaces as well as one continuous surface. We will show how big is the area of the cut in this case compared to the one obtained in the usual way to slice the bagel. It is hard to describe these surfaces in words but they can be seen at https://www.youtube.com/watch?v=SArmcV8XyFY. In each case we will find a parametrization of the cut and use it to compute its area.

Emilia Alvarez, Concordia University
Every Convergent Series has an Absolutely Convergent Regrouping

The reader is likely familiar with the terms conditional convergence and absolute convergence as they apply to infinite series, which will be reviewed briefly. This result demonstrates how any conditionally convergent infinite series can be regrouped to form an absolutely convergent series. The result holds for any series, and can be expanded to series of functions under certain conditions.

Wyatt Ashby, Denison University
Patterns of Dyck Paths

A Dyck Path is a sequence of moves of one unit on a graph in the North or East direction. This path travels n moves in the first quadrant above the $y = x$ line from the $(0, 0)$ location up to (n, n). In a paper, Haglund proposed that there exists a bijection between two multisets of a Dyck path. In order to further examine this bijection, we observed patterns that occur between the two multisets when the length and area are fixed. Furthermore, by studying and understanding these patterns, we are able to predict the two multisets for any Dyck Path of any length and any area.

Stacie Baumann, West Virginia Wesleyan College
Completing Partial Latin Squares Arising from Latin Arrays

Completing partial Latin squares has been studied since the 1940s. Recently, Kuhl and Schroeder looked at a specific problem where an $r \times r$ Latin array A is copied n times down the diagonal of a blank array. Call this partial Latin square nA. In 2015, they proved that if $n > r$, then nA is completable for any $r \times r$ Latin array A, and if $n < r$, there exists an $r \times r$ Latin array A such that nA is not completable. They failed to resolve the case when $n = r$. At the Summer 2016 Marshall University REU, we improved upon their techniques. In this work, we show that rA is completable for every $r \times r$ Latin array A.

Emma Bayless, Washburn University
Hannah Johnson, Washburn University
Rankings and Salaries

Our team is interested in comparing salary distribution between categories of employees at Washburn University. The data is compared with the ranking of Washburn University over the same time period. Our goal was to find any correlations, trends, or connections between the categorical salary data and the university ranking. We became interested in the formula of the US News and World Report ranking and how each part of it correlated with the salary data. We will present some of the connections between these statistics that our data yielded.

Madeline Boster, Denison University
Fault Tolerance in Autonomous Systems

With the rapid growth of autonomous systems comes a corresponding increase in faults and thus, a greater urgency to mask these faults. We wanted to take fault tolerant mechanisms previously researched in regular systems and extend their application by studying and implementing them in the autonomous system environment. Two of these mechanisms are primary-backup and state machine, in which servers are replicated and then communicate according to protocol. In primary-backup, one of the replicated servers is designated to interact with the environment until it encounters failure and another replica takes over; in state machine, all replicas interact with the environment to mask failure. Challenges in our work included implementing low-level communication between servers to prevent reordering and loss of messages, and transforming non-fault tolerant code into fault tolerant form within the control program. We successfully implemented these protocols on an application in which two joysticks control a robotic arm.

Samantha Brooker, University of Denver
Finite-Dimensional Quantum Metric Spaces

According to K. Aguilar and F. Latrémolière, approximately finite-dimensional C*-algebras (AF algebras) can be endowed with a quantum metric, which then allows one to prove that AF algebras are limits of finite-dimensional quantum metric spaces for a noncommutative version of the Gromov-Hausdorff distance, named the quantum Gromov-Hausdorff propinquity. Our research concerns the geometry, for the quantum Gromov-Hausdorff propinquity, of the class of these finite-dimensional quantum metric spaces. We have established thus far that several of these spaces are not isometric, in the sense of quantum metrics. The examples that we have studied are described via full matrix algebras endowed with various quantum metrics, and we prove that no automorphism of the full matrix algebra can carry one quantum metric to another. We hope that our work is a first step in establishing lower bounds on the propinquity between these finite-dimensional quantum metric spaces, which in general are difficult to establish.

Sterling Campbell, Alfred University
Discrete Morse Theory for Medial Subdivision

This talk is based on research complete this summer during an REU at Sam Houston State University. The research was done in the field of discrete Morse Theory, which is a field of mathematics related to topology. The research uses ideas and theories both from topology and discrete Morse Theory. More specifically, the talk is about applying discrete Morse Theory to Medial Subdivisions.

Rosemary Carroll, University of Wisconsin-Platteville
Quivers and Representation Theory With Linear Algebra

A quiver is a collection of points and arrows between these points. A quiver representation is an assignment of vector spaces to the points, and matrices to the arrows, which act as linear maps between the vector spaces at the points. We can create maps between two representations of the same quiver. Using some of these maps (the invertible ones) we can transform a representation into one that can be broken down into the most basic representations, called the indecomposable representations, for this quiver. There are some well-behaved quivers which have only finitely many indecomposable representations. For a specific family of these quivers, we demonstrated how to break the representations up into the indecomposable representations of these quivers using only the most elementary tools from linear algebra.

Emily Castner, Mount Holyoke College
A distance-based method for phylogenetic tree reconstruction using algebraic geometry

Using algebraic geometry and optimization software, we present a new method for phylogenetic quartet reconstruction. Representing tree topologies as varieties and genetic data as points, we determine how well the data fits a Markov model on the associated tree topology by minimizing the distance from the point to the variety. We implement this for the heterogeneous Jukes-Cantor, Kimura 2- and 3-parameter, and general Markov models of evolution. The Kimura 3-parameter model is most accurate on data simulated under the same model. We see that the Jukes-Cantor model is almost as accurate, even with model misspecification on all data, and is by far the fastest.

Ariana Cavazos, California State University, Fresno
Association Between Initial Treatment and Subsequent Primaries in Hodgkin's Lymphoma Patients

Hodgkin's Lymphoma (HL) is a type of cancer that affects the lymphatic system and compromises the human body's ability to fight infection. HL typically begins in white blood cells. It occurs when a specific type of cell, the Reed-Stenberg cell, is present in the host's system, causing the body's infection fighting cells to develop a mutation. Each year, there are several thousand individuals in the U.S. and worldwide who develop HL. It has been hypothesized that initial treatment after diagnosis may be associated with subsequent recurrence. We explore this association using the Oncology Registry at the University of Iowa. Using an adaptation of the Cox regression, we have found a significant effect of initial treatment on the hazard of recurrence, with Radiation Therapy most likely to significantly increase this hazard. Other prognostic factors such as Age and Gender have significant effect as well. In our findings, we adjusted for subsequent treatments following secondary primaries.

Sarah Childs, Northeastern University
Elliptic Curves over the Complex Field

During my Research Capstone class taught by Anthony Iarrobino, I had the wonderful opportunity to create a base understanding of elliptic curves over any field. I began with an introduction to projective space and projective curves. I studied the Group Law of Elliptic Curves and was able to algebraically describe the points and the relationship between rational points on an elliptic curve. I studied the properties of torsion points of order two and three on elliptic curves, and was able to prove important characteristics of these torsion points on elliptic curves.

Kayla Cummings, Pomona College
Bounding Integer Roots of Certain SPS-Polynomials: A p-adic Approach

An SPS-polynomial is a polynomial expressible as a sum of products of sparse univariate polynomials. SPS-polynomials are closely related to depth-4 arithmetic circuits (of recent interest in complexity theory), and Koiran has shown earlier that new lower bounds for the complexity of the permanent hold if SPS-polynomials of low complexity have few integer roots. Some effort has been made toward bounding the number of real roots of SPS-polynomials, but bounding the number of integer roots still appears out of reach. Bounding p-adic valuations of the integer roots is a potentially promising, alternative approach that has yet to be explored. We show that an upper bound for the number of p-adic valuations, in line with Koiran's conjectures, can be proven for a particular family of SPS-polynomials.

Yaqi Dai, Texas A&M University
Relative monotonicity of secular determinants of quantum graphs

Eigenvalues of a quantum graph with standard vertex conditions can be found as roots of a real-valued function, the so-called secular determinant. In certain cases, this function has positive derivative, except at the location of its poles. This monotonicity significantly simplifies numerical calculation, as there is precisely one root between each pair of consecutive simple poles. We conjecture that one can always achieve this effect by dividing the secular function of a given graph by the secular function of its modification. We have tested this conjecture numerically and proved an analogous result in the case of matrices, paving the way for the proof in the case of quantum graphs.

Alexandra Doxey, Furman University
Signing Away Your Time: Using Statistics to Estimate Wait Time for Disney Characters

Hundreds of thousands of people pass through the Walt Disney World theme parks every day. This can mean long lines for families waiting to meet their beloved Disney characters. Thus, a key concern for some parents is how long they will be waiting in line to meet the Disney characters. During our Math and the Mouse May Experience course, we collected data and analyzed wait times based on party size and number of autographs collected. The poster will focus on analyzing the results to predict the wait time for a given line configuration.

Kelly Emmrich, University of Wisconsin-La Crosse
Sufficient Conditions for a Linear Operator on $\mathbb{R}[x]$ to be Monotone

We demonstrate that being a hyperbolicity preserver does not imply monotonicity for infinite order differential operators on $\mathbb{R}[x]$, thereby settling a recent conjecture in the negative. We also give several conditions, some necessary, some sufficient, for such operators to be monotone.

Sabrina Enriquez, University of Southern California
Lengths of Simple Closed Curves on the Punctured Torus

I am studying the behavior of the lengths of simple closed geodesics on the surface of a punctured torus endowed with a hyperbolic metric. In particular, my goal is to identify the maximum and minimum values taken by the Mirzakhani function, over the space of all hyperbolic metrics on the punctured torus. The Mirzakhani function, introduced by Maryam Mirzakhani, controls the growth rate of lengths of simple closed curves on hyperbolic surfaces. Through a heuristic method, I have found that the minimum of the Mirzakhani function seems to be attained at the (unique) hyperbolic metric that has a symmetry of order 3. The function is also unbounded.

Brooke Hatanaka, Keene State College
Characterization of Pythagorean Triples in $\mathbb{Q}(\sqrt{2})$

In high school, every geometry student learns the Pythagorean Theorem, which states that a triangle ABC with integer sides a, b, and c is a right triangle if and only if $a^2 + b^2 = c^2$. We can use this theorem to define a Pythagorean triple, which is a triple of three positive integers (a, b, c) such that $a^2 + b^2 = c^2$. All positive Pythagorean triples can be both generated and characterized with one formula. On this poster, we will characterize Pythagorean triples in $\mathbb{Q}(\sqrt{2})$ where each value of the triple will be of the form $p + q\sqrt{2}$ where $p, q \in \mathbb{Z}$. We then compare these triples with Pythagorean triples in the integers.

Yixuan He, Dartmouth College
Analyzing in vivo Xenograft Culture Response of Neuroblastoma IMR-32 to Bevacizumab (Avastin) Anti-VEGF Drug Treatment

Cancer is a leading cause of morbidity and mortality around the world. This year alone, an estimated 1.5 million new cases of cancer will be diagnosed in the United States. Unfortunately, the demand for anticancer drugs cannot be met due to the difficult and extensive process of drug development. To facilitate and expedite drug synthesis, we designed a simple mathematical model for cancer growth in vitro for neuroblastoma IMR-32 in order to better study the effects of anti-VEGF drugs on tumor growth. Our model uses the simplest possible system of ordinary differential equations to model qualitative results observed in a cell whether grown in monolayer, 3D spheroid, or xenograft culture. It includes compartments corresponding to rapidly proliferating cells in various stages of the cell cycle, quiescent and necrotic cells. The model also accounts for growing vasculature, presence of signaling compounds, and drug treatments. Using our model, we were able to successfully characterize the growth of neuroblastoma, the leading type of cancer in infants, with and without the treatment of anti-VEGF anti-cancer drug Avastin.

Qixuan Hou, Georgia Institute of Technology
Gathering high quality information on landslides from Twitter

Social networking platforms are increasingly used to report or pass along news and other valuable information. Their use rises especially during emergency situations and can be monitored for the analysis of adverse events, such as disasters. In this talk, I provide an overview of a comprehensive disaster information system using social networks with landslides serving as an illustrative example.

Sijia Huo, University of Illinois at Urbana-Champaign
Yantong Zheng, University of Illinois at Urbana-Champaign
Statistical Analysis of Weather Forecasts: Accuracy of Online Forecasts vs. Statistical Models

When a meteorologist says that it is going to be sunny and 80 degrees 10 days from now, how well can we rely on this prediction? This project analyzes the accuracy of weather forecasts obtained from online sites and compares these to predictions based on historical climate data using different statistical models such as the persistence, climatology, and time series models. The analysis is based on over 10 million individual predictions from wunderground.com, and historical weather data from over 10000 locations in the U.S.

Hannah Johnson, Washburn University
see **Emma Bayless**

Emily Joslin, Baylor University
Chaos and Integrability in Mushroom Billiards

Mathematical billiards are simple mechanical models of systems of particles colliding with a fixed boundary. While chaotic and integrable billiards are well understood, much less is known about systems with mixed phase space, in which chaotic and integrable components coexist. We present a numerical study of a class of mushroom billiards with mixed phase space. We classify the phase space for a family of billiard tables depending on several parameters by deriving explicit formulas for periodic orbits that correspond to the principal elliptic islands. We also formulate and provide evidence to support an original conjecture. In an effort to quantify the hyperbolicity of the billiard table, we present data from a newly created add-on to the billiard simulation software that computes the Lyapunov exponent along a given orbit. This work was done as part of the Fairfield University 2016 REU.

Carol Lewis, Furman University
The Phony Express

The Phony Express puzzle is a problem in dynamic programming. Its object is to efficiently collect and bring the mail letters of people spaced at certain distances on the positive real number line to a post office located at the origin. We will examine the intricacies of the cost function for the puzzle, and produce an algorithm to find one of the cheapest solutions. The Phony Express puzzle is an adaptation of a puzzle involving switches from Averbach and Chein's book "Problem Solving through Recreational Mathematics."

Anran Lu, University of Southern California
Twitter Location Prediction Using Topic Modeling

The location of social media users is valuable in commercial, social and academic contexts. We develop a new method to predict the fine-tuned locations of tweets within a known city, and test the method on tweets from Vancouver and Barcelona. Our method uses a variation on text-based topic modeling that specifically identifies location sensitive topics in a set of training tweets. The method then uses these location sensitive topics to classify new tweets and predict their locations.

Harjasleen Malvai, Brown University
Continuous Time Opinion Formation on Directed Weighted Graphs

Ideas that challenge the status quo either evaporate or dominate. The literature that mathematically studies the evolution of ideas treats space as uniform and considers individuals in an isolated community, using an ODE model. We extend these models to include multiple communities and their interaction by using a directed weighted graph. We study in detail some special cases, state general properties, and indicate pathways for further research.

Katherine Marinoff, Keene State College
Selective Sums

When infinite series are first introduced to mathematics students, there is a focus on whether or not a series converges, and if so, to what number. However, suppose we were to look at the sum of only a certain set of the series, say, only the even terms or a finite number of terms. These are known as selective sums of a series, and through examples, we will explore this topic.

Abby Martin, Augustana University
Model Trees for Electric Load Forecasting

Electric load forecasting is essential to the electric generation industry and is therefore research into creating more accurate forecasts is of vital importance. The model tree is a type of decision tree that has linear regression models at each leaf that are used for predicting. Model trees are an improvement over other forecasting methods, such as linear regression or possibly even artificial neural networks, because the models are built on a smaller subsection of data and therefore more effectively model instances with specific characteristics.

Katelyn McCoy, Lamar University
Predicting Light Rotation with Knot Theory

It is well known that the fields of knot theory and chemistry intersect non-trivially. We will examine what is known about how knots affect the rotation of light, and investigate if we can mathematically predict light rotation from knot type.

Madalynn McKelvey, Wartburg College
Experience in an Inquiry-Based Learning Differential Equations Course

Differential Equations is a course that serves several purposes in applying mathematics to the physical sciences. An inquiry-based learning approach to Differential Equations provides the opportunity for students not explicitly studying mathematics to find meaningful connections between the fundamentals of Differential Equations and their chosen field of study. This study is an analysis of the teaching strategies used in Inquiry-Based Learning and their application to Differential Equations. To illustrate the effectiveness of an Inquiry-Based learning approach to Differential Equations, I will reflect on my own experience in the course, discussing how the structure of the course stimulated interest in the subject matter, and how I applied it to my primary field of study (Engineering).

Sararose Nassani, Case Western Reserve University
Characterizing Motility and Phototropism in Chlamydomonas reinhartdii

Microtubule-based motility allows many organisms to alter their location in response to external factors including light, gravity, or chemical signals. Yet dysfunctions in motility lead to a variety of disorders in humans, specifically in the respiratory and reproductive systems. Examining microtubule-based motility at the unicellular level could provide insight into the underlying mechanisms of these conditions, however, there is currently no standardized method for confidently examining and analyzing cellular motility. A unicellular photosynthetic algae, Chlamydomonas reinhardtii, is a model organism used in examining cellular reproduction, photosynthesis, and motility. Yet previous research on C. reinhardtii has been limited due to conflicting phenotypic results and limited scope of information gathered per study. While recording cell movement in real time under a microscope, we were able to use image analysis and automated particle tracking to collect and analyze data on cellular motility. Herein we present standardized methods for tracking unicellular ambulatory organisms at a cellular level in real time while confidently measuring motility, directionality, and velocity trends on a population and individual level. By using this method, we have investigated C. reinhardtii's motility and velocity trends under various light conditions to offer an explanation for previous literature discrepancies.

Yue Pan, Washington and Lee University
Sum of Two Squares

Using Fermat's two squares theorem and properties of cyclotomic polynomials, we prove assertions about when numbers of the form a^n+1 can be expressed as the sum of two integer squares. We prove that a^n+1 is the sum of two squares for all n in N if and only if a is a perfect square. We also prove that for $a \equiv 0, 1, 2 (\text{mod } 4)$; if $a^n + 1$ is the sum of two squares, then $a^d + 1$ is the sum of two squares for all d divided into N; $d > 1$. Using Aurifeuillian factorization, we show that if a is a prime and $a \equiv 1 (\text{mod } 4)$, then there are either zero or infinitely many odd n such that $a^n + 1$ is the sum of two squares. When $a \equiv 3 (\text{mod } 4)$; we define m to be the least positive integer such that $(a+1)/m$ is the sum of two squares, and prove that if $a^n + 1$ is the sum of two squares for any odd integer n; then m divided into n, and both $a^m + 1$ and n/m are sums of two squares.

Grace Rants, Creighton University
Effects of Obesity on Cardiac Action Potential Propagation

Obesity in recent years has had a significant effect on the population, including on the cardiac tissue of those affected. Fat cells that are accumulated in cardiac tissue have a detrimental effect on the functioning of the sino-atrial node, which is the natural pacemaker of the heart. We investigate these effects by incorporating new parameters into the DiFrancesco-Noble (1985) ODE model of the cardiac action potential, to reflect the modified ion flow in the heart of an obese patient. After simulating the action potential propagation under various conditions, we describe a bifurcation in the ODE parameters possibly leading to cardiac arrest.

Morgan Rozman, Seattle University
Stability of Travelling Wave Solutions to the Whitham Equation with Surface Tension

The Korteweg-de Vries equation (KdV) is a partial differential equation that models the evolution of waves with small amplitude on shallow water. Bottman and Deconinck (2009) prove that all travelling-wave solutions of KdV are stable. The Whitham equation, an integro-partial differential equation generalization of KdV, more accurately models the evolution of waves in this regime. We compute periodic travelling-wave solutions to the Whitham equation with both zero and non-zero mean, highlighting the differences between the two. We analyze the properties of these solutions and compute their stability. We relate the stability of each type of solution to its wave speed, period, and amplitude. Finally, we generalize the Whitham equation in order to take into account surface tension. This will provide new conclusions about the stability of surface-tension influenced traveling-wave solutions.

Huei Sears, Michigan State University
Symmetries of the Dodecahedron

The dodecahedron is the regular polyhedron with 12 sides. This shape appears as a form of the Wolfram Research logo, the architecture of the dodecahedrane molecule, and is featured in M.C. Escher's 1943 lithograph print, Reptiles. There are 60 unique symmetries of the dodecahedron. It is known that this group of symmetries is isomorphic to the alternating group on a set of five elements. So then, looking at the dodecahedron, what five features are being permuted? This talk will provide descriptions of those five things.

Carissa Slone, Cedarville University
Models of Nation-Building via Systems of Differential Equations

Nation-building modeling is an important field of research given the increasing number of candidate nations and the limited resources available. A modeling methodology and a system of differential equations model are presented to investigate the dynamics of nation-building. The methodology is based upon parameter identification techniques applied to a system of differential equations to evaluate nation-building operations. Data from Operation Iraqi Freedom (OIF) and Afghanistan are used to demonstrate the validity of different models as well as the comparison of models.

Karina Stetsyuk, Hood College
Adding automated uncertainty estimates to property calculations of iron from molecular dynamics

The Interatomic Potentials Repository (IPR) project at NIST has for years hosted interatomic potentials (force fields) of known provenance, primarily for metallic materials. Now the project is expanding to include an open-source framework to calculate material properties for potentials on the IPR website. A number of calculations are being developed in this framework to help users select potentials best suited for their needs. In this study, we focus on measuring lattice parameters of a crystal structure for iron at different temperatures using molecular dynamics. In order to do this, we implement a method for finding an appropriate section of data in which the structure is at equilibrium. Routines are constructed to properly estimate mean and standard deviation of mean for property values at intermediate temperatures. This improves understanding of potentials and their associated material properties by demonstrating how they behave over a wider range of values than just those explicitly calculated.

Gabrielle VanScoy, Youngstown State University
Making Muscles: Math Models of Muscle Formation

Muscle formation is an important and complex process. At the beginning, myoblast cells, which are small round embryonic cells, have to transition into myocytes, which are elongated muscle cells. Myocytes then fuse into myotubes, which are the building blocks for muscles. Principles learned from the study of myoblast fusion not only enhance our understanding of myogenesis, but also contribute to our perspectives on membrane fusion and cell-cell fusion in a wide array of model organisms and experimental systems. A computer simulation and a mathematical model is created to help better understand this complex process.

Catherine Wallick, St. Catherine University
Homology of Permutation Complexes

We form permutation complexes by inducing simplicial complexes upon the cliques of permutation graphs. To define a permutation graph of order n, we take a permutation π on vertex set $\{1, \ldots, n\}$ and create an edge between vertices $x < y$ if and only if $\pi^{-1}(y) < \pi^{-1}(x)$. We generate a simplicial complex from this graph by building a face from each complete subgraph. Within our research, we look at the properties of these complexes by relating their structures to possible permutation patterns. We explore the homology of these complexes and, for any d, uniquely determine the precise permutation pattern for which a d-cycle appears in the complex.

Samantha Wyler, State University of New York at New Paltz
Sums of Consecutive Polygonal Numbers

In this presentation we will briefly explain what polygonal numbers are and give a formula for computing them. We will then show a general formula involving sums of consecutive polygonal numbers and give examples.

Yutong Yang, Kennesaw State University
Generalization of Cross-Polytope Numbers

This project involves investigations in the mathematical field of combinatorics. The investigations extend and vary results of Professors Steven Edwards and William Griffiths, who recently found a new formula for $C(n,k)$, the number of combinations of n objects taken k at a time. My research is focused on their result of $E(n,k)$ and $O(n,k)$, which are two distinct combinatorial expressions that satisfy the same recurrence formula. We prove the recurrence formula of E and O algebraically by using Pascal's identity, from which it follows that $E(n,k) = O(n,k)$ and the reflection in the table of E. Now we are working on the new formula $E_k(m,l)$ and $O_k(m,l)$, which are similar to the formulas of E and O, where E and O are related cross-polytope. And we make a generalization of the cross-polytope numbers. Our big explore is the recursion formula for every column of the tables of E_k. We also proved that E_k and O_k share the same recurrence formula with what we have for E and O.

Yantong Zheng, University of Illinois at Urbana-Champaign
see **Sijia Huo**

Jenna Zomback, State University of New York at Geneseo
Coloured Unlinking

In links with two components there are three different types of crossings: self-crossing in the first component, self crossing in the second component, and crossing between components. Previous work by Peter Kohn has mostly not made this distinction between the different types of crossings. In this talk we examine the minimum number of crossing changes needed to unlink without changing the crossings between components. Therefore we restrict our attention to unlinking two component links with linking number zero and both components unknotted. We gather examples of links of this kind and use some technical tools to analyze them such as Conway and Alexander Polynomials, the Thistlethwaite Link Table, and yarn. After observing the number of crossing changes needed to unlink in these cases, we attempt to generalize our results beyond examples.

Posters by Undergraduate Students
Session B

Brittany Alexander, Texas Tech University
A Bayesian Statistical Model for the Prediction of the 2016 United States Presidential Election

Using a combination of polling data and previous election results, Nate Silver successfully predicted the Electoral College distribution in the presidential election in 2008 with 98% accuracy and in 2012 with 100% accuracy. His success was attributed largely to his focus on Bayesian statistical modeling. However, Bayesian statistical modeling for presidential election prediction has not been studied prospectively since Nate Silver's success in 2008. This study is aimed at utilizing Bayesian modeling for predicting the results of two sets of experiments - all 50 of the 2016 Republican Presidential primary elections and the 2016 general Presidential election. In both cases, the data will consist of the most recent polling results. In the primary process, past elections will serve as a prior. In the general election the prior will be based on either a national poll or a similar state with large amount of polling data.

Charlotte Aten, University of Rochester
The Topology of Magmas

In mathematics it is often useful to encode abstract algebraic structure as geometric structure, both to aid one's intuition and to permit the application of geometric methods to ostensibly algebraic questions. We examine one such encoding scheme, which we use to obtain directed graphs from unary operations. These graphs are then used to obtain lower bounds on the number of solutions to certain equations. We then apply a slightly weaker generalization of this technique to obtain 2-dimensional simplicial complexes from binary operations. These simplicial complexes permit the application of topological methods to the study of group structure.

Ruby Bayliss, St. Catherine University
Investigating Examples of Non-Convex Open Neural Codes

The study of neural codes is motivated by the need for the mathematical model of an interaction of place cells in the hippocampus. We define a codeword, σ as a subset of $[n]$, where $[n] = \{1, 2, \cdots, n\}$, and a neural code $\mathscr{C}$ a subset of $\mathscr{P}([n])$. An open cover associated with a neural code is determined by the nonempty intersections of sets in the cover. However, not all neural codes can be realized this way. We will discuss using local obstructions to construct an explicit example of a code on $n \geq 5$, which cannot be realized as the code of a convex open cover.

Kristina Benton, University of Central Oklahoma
Modeling the Effects of Tannin on Giraffe Physiology

Tannin (a bitter-tasting organic substance) is produced by acacia trees as a defense against over-browsing by giraffes. In conservatory enclosures, where food sources are limited, giraffes are forced to eat the tannin-rich acacia trees, which can adversely affect their health. I built a mathematical model of how the tannin levels of the acacia tree affect the health of the giraffe. This model consists of the different interactions in the gut of the giraffe between tannin, protein, parasites, and salivary muco-proteins. I will present results of the models that can be used to help conservationists with the health and wellness of the endangered Rothschild giraffe species by recommending ideal population levels and proper feeding systems.

Monica Busser, Youngstown State University
V_m and Fibonacci-like Diffsequences

A D-diffsequence, where $D \subseteq \mathbb{Z}^+$, is defined as a sequence of positive integers $x_1, \ldots, x_k$ where $x_i - x_{i-1} \in D$ for all $i \in \{2, \ldots k\}$. We will discuss these sequences through the lens of Ramsey Theory, in which we will partition all positive integers and determine when we are guaranteed to obtain a D-diffsequence in one of the sets of the partition. Ramsey theorists have previously studied V_m-diffsequences where $V_m = \{x \in \mathbb{Z}^+ : m \nmid x\}$, and formulas for $\Delta(V_m, k)$ and $doa(V_m)$ have been established. In this talk we will discuss progress made on extending these results to $V_S = \{x \in \mathbb{Z}^+ : \forall s \in S, s \nmid x\}$. We will also discuss progress made regarding E-diffsequences where E is defined by a linear homogenous recurrence relation.

Karen Butt, University of Chicago
Elliptic Curves and the Mordell-Weil Theorem

The Mordell-Weil theorem states that for an elliptic curve E over the field rational numbers $\mathbb{Q}$ the group of rational points $E(\mathbb{Q})$ is finitely generated. The proof of this theorem relies on the deep fact that the quotient group $E(\mathbb{Q})/2E(\mathbb{Q})$ is finite. We compare two proofs of this fact, one elementary and one using group cohomology. The connection between the proofs is elucidated by an explicit computational proof for the special case where the 2-torsion $E[2]$ is contained in $E(\mathbb{Q})$.

Brittany Carr, Northern Arizona University
Star reduction graphs for symmetric groups

Recall that the symmetric group S_n is generated by adjacent transpositions. Each permutation w in S_n can be expressed as a product of adjacent transpositions in multiple ways. If the number of transpositions in an expression for w is minimal, we say that the expression is reduced. If a permutation w has a reduced expression beginning (respectively, ending) with st (respectively, ts) such that s and t are a pair of non-commuting adjacent transpositions, then we say that w can be "star reduced" to the permutation given by the removal of s. This naturally leads to the construction of an edge-labeled directed graph, called the "star reduction graph" for S_n. The vertices are the permutations and there is a directed edge labeled by s from vertex w to vertex u if w can be star reduced to u by removing s from the beginning or end of some reduced expression for w. In this talk, we will discuss our current findings concerning the overall structure of this graph.

Xinying Chen, Georgia Institute of Technology
Solvability of implicit final size equations for SIR epidemic models

Final epidemic size relations play a central role in mathematical modeling of epidemic networks. While final size relations were derived for several complex models, including multiple infective stages and models in which the durations of stages are arbitrarily distributed, the solvability of those implicit equations have been less studied. Therefore, our research explored the solvability of final epidemic size in mathematical epidemiology. The Susceptible-Infected-Recovered (SIR) homogeneous mean-field and pairwise models and the SIR heterogeneous mean-field model were studied. We proved that for each model, the implicit equation for the final epidemic size has a unique solution; moreover, through writing the implicit equation in fixed point format, the iteration of the fixed point equation converges to the unique solution. Besides approximation models, we studied the exact Markovian SIR epidemic model on finite networks using generation-based approaches. Explicit analytic formulas for final size distribution are derived for line and star graphs of arbitrary size. Lastly, we used iterative formulas for the exact final size distribution to study the accuracy of mean-field approximations on complete graph as epidemic network.

Emma Christensen, College of Saint Benedict/Saint John's University
Pattern Avoidance in Set Partitions

A set partition avoids a pattern if no subdivision of that partition standardizes to the pattern. We find the sizes of avoidance classes based on a single partition of [4] as well as classes based on multiple partitions of [3] and [4]. We also characterize the restricted growth functions which are in a bijection with the set partitions of the avoidance classes of interest, and examine the distributions of various statistics on these avoidance classes.

Alyssa Ciurlik, Furman University
Parties will be Separated: An Analysis of Single Rider Lines in Walt Disney World

To combat long wait times Disney has created a single rider line that creates a separate queue for those willing to ride without their party. The goal of this project was to create an equation that would allow a passenger to count the number of people in front of them and then be able to calculate the approximate time they would have to wait in the line. We collected and analyzed data for two Disney attractions, Rock 'n' Roller Coaster and Expedition Everest. To create this model, we collected the party size distribution and throughput (number of passengers that could ride in an hour) for each attraction and used statistics to analyze our model's effectiveness.

Catherine Cooper, Trinity College
Packing Colorings of Graph Products

The packing chromatic number $\chi_\rho(G)$ of a graph G is the smallest integer k such that $V(G)$ can be partitioned into disjoint classes $X_1, \ldots, X_k$ where any pair of vertices in X_i are distance greater than i apart for each $i \in \{1, \ldots, k\}$. Goddard et al. showed that for any grid graph $P_m \Box P_n$, $\chi_\rho(P_m \Box P_n) \leq 23$. It was later proven by Ekstein et al. that $\chi_\rho(\mathbb{Z}^2) \geq 12$ where $\mathbb{Z}^2$ represents the infinite 2-dimensional grid. In an effort to give the exact upper bound for $\chi_\rho(P_m \Box P_n)$ for any positive integers m and n, we investigate packing colorings in the hierarchical product of two paths.

Niyousha Davachi, University of Texas at Arlington
Standard and Non-Lagrangians

A concept of non-standard Lagrangians is introduced and general conditions for the existence of such Lagrangians are presented. The conditions are used to determine classes of ordinary differential equations (ODE's) that can be derived from non-standard Lagrangians. The obtained results are used to obtain non-standard Lagrangians for several ODE's of special interest in applied mathematics.

Elizabeth Franko, University of Scranton
Theoretical Model of Flow Compensation following Vascular Occlusion

Peripheral arterial disease (PAD) is a major health problem in which arteries within the systemic vasculature become partially or fully blocked, often due to atherosclerosis, leading to a significant reduction in blood flow to tissue. The absence of data regarding the relative importance of adaptations in collateral arteries, arterioles, and capillaries to compensation after arterial occlusion is a major roadblock for the development of successful and noninvasive therapies. The objective of this project is to integrate experimental and theoretical techniques to assess the significance of changes in vascular segments at rest and during exercise subsequent to a major arterial occlusion on an acute and chronic time frame. The project's goal is extended to assess mechanistic responses in vasoactive vessels in the model. Ultimately this project offers a first step in optimizing experimental design and diagnostic criteria to focus on the most relevant vascular segments in studies of vascular compensation.

Anna-Sophia Hirst, California State University, Dominguez Hills
Self-Similarity in Level Set Trees of Geometric Random Walks

Level set trees provide insight into the topology of a function's relative extrema. We consider a random walk where the displacement between successive states is determined by a mix of geometric variables, and calculate how the parameters of the transition kernel evolves under the operation of pruning. We find that the level set tree of the geometric random walk in a discrete state space does not retain Horton self-similarity or Tokunaga self-similarity, but does maintain asymptotic Horton self-similarity.

Megan Hollister, Baylor University
Modeling Dermal Diffusion and Metabolism for Consumer Products

Since experiments can be costly, the US EPA has developed a program to mathematically predict toxicity information for 80,000 chemicals. Specifically, dermal absorption of chemicals increases the likelihood that the chemical will enter the bloodstream and result in toxicity of body organs. Mathematical modeling has been used for the textitin silico calculation of dermal absorption parameters like permeability and lag time. In addition, dermal metabolism can clear chemicals from the skin and prevent them from entering circulation. Current dermal models do not include metabolism, but it could significantly improve current model's results. Our research aims to develop a more accurate dermal model which will incorporate metabolism, absorption, and diffusion. Optimization will be used to calculate parameter values, and then numerical methods will be used to approximate the analytical solution of our model. Our goal is to minimize the number of parameters while increasing confidence in our model's predictions.

Hayley Hutson, Missouri State University
Global Stability Analysis Of Zika Virus Dynamics

The very few mathematical models available in the literature to describe the dynamics of Zika virus are still in their initial stage of development, and they were in part developed as a response to the most recent outbreak that started in Brazil in 2015, which has also confirmed its association with Guillain-Barre Syndrome and microcephaly. The interaction between and the effects of vector and human transmission are a central part of these models. This work aims at extending and generalizing current research on mathematical models of Zika virus dynamics by providing rigorous local and global stability analyses of the models. In particular, for disease-free equilibria, appropriate Lyapunov functions are constructed using a compartmental approach and a matrix-theoretic method, whereas for endemic equilibria, a relatively recent graph-theoretic method is used. Numerical evidence of the existence of a transcritical bifurcation and some other simulations using Matlab are presented.

Christine Izyk, College at Brockport, State University of New York
The Maximum Minimal Distance

We will discuss the following general problem: how can we place n points on a surface such that the smallest distance between any two of them is as big as possible and what is the value of this maximal minimal distance. We will consider two surfaces, a sphere of radius 1 and a cube of side length 1. For the case of a small number of points we will find the exact value of the maximal minimal distance. For a bigger number of points we will offer some estimates. In each case we will indicate a construction for which either the exact maximum or the estimate are achieved.

Jiyi Jiang, Hope College
Incorporating Information from Exogenous Variables in Models for Disease Incidence

Dengue Fever, Dengue Hemorrhagic Fever. Chikungunya and Zika are four viral diseases which share a common vector, the Aedes mosquito, which is found in tropical and sub-tropical regions of the world. Environmental factors play a role in the survival of the Aedes mosquito. Thus, modeling disease incidence trends using environmental data, as well as information about the diseases themselves, would be a viable approach. Various models (both frequentist and Bayesian) for predicting disease incidence using exogenous variables are suggested and compared, with one of the comparison metrics being prediction accuracy.

Emily Kelting, University of Central Oklahoma
Modeling Toxoplasma gondii transmission in cats

We will discuss the transmission of Toxoplasma gondii and its effects in cats. Due to the severity of T. gondii spillover infections in pregnant women and monk seals, understanding its transmission dynamics in cats is key to unlocking preventive measures against this parasite. Taking into account susceptible and infectious cats and kittens, chronically infected cats, and the surrounding environment, I built a differential equations model of T. gondii transmission in cats. I will present my model and the results, identifying details of how the parasite is transmitted between cat hosts and how the risks to other species can be minimized.

Rachel Knak, Grinnell College
Nielsen Classes $A_n : 2 * 3 = 7$

In this talk we discuss a summer research project where we worked to find the cycle structures of elements of the alternating group, denoted A_n, x and y, satisfying $x^2 = y^3 = (yx)^7 = 1$, which generate A_n. We used tools from representation theory, specifically dealing with characters, to write programs for the computer algebra program MAGMA that identified conjugacy classes of A_n that could not contain elements x and y. Using these results we formed conjectures and were able to prove lower bounds on the number of cycles in any element x or y that fit our criteria. Since the relevant conjugacy classes of A_n are defined by cycle structure, we narrowed down the list of possible conjugacy classes substantially. This work has applications to the automorphism groups of Riemann surfaces.

Samantha Law, Grand Valley State University
3D Printing of Eugenia Cheng's Associahedron

In her new book How to Bake Pi: An Edible Exploration of the Mathematics Behind Mathematics, Eugenia Cheng introduces a three-dimensional figure called an "Associahedron," which she derives from category theory related to baking. The associahedron is originally a two dimensional net made up of three squares and six regular, congruent pentagons. It requires folding to be turned into a three-dimensional object. However, Cheng warns that the polygons that make up the net will not quite fit together. The point of this project is to fold and successfully 3D-print the associahedron. We will utilize parametric equations, matrices, and other mathematical tools in order to create two different designs in Mathematica. These designs can then be converted to Stereolithograph files and printed. One design will use a pentagon as a base and the other a square. The malformations in each design support the idea that the polygons don't fold perfectly.

Huyen Le, California State Polytechnic University, Pomona
An Investigation of the Set of Primitive Non-deficient Numbers

A number is perfect if the sum of its proper divisors equals to the number itself. Much current research focuses on the easier-to-study, but similarly defined, numbers called non-deficient numbers. Our research project takes the techniques originally used to study prime and perfect numbers, and adapt them to investigate primitive non-deficient (pnd) numbers. In particular, it is known that some of these numbers have a very simple form involving only two primes. Namely, if a pnd is the product of two distinct primes, then it must have the form $2^a p$, where p is an odd prime between 2^a and $(2^a + 1)$. We study a similar characterization for pnds with three distinct primes, allowing us to better understand the pnds and to give insight on how many pnds there are.

Laura LeGare, Concordia College, Moorhead
The Calculus of Proportional α-Derivatives

We introduce a new proportional α-derivative with parameter α in $[0, 1]$, explore its calculus properties, and give several examples of our results. First, we provide an introduction to our proportional α-derivative and some of its basic calculus properties. We next investigate the system of α-lines which make up our curved yet Euclidean geometry, as well as address traditional calculus concepts such as Rolle's Theorem and the Mean Value Theorem in terms of our α-derivative. We also introduce a new α-integral to be paired with our α-derivative, which leads to proofs of the Fundamental Theorem of Calculus Parts I and II, as applied to our formulas. Finally, we provide instructions on how to locate α-maximum and α-minimum values as they are related to our type of Euclidean geometry, including an increasing and decreasing test, concavity test, and first and second α-derivative tests.

Xiran Liu, Washington University in St. Louis
Optimizing the Quality-Cost Tradeoff of Human Annotation

Real world classification problems require data from humans. Google uses human annotators to get data for binary web page classifiers. Accuracy of the annotated data is important to the classification. We want to develop and analyze strategies to mitigate human mistakes to achieve best possible classifier performance. We simulate human annotated data based on known rater accuracy and develop two strategies: the first is an iterative multiple rating strategy in which multiple raters annotate a page with a distribution of raters assigned to each page beforehand. The second is combing the prior probability of human mistakes with confidence produced by the classifier to clean the evaluation data. We believe these strategies offer solutions to optimize the quality-cost tradeoff of human annotation. We observe that certain multiple rating orders and combinations lead to better data quality, which indicates that optimal solution would focus on better quality raters with an appropriate strategy.

Sarah Maples, University of San Francisco
Micro-location Prediction of Twitter Users

The location of social media users is valuable in both a commercial and social context. In this paper, we employ multiple methods to predict the fine-tuned (< 1 kilometer) locations of tweets within a known city, using tweets from Vancouver and Barcelona. We create 3 general prediction schemes to find the location of a given tweet: 1. Location oriented topic modeling, 2. Hashtag (#) clustering, and 3. Social network. For the topic modeling approach, we create a robust algorithm that automatically identifies tweets purely based on their text. We first train location-sensitive topics generated automatically from our NMF clustering, and then predict the location of our testing tweets using their topic associations. For our hashtag clustering prediction scheme, we use personalized PageRank clustering to group similar hashtags and then predict tweets that contained the clustered hashtags. For the social network, we chose to use the locations of a user's friends within a given time frame as a way to infer tweets' locations. The intuition here is that connected users will be tweeting near each other. Each of our methods provides promising results in the micro-scale location prediction. This is the abstract from our final report over the summer. This project was in collaboration with 5 other people, and I was focused on the social network, so that would be the topic of my talk.

Kelsey Miner, Wartburg College
Model for Whiskey Evaporation - PIC Math

As time passes, whiskey aging in barrels will evaporate due to a variety of factors. Our goal was to create a tool for the Blaum Brothers Distillery that would help them accurately predict the volume of product lost to evaporation while it ages. With this information, the distillers can then determine the amount of whiskey they will need to distill to have a certain amount in the future accounting for that volume lost over a given amount of time.

Uyen Nguyen, California State Polytechnic University, Pomona
Eigenvalues of a Class of Tridiagonal, Stochastic Matrices

We consider two birth-death Markov chains. The first birth-death chain has states $0, 1, 2, \ldots, H$. The second birth-death chain is the dual of the first birth-death chain with states $-1, 0, 1, 2, \ldots, H$. Suppose $P1$ is the matrix of one-step probabilities of the first birth-death chain and $P2$ is the matrix of one step probabilities of the dual birth-death chain. Under suitable general conditions we conclude: *$P1$ and $P2$ have the same set of eigenvalues. * A simple, explicit formula for these eigenvalues is determined as a function of H. * Formulas for powers of $P1$ and $P2$ and ruin probabilities are determined.

Hayley Olson, Gonzaga University
Nested and Fully Augmented Links

This presentation focuses on two subclasses of hyperbolic generalized fully augmented links: fully augmented links and nested links. The link complements of fully augmented links have several nice geometric properties that many generalized fully augmented links do not have. Nested links are a class of generalized fully augmented links that share many qualities with fully augmented links, including cell decomposition properties, cusp properties, and sharpness of a volume bound.

Adele Padgett, University of Chicago
An Introduction to Keisler's Order

In model theory, the complex numbers as an algebraically closed field are often given as an example of a simple, well-behaved mathematical structure, while the reals as a dense linear order without endpoints are more complicated and behave more strangely in many ways. Can we compare the complexity of other mathematical structures in a meaningful and informative way? Keisler's order seeks to address this question by moving from the realm of structures to the theories that describe them. The complexities of two theories can be compared by measuring the relative saturation of certain ultrapowers of each theory's models. The details of how this comparison works will be discussed in detail and justified at each step.

Leilani Pai, University of Southern California
Convolutional Neural Networks in Image Processing

As machine learning techniques have improved in the last few decades, the viability of using machine learning in medicine and health-related contexts has risen. In particular, we are interested in using machine learning techniques to locate the brachial plexus, a bundle of nerves in the neck. Identifying these nerves quickly and reliably will help improve post-surgery pain management by allowing for the placement of catheters that reduce patients' dependency on narcotics. Here, we are provided with a set of still ultrasound images of the neck and attempt to use machine learning to extract information from them. We explore the use of convolutional neural networks for image processing in this context. Specifically, we focus on convolution as a theoretically appropriate (but practically demanding) means of processing two-dimensional images.

Danielle Pham, Creighton University
Vanishing Dissipation Limits for a generalized Magnetohydrodynamic Equation

The Magnetohydrodynamic (MHD) system of equations governs kinematic fluids that are subjected to a magnetic field. The equation is a combination of the Navier-Stokes equation and Maxwell's equations. Due to the difficulty in solving the MHD system, it has become common to study approximating versions of the equation, including the MHD- system, which regularizes the velocity field in exchange for the addition of non-linear terms. Both the kinematic and magnetic parts of the MHD- system have diffusive terms which dissipate the initial energy of the system. Setting those terms equal to zero returns the Ideal MHD- system. The goal of this project is to show that solutions to the MHD- system with diffusion will converge to the Ideal MHD- system as the diffusion parameters are sent to zero by adapting known results for the analogous problem of determining when solutions to the Navier-Stokes equation will converge to a solution of the Euler Equation.

Beth Rawlins, University of Central Oklahoma
Using Mathematical Models from Epidemiology to Describe Drug Use and Recovery

We apply compartment models from mathematical epidemiology to describe drug use and recovery. Our model accounts for non-users (susceptible), users (infected), and recovered users (removed), and describes the transitions and interactions between these groups using differential equations with an SIR model. We attempt to parameterize our model to represent the population of Oklahoma City and present numerical results describing a variety of intervention/reform strategies. Where possible, we develop analytical results, including an analysis of equilibrium solutions and their stability, to complement the numerical analysis and describe additional extensions to our model equations. Upon completion of our work, we hope to apply our results to better understand how mass incarceration impacts drug use.

Majerle Reeves, California State University, Fresno
Classification of Locations Using Geo-temporal Data

The availability of large localized datasets from popular social networking sites such as Foursquare and Twitter has enabled the expansion of the field of human mobility analysis. Identifying locations and inferring how people will move between them increases the understanding of human mobility, which aids public health, city planning, and crime reduction. We seek to use user-supplied locational data and user movements to identify and classify locations. Utilizing tweets encoded with geo-temporal data, we create a complex network of human movement throughout the Manhattan area (NYC). Using features extracted from the nodes (locations) of the graph we use semi-supervised learning to label each location and to train a classifier. To gain insight into the structure of the feature space we spectrally cluster the features and perform text analysis.

Monika Satkauskas, Creighton University
Modelling Host, Parasite, and Commensal Interactions to Determine Pollution Levels

Pollution can affect the biodiversity of an area. Environmental scientists have proposed the severity of pollution of an area can be determined by studying the interactions of organisms in an area. Using field site data from the Pine Ridge Indian Reservation, we offer a model for a freshwater snail-trematode-Chaetogaster ecosystem, which is composed of five coupled ordinary differential equations. This host-parasite-commensal model was modified to account for the effects of pollution in the microsystem. A numerical solver in Mathematica 10 was utilized to create simulations for the model, using NDSolve to manipulate slider graphs. We found the periodicity between the populations changed as the level of pollution was varied. Our results suggest increasing pollution changes the steady state of the system.

Alyson Schultz, Mount Mercy University
Parallelizing Kruskal's Algorithm for MST

In a connected graph with positively weighted edges finding a spanning tree, a connected subgraph containing all vertices and having no cycles, of minimum weight is referred to as the Minimum spanning tree problem (MST). This problem has many applications especially in network design and gives an approximate solution to the traveling salesman problem. Kruskal's Algorithm is a greedy algorithm used to find an MST. The goal of this project is to develop a parallel version of Kruskal's algorithm and to perform a run-time analysis comparison with the original serial version. Both versions will be implemented using C and MPI C.

Emily Stark, Austin Peay State University
Variations of Network Attitudinal Models

Applications of network theory are becoming more common in non-mathematical fields such as sociology and political science. However, networks can also be used to explain how we view the world. Social psychologists and cognitive psychologists agree on the merit of a network representation of an attitude state, but arrive at many possible algorithms and models. Therefore, it is crucial to understand how these models process data and arrive at their final representation. This study uses data from the American National Election Survey from 1984 to explore three different algorithms and assess the implications of each: the Causal Attitude Network Model, the Schema Model and Neural Network Computation.

Hailey Stirneman, Texas State University
The Impact of Preferred Mixing on the Sexual Transmission of ZIKV at the 2016 Summer Olympics

Zika virus (ZIKV) has started to plague South and Central America. Following the outbreak in Brazil, cases of microcephaly and other neurological disorders arose steadily. Despite the control strategies, ZIKV continues to spread in Brazil where the 2016 Summer Olympic games are to be held. Thus holding the Olympics in Rio de Janeiro subjects people to a range of health risks. This was confirmed in February 2015 when researchers found that males can transmit the disease via sexual intercourse. Using SIR models, we investigate three male-seeking-male (MSM) subpopulations: male natives in Rio, male visitors from outside of Rio, and male sex workers in Rio. We formulated the basic reproduction number and also calculated implicitly the final size of the epidemic. For specific values of preference, we calculated a basic reproductive number of 4.7886. The final PRCC charts show that the most sensitive parameters are c_1, c_2, c_3. This indicates that the most important parameters to consider when trying to decrease the infected individuals of each subpopulation is the number of sexual contacts that each individual is involved in. Overall, the preference parameter, f_i, does not reduce the final size for a population the way the c_i parameter can for final size distribution.

Yimeng Sui, University of Nebraska at Omaha
Discussion on Normalization Methods of Interval Weights

This paper is collecting the classic and newly normalization methods, finding deficiency of existing normalization methods for interval weights, and introducing a new normalization method for interval weights. When we normalize the interval weights, it is very important and necessary to check whether, after normalizing, the location of interval centers as well as the length of interval weights keep the same proportion as those of original interval weights. It is found that, in some newly normalization methods, they violate these goodness criteria. In current work, for interval weights, we propose a new normalization method that reserves both proportions of the distances from interval centers to the origin and of interval lengths, and also eliminates the redundancy from the original given interval weights. This new method can be widely applied in information fusion and decision making in environments with uncertainty.

Catherine Wolfram, University of Chicago
Recursive Derivation of $2n$-gon Topologies

A compact surface can be presented as a polygon whose edges are identified in pairs with orientation. Some presentations like this are commonly used, such as drawing a torus as a square with opposite edges identified. But there are many other ways to identify the $2n$ edges of a polygon with orientation. For a given n, the set of possible identifications define a set Pn of polygons with identified edges. Each element of Pn is a presentation of a compact surface, determined by two invariants: orientability and Euler Characteristic. We will prove various results about these invariants in the sets Pn, mostly using an indexed collection of maps from Pn to $Pn + 1$. Ultimately, we will find a computational formula for the number of elements of Pn that present a given compact surface S.