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NCUWM Talk Abstracts 2010

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TALK ABSTRACTS

PLENARY TALKS

Dr. Bryna Kra, Northwestern University
From Ramsey Theory to Dynamical Systems and Back

Ramsey Theory is the study of "large" structures that are preserved under partitions. An example is van der Waerden's Theorem: if the integers are partitioned into finitely many pieces, then one of these pieces contains arbitrarily long arithmetic progressions. Many of the original proofs in Ramsey Theory were combinatorial, but in the 1970's, Hillel Furstenberg introduced a new approach to the problems, first translating the combinatorial problem into a problem in dynamical systems and then using techniques in dynamical systems to solve the reformulated problem. This talk is a survey of the ongoing interactions between combinatorics and dynamics.

Dr. Karen Vogtmann, Cornell University
Symmetries, Ping-pong and Outer Space

Groups are very basic algebraic objects in mathematics, but one can often find an alternate description as symmetries of a geometric object. In fact it turns out that there is a natural way to think of any algebraically-described group as symmetries of something geometric, and the geometric properties of this object can reveal characteristics of the group which were not obvious from the original algebraic description.

One of the simplest of all types of groups are free groups. I will discuss the geometry of free groups, and use it to show how to recognize when a group which looks like it might be very complicated is in fact just a free group. The method is to use the geometric object as a ping-pong table; the reason for this terminology will be clear when the method is described.

The symmetries of free groups themselves form a group; the ping-pong table for this group is known as Outer space, and I will show how to play ping-pong in Outer space.

Talks by Undergraduate Students

Lindsay Baun, College of St. Benedict/St. John's University
Puzzles on Graphs: The Towers of Hanoi, The Spin-Out Puzzle, and The Combination Puzzle

The Towers of Hanoi is a well known puzzle that has been studied for years. The Spin-Out puzzle is a lesser known and less studied puzzle. However, both the Towers of Hanoi puzzle and the Spin-out puzzle can be represented by a labeling on iterated complete graphs. These graphs have constructions for their labelings corresponding to moves of the puzzle and a Perfect One-Error Correcting Code. The Towers of Hanoi puzzle corresponds to odd-dimensional iterated complete graphs, while the Spin-Out puzzle corresponds to iterated complete graphs of dimension 2^m. In addition, there exists a combination puzzle which combines the Towers of Hanoi and the Spin-Out puzzle to create a puzzle corresponding to iterated complete graphs on other even-dimensions. In addition to the labeling construction, we also observe Encoding and Decoding procedures using Hamiltonian paths for the graphs corresponding to the Towers of Hanoi and the Spin-out puzzle.

Danica Belanus, University of North Dakota
Generalized Ducci Sequences

A problem dating back to the 1930s considers what happens when a sequence of vectors is formed by taking each vector in the sequence and forming the next term by taking differences of adjacent entries. The map whose iterates form such a sequence is called the Ducci map. One can view this as using a permutation to determine which terms are adjacent to each other. We generalized how random permutations affect the Ducci sequence.

Hayley Belli, University of Oregon
Stochastic Modeling and Analysis of Unemployment

The question of how to model volatile economic data is a common problem proposed by applied mathematicians. In this presentation, methods for mathematically modeling U.S. unemployment rates are analyzed and explored. To better understand the dynamics of the unemployment process, correlations between unemployment and other economic time series are calculated, with the discovery of a relationship between unemployment and two-year-prior interest rates. Additionally, the cyclical pattern between documented U.S. recessions and spikes in unemployment data suggests that a Poisson process could be used to model recession frequency and the timing of future unemployment peaks. The focus of the talk then turns to a discrete-state Markov chain model, which assigns probabilities to the transactions between states of unemployment. Within each state, unemployment follows a specific dynamic that suggests using parameterized arithmetic Brownian motion and stochastic simulation to provide future unemployment rate projections.

Tiffany Bradford, Saint Francis University
Invariant and Idempotent Measures on Two Element Semi-Groups

This talk will investigate how a general theory on topological semi-groups applies to a two element semi-group. Invariant and idempotent measures will be introduces as well as the support of a measure. Conclusion from this research will be presented as well.

Kathryn Bryant, Northern Arizona University
Recent Developments in Numerical Semigroups and Perfect Bricks of Higher Dimension

Definitions are given of: "numerical semigroup," "perfect brick," "balanced," "unitary" and "cluster." The presentation focuses on the following two open questions: How can we generalize the concepts of balanced and unitary to bricks larger than 2×2? and Do perfect bricks of all sizes, that is, $n \times m$ perfect bricks, exist? The developments regarding these two questions are discussed, as well as the methods of investigation, new open questions and conclusions.

Laura Buggy, College of St. Benedict
Energy of Graphs

Define G to be a simple, finite and undirected graph with no loops or multi-edges. Let n be the number of vertices of G and let m be the number of edges of G. For each graph, an n by n matrix, denoted as $A(G)$, can be constructed to represent which vertices are adjacent in G. Then the energy of G is defined to be the sum of the absolute value of the eigenvalues of A. In this talk, I will present results from the REU research group I participated in as well as some of my own results from this fall. As well as energy, I will discuss bounds and relationships for different graph classes for distance energy, Laplacian energy and signless Laplacian energy.

Katharina Carella, Ithaca College
Sudoku, Shidoku, and ... Groebner Bases? An Algebraic and Computer Systems Approach to Counting Boards

Sudoku, and its smaller counterpart, Shidoku, have been studied to try to determine the conditions that lead to a unique completion of a given incomplete puzzle. In this talk, we consider instead the number of possible solution boards from incomplete puzzles. We present the algebraic group derived from symmetries of Shidoku boards. We then use this group to define equivalent puzzles in terms of the orbits of set elements under these group actions to classify all possible numbers of solutions from incomplete puzzles. We use Groebner Basis representations of Shidoku and Sudoku to obtain these results. Ultimately, we provide a complete classification of all the possible number of solutions that can result from incomplete Shidoku puzzles.

Kathleen Carroll, Wheaton College
Determining the Number of Distinct Loops of Non-Overlapping Regular n-gons

In his article Loops of Regular Polygons, K. Robin McLean completely characterized when a loop of non-overlapping regular n-gons of length s exists. In order to prove the existence of a loop for a given s and n, McLean showed how to construct one such loop. However, it is not known how many distinct loops of s regular n-gons exist. This is precisely the question I have chosen to address in my thesis this year. In my presentation, I will discuss my current findings thus far.

Elizabeth Collins-Wildman, Carleton College
Small Norm Matrices and Tensors

For matrices and tensors with ± 1 entries, norm estimates as a function of the order are important tools in functional analysis and operator theory. The operator norm of an order n matrix or tensor can never be smaller than $\sqrt{n}$; we determine sharp lower bounds. Using properties of Hadamard matrices (± 1 entry matrices H of order n such that $HH^T = nI$) along with combinatorial bounding arguments, we prove that for matrices of order $4n+1$, $4n+2$, $4n+3$, and $4n+4$ with ± 1 entries the minimal operator norm is $\sqrt{4n+4}$ provided that there exists an Hadamard matrix of order 4n+4. If the Hadamard Conjecture is correct, there exist Hadamard matrices of all orders divisible by 4. This would give sharp lower bounds on the norms of ± 1 entry matrices of all orders. We use an inductive argument to prove that for ± 1 entry tensors of order 2, the minimal norm is $\sqrt{2}$, regardless of the dimension.

Rebecca Dorff, Brigham Young University
The Cube Bubble in $\mathbb{R}^n$

When you dip a cube shaped wire frame in soap solution, the film naturally forms into a minimal surface. When a bubble gets trapped in the surface, it forms a surface with regions of nonzero curvature, but is still conjectured to be area minimizing. We prove for a standard case that the naturally occurring soap film with bubble is area minimizing for a cube frame in $\mathbb{R}^n$.

Melisa Emory, University of Nebraska at Omaha
Quadratic Solutions to $x^4 + y^4 = D^2 z^4$

The Austrian mathematician Alexander Aigner proved in 1934 that there are no nontrivial quadratic solutions to the Fermat equation, $x^4 + y^4 = z^4$, except in $\mathbb{Q}(\sqrt{-7})$. This result was reproved in 1960 by the Russian mathematician D. K. Faddeev. The argument was simplified in 1969 by the British/American mathematician L. J. Mordell. This talk discusses work to extend Aigner's result to beyond the case $D = 1$.

Avis Foster, George Mason University
Numerical Modeling and Analysis of Fluid Structure Interaction in Biological Systems

This research work expands on an analytical solution for a mathematical model of blood flow through an artery, and the blood's interaction with the arterial wall and the surrounding cerebral spinal fluid. A mathematical model is developed using a wave equation and boundary conditions derived from a combination of Fourier series, a spring-mass equation, and a simplified Navier-Stokes Equation. The coupled system is solved via a method of lines numerical approach that predicts the mechanics of the arterial wall. The resultant model was validated against the analytical solution and analyzed for application to cerebral brain aneurysms. Influence of various model parameters is also investigated.

Xiaojing Fu, Clarkson University
Understanding the Impact of Low Permeability Media on Remediation Strategy via Numerical Simulation

In groundwater remediation, contaminants trapped in low permeability soil after clean-up can cause re-contamination in the same area after a long period of time. Currently, there is a lack of understanding and tools to predict the behavior of the trapped contaminant in terms of its rate and extent of release from storage. Understanding this issue can help hydrologists decide the scale and type of treatment method that is suitable for a site as well when the re-treatment should occur. The motivation of this work is to study the behavior of trapped contaminant in low permeability media (LPM) and how it affects the long-term remediation strategy. The mathematical model in this study is based off existing equations that describe the groundwater flow, contaminant advection and diffusion, as well as contaminant sorption and desorption. The mathematical model is then developed into computer-simulated numerical model using certain numerical algorithms and then used to observe contaminant behavior.

Jennifer Garbett, Kenyon College
Metabolism, Microvilli, and the Manduca sexta Midgut: A Mathematical Model

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

Nicki Gaswick, University of Nebraska-Lincoln
Sound Diagnostics: Guitar Chord Recognition

Sound diagnostics is a broad field encompassing applications such as distinguishing between animal calls to recognizing vocal pitches in popularized video games. Specifically our research hoped to show that a computer could differentiate between pitches to definitively recognize the sound of a failing machine. We modeled the sounds/pitches a machine makes using guitar chords. Creating a library of accepted machine sounds, we used Daubechies wavelets and Fourier analysis to create an algorithm that was able to compare new guitar chord samples to our accepted library. In successfully creating the algorithm that can differentiate between 5 closely related cords, we determined that an algorithm may be created that could differentiate between pitches of failing machines and properly working machines.

Rita Gnizak, Fort Hays State University
Investigating the Properties of Pruned, Planar, Binary Fractal Trees

Symmetric binary branching fractal trees have been extensively described by Benoit Mandelbrot and Michael Frame, however, little is known about the effects that pruning has on the properties of these trees. Investigation of self-contact, connectedness, fractal dimension, and the space-filling properties of pruned fractal trees has lead us to the creation of a new method for calculating fractal dimension as well as a proof that the space-filling property of the special 90° and 135° trees is lost when any finite sequence of transformations is forbidden.

Kailee Gray, University of South Dakota
Positive Hankel Matrices are Sums of Squares

We will show that any given $n \times n$ positive semi-definite Hankel matrix B_k of rank k where the first entry is 1 can be written as a convex combination of k rank 1 Hankel matrices. These in turn can be written in the form $[\ 1 \quad a \quad a^2 \quad \cdots \quad a^n\ ]^t[\ 1 \quad a \quad a^2 \quad \cdots \quad a^n\ ]$ where $a \in \mathbb{R}$. More specifically, we will show

$$B_k = \sum_{j=1}^{k} c_j[\ 1 \quad v_j \quad v_j^2 \quad \cdots \quad v_j^n\ ]^t[\ 1 \quad v_j \quad v_j^2 \quad \cdots \quad v_j^n\ ]$$

where $v_j \in \mathbb{R}$, $0 < c_1, \ldots, c_k < 1$ and $c_1 + \cdots + c_k = 1$. The tools used to reach this result will include a representation theorem for positive polynomials and Smul'jan's theorem for positive semi-definite matrices.

Samantha Hilker, Sam Houston State University
Constructing Cube Knots

Knot theory is a branch of topology that studies mathematical knots. Our specific area of research this past summer was in cube knots, mathematical knots made out of cubes. Our presentation will explain the process of creating cube knots, compare our findings to the best known cube numbers found in literature, and we will give many examples of our findings.

Ruthi Hortsch, University of Michigan
On the de Rham Cohomology of Curves in Characteristic p Admitting an Automorphism of Order p

In algebraic number theory, we study algebraic curves both to further our theoretical understanding, and for their practical applications in cryptography. Specifically, one area of interest is the study of cohomology groups associated with a curve as representations of the automorphism group. I recently completed a project in which I studied the smooth projective curve associated to the curve $y^2 = x^p - x$ over a field of characteristic p and determined this structure for the first de Rham cohomology as a representation of its automorphisms. This talk will discuss the motivation and background for this topic, and then outline the details of the proof of this.

Jennifer Iglesias, Harvey Mudd College
Linear Complexity of Partially Ordered Sets

The linear complexity of a matrix is the minimum number of additions, subtractions, and multiplications necessary to multiply the matrix by an arbitrary vector. I define the linear complexity of a partially ordered set as the linear complexity of its Möbius inversion matrix. In my talk, I will present bounds for the linear complexity of several partially ordered sets. I will also present an intriguing conjecture relating the incidence matrix and Möbius inversion matrix for a partially ordered set.

Laura Janssen, University of Nebraska-Lincoln
Extensions of the Heisenberg Group

The Heisenberg group is a Lie group with applications in quantum physics and Fourier analysis. Therefore, it is important to understand its extension groups and how to construct them. This talk discusses central extensions of the Heisenberg group and ways of constructing them using 2-cocycles. We then go on to consider extension groups of the groups resulting from central extensions of the Heisenberg group.

Laney Kuenzel, Stanford University
The Development and Evaluation of a Geographic Profiling Algorithm

The Los Angeles Police Department (LAPD) currently uses a geographic proling software package that implements a simplistic algorithm based solely on distance to crime. In this project, a new geographic proling algorithm called the RIPS algorithm was developed and incorporated into prototype software. The algorithm, which is based on crime clustering, takes into account not only distance but also crime order, the spatial layout of crimes relative to one another, and population or demographic distribution. An evaluation metric called the population reduction score was developed and used to compare the RIPS algorithm with the algorithm currently used by the LAPD. On fifteen crime series provided by the LAPD, the RIPS algorithm slightly outperformed LAPDs current algorithm. However, due to the small size of the data set, no general conclusions could be drawn with certainty. More series data would allow for parameter optimization in the RIPS algorithm and likely lead to significantly improved performance.

Ellen Le, Pomona College
The Algebraic Structure of Toric Codes

Building on the recent work surrounding toric codes, introduced in 2000 by J. Hansen, we further investigate the properties of this interesting class of error correcting cyclic codes. A toric code C is generated by creating monomials from a set of lattice points P in dimension m, and evaluating each of those monomials over all m-tuples of non-zero elements in a finite field of size q. Just as “ordinary” cyclic codes can be studied via properties of polynomials in one variable, we show that toric codes, which are m-dimensional cyclic codes, can be studied via m-variable polynomials. We aim in our work to generalize explicitly what the algebraic structure is for toric codes. In particular, we give formulas for finding the roots of (generalized) toric codes and their dual codes,and from these roots we derive a formula for an idempotent polynomial that generates the toric code.

Thu Le, University of the South
A Guessing Game with Surprisingly Trivial Solution

Consider the following game: a vector called the target is randomly chosen from a given multivariate probability distribution. We along with n other players attempt to guess what the target is; the winner is the one whose guess is closest. Given certain assumptions about the other players' guesses, Drinen, Kennedy, and Priestley found an optimal strategy in the case $m = 1$. This paper generalizes their main results to an arbitrary m.

Shauna Leonard, Arkansas State University
Computer Simulation Study of Confidence Intervals for Intraclass Correlation Coefficients

A single score obtained on a particular exam with a single test grader is not fully dependable. It is important to take into consideration the variability due to the variables separate from student knowledge when using exam scores to make decisions. If we are interested in the knowledge of students, we do not want other factors to affect our decisions. The statistical analysis of variance (ANOVA) can be employed to assess the source and to estimate the magnitude of variability due to different sources. Furthermore, it is necessary to calculate the reliability coefficient which often takes the form of intraclass correlation coefficients (ICC). The confidence interval for an ICC is a useful way to estimate the population ICC based on a particular sample at hand. This research project involves computer simulation to examine the performance of proposed confidence intervals for ICCs under different random effects models.

Tova Lindberg, Bethany Lutheran College
Dominant Eigenvalues and the Structure of Matrix Spaces

The dominant eigenvalues of a matrix are an important tool in applied mathematics, but it turns out that dominant eigenvalues can also be used to study the algebraic structure of spaces of matrices. Even though the eigenvalues of a single matrix really only tell us about that particular matrix, those of polynomial combinations of matrices can tell us more. In particular, the dominant eigenvalues of a matrix in combination with a set of rank-one matrices carry more information. These eigenvalues can be used to extract structural information about the space of the matrices, and in this project, we characterize conditions for which this is the case. Analogous results can be shown for the spectral values of bounded linear operators on infinite-dimensional Banach spaces.

Kaitlyn McConville, Westminster College
Analyzing a Deficient Height Sample of Pennsylvanian National Guardsmen

Human height has often been used by economic historians as a proxy to measure economic well being. However, historical measures of height, specifically those found in military enlistment records, have many problems based on accuracy and truncation due to minimum height requirements. This project explores statistical and mathematical corrections to an empirical distribution of late 1800 Pennsylvania National Guard data seeking to correct these problems.

Lisa Moats, Concordia College
Cost-Conscious Voters in Referendum Elections

Referendum elections often require voters to cast ballots simultaneously on multiple proposals, some of which may be interrelated. When a voter's preferences on one proposal depend on the known or predicted outcomes of other proposals, the voter's preferences are said to be nonseparable. This talk will explore ways to mathematically model and analyze various forms of nonseparability, particularly with respect to cost-conscious voters.

Jillian Neeley, Ithaca College
Chebyshev Polynomials and Their Relationship to Trigonometry and the Fibonacci Numbers Part II

In this presentation, we will discuss Chebyshev Polynomials and their properties. In particular, we will focus on how we can connect them to trigonometric identities, the Fibonacci numbers, and the Lucas numbers. If we have a known trigonometric identity, we can translate this into a Chebyshev identity, which in turn can become a Fibonacci identity. We will exploit these relationships to prove Fibonacci and Lucas identities.

Marlene Ouayoro, George Mason University
Retrieving Economic Parameters In Asset-Flow Equations

This research attempts to replicate the observed price points of financial instruments by modeling with the Caginalp-Balenovich differential equation. We fit the equation to the observed curve using the Gauss-Newton Method to estimate the initial parameters and initial values of the data.

Kelsey Quarton, Bradley University
Rebecca Scofield, University of Iowa
Shapes and Symmetry

In this project, we explore the ideas of shape and symmetry. By looking at the groups of orthogonal transformations that fix symmetric shapes in space, we are able to act on shapes that are not quite symmetric, but may somewhat resemble polygons or poyhedra that we know to be symmetric. By comparing a dissymmetric shape to its image after an orthogonal transformation, we can quantify its amount of dissymmetry. We do so by performing various tests that we have formulated to create a grading scale that can be used to weigh the symmetry of such shapes. Research funded by: VIGRE (DMS 0602242) University of Iowa

Brooke Quisenberry, Hope College
How Does Inquiry-Based Statistics Curriculum Measure Up?

Research shows that students in an introductory Statistics course finish the class without gaining practical understanding of core statistical concepts. Students pick up the mechanics of statistics but have problems analyzing data collected in order to draw inferences or make predictions. This lack of understanding represents gaps within the traditional curriculum that statisticians at Hope College are attempting to alleviate with their Inquiry-based curriculum. This quasi-experimental study compares the traditional approach to teaching statistics with this Inquiry-based approach through the pre-post CAOS assessment scores of six sections of the intro Stats course. Through an evaluation of the curriculum based on the student learning outcomes, the following questions will be answered: How does an inquiry-based statistics curriculum measure up? Are the gaps found in the old curriculum filled by the new? How do student outcomes compare with the national outcomes of what students know, learn and never learn?

Hannah Ross, Kenyon College
Finding the Metric Center

Our work generalizes the concept of center of mass for a finite number of points. In a finite dimensional normed linear space, any finite set will have at least one metric center. Unlike the center of mass of a finite set in Euclidean space, the metric center of a set in a general normed linear space need not be unique, and all of the metric centers of a given set K together will form a convex set. Also, if we have two metric centers x and y for the same finite set K, the distance from x to k is the same as the distance from y to k for every k in K. In addition, we found that, in the plane, a taxicab metric center will always be either a point or a line segment. The function used to define the metric center is a convex function. Thus all of the directional derivatives of the function will exist for all points in its domain. So we can always find the metric center by following the negative of the gradient down to a global minimum. Convexity guarantees that this method will lead us to a metric center.

Karla Schommer, College of St. Benedict
Subtraction Games & Computer Applications

Subtraction games have been periodic. We combine programming skills and game theory to investigate patterns in the periods of subtraction games.

Rebecca Scofield
see **Kelsey Quarton**

April Scudere, Westminster College
Catalan Numbers and Random Trees

The Catalan numbers are a well-known integer sequence that arises in a variety of combinatorics problems. This talk will explore the occurrence of these numbers in a particular random tree construction created by Bahls, Knox, and McClure. They conjectured that the Catalan numbers appear as the number of recurrent states in a complex system associated with the construction. We will describe the basic tree construction and prove that the Catalan numbers give us the number of recurrent states. The proof will involve an inductive argument on the rows of Catalan's triangle.

Natalie Sheils, Seattle University
Stability of the Soliton Solution of the Two-Dimensional Nonlinear Schrödinger Equation

The two-dimensional (2D) cubic nonlinear Schrödinger (NLS) equation can be used to model the evolution of waves on deep water, pulse propagation in optical fibers, and Bose-Einstein condensates. The 1D soliton solution of the 1D NLS equation is linearly stable. However, the 1D soliton solution of the 2D NLS equation is unstable. Currently, both asymptotic and numerical results establish that the 1D soliton solution is unstable with respect to low-frequency 2D perturbations. Further, numerical results establish the soliton solution is unstable with respect to high-frequency 2D perturbations, but no analytic or asymptotic results exist in this limit. The goal of our current work is to examine the stability of the 1D soliton solution of the 2D NLS equation with respect to high-frequency perturbations using asymptotic analysis.

Kaitlin Speer, Baylor University
Continuous Threshold-Policy Harvesting in Predator-Prey Models

The dynamics of predator-prey models with continuous threshold policy harvesting on the prey is studied. Theoretical and numerical methods are used to investigate uniform boundedness of solutions, existence of bionomic equilibria, and the stability properties of coexistence equilibrium points and periodic orbits. Several bifurcations as well as some heteroclinic orbits are computed.

Meredith Stevenson, Murray State University
Using Percentage Change as the Universe of Discourse in Fuzzy Time Series Analysis

One of the main purposes of statistics is to predict future outcomes. A relatively new area of statistics is called fuzzy statistics. Fuzzy statistics can be described as the union of fuzzy logic and traditional statistical methods. This marriage of fuzzy logic and statistics is demonstrated by the fact that fuzzy statistics takes a linguistic quantifier and assigns it a numerical value in order to categorize data. Song and Chissom were the first to apply these methods to statistical forecasting, and thus pioneered the field of fuzzy time series analysis. In my project I will modify existing fuzzy forecasting methods for prediction and compare my results with the original models. I propose that using a percent of increase/decrease we will more accurately portray the significance of these changes between time periods and will have more accurate results. Calculations will be performed using car accident data provided in a paper by Jilani, Burney, and Ardil whose method I am attempting to improve upon.

Kiri Sunde, University of North Carolina
Spiraling to My Doom: The Revenge (In 3D!)

Given $n \geq 3$ points $P_0, P_1, \ldots, P_{n-1}$ in $\mathbb{R}^2$, we examine piece-wise linear spirals generated by taking convex combinations of m of those points. In particular, for each $k \geq 0$, let $P_{n+k} = t_1 P_k + t_2 P_{k+1} + \cdots + t_m P_{k+m-1}$ where $0 \leq t_1, t_2, \ldots, t_m \leq 1$ and $t_1 + t_2 + \cdots + t_m = 1$. For each $k \in \mathbb{N}$, let $Q_k = P_k - P_{k-1}$ be the vector connecting consecutive points. We establish conditions on $P_0, P_1, \ldots, P_{n-1}$ such that the lengths $\|Q_k\|$ form a geometric sequence. We call the resulting piece-wise linear spirals *geometric spirals*. We prove that the geometric ratio is the modulus of an eigenvalue of a certain matrix and that the angle between consecutive Q_k's is constant and calculable from the starting points. Our research culminates in the following theorem: Given a spiral in $\mathbb{R}^3$, if the spiral is geometric then the points of the spiral are coplanar.

Kaylee Sutton, John Carroll University
Pell's Equation and quadratic non-residues.

The equation $y^2 - nx^2 = \pm 1$ is Pell's Equation. When n is an odd prime, the theory of quadratic resides and non-residues applies or can give insights to solutions.

Frances Tirado, University of Florida
The Gauss-Bonnet Theorem Unveiled

Upon obtaining a primitive form of this celebrated and fundamental result, Gauss proclaimed This theorem, if we mistake not, ought to be counted among the most elegant in the theory of curved surfaces. The goal of this talk is to convince the audience that Gausss wisdom applies to the modern generalization. We will discuss how differential geometry, algebraic topology, and analysis are intertwined by the Gauss-Bonnet Theorem. The speaker will illuminate the beautiful underlying mathematics in manner which requires little background knowledge. First, simplicial complexes will be introduced in order to contsruct the topologically invariant Euler characteristic. Next, curvature will be defined by introducing the concept of a tangent space, the shape operator and the second fundamental form. Finally, applications of the theorem will be discussed as time permits.

Anna Tracy, University of the South
The Linear Chromatic Number of a Graph

We study linear colorings and the linear chromatic number of graphs and describe a strategy we use to find linear colorings of graphs. We compute the linear chromatic number for specific graphs and briefly discuss linear N-graphs. We then find bounds on the linear chromatic number of graphs.

Kelsey Uherka, Morningside College
Selectivity Rado Numbers for the Equality $cx_1 + x_2 = x_3$

The t-color selectivity Rado number for the equality $cx_1 + x_2 = x_3$, where $c \in \{1, 2, 3, \ldots\}$, is defined to be the least integer n that guarantees either a monochromatic solution or a totally multicolored solution to the equation, regardless of the assignment of the t colors to the set of integers $\{1, 2, 3, \ldots, n\}$. This presentation summarizes my results for specific values of c and t.

Danielle Wheeler, Coe College
Sona Drawings

A Sona drawing is an art form of storytelling that originated in southwest Africa. Sona drawings are highly mathematical yet relatively unexplored in the mathematical world. Drawings are created by drawing diagonal lines through a selected grid, turning 90 degrees at each edge. The mathematical question: which grids are monolinear (able to be drawn with one continuous line)?

Lindsay Willett, Grove City College
Taking Curvature to the EXTREME!

Let F be a real polynomial of degree N. Then the curvature of F is defined to be

$$\kappa = \frac{F''}{(1+(F')^2)^{\frac{3}{2}}}.$$

Determining the maximum number of zeros of κ is an easy problem: since the zeros of κ are the zeros of F'', the curvature of F is 0 at most $N-2$ times. A much more intriguing problem is to determine the maximum number of relative extreme values for the function κ. In 2004, Edwards and Gordon showed that if all the zeros of F'' are real, then F has at most $N-1$ points of extreme curvature. My group examined the level curves of certain auxiliary functions in the complex plane to try and remove the hypothesis that the zeros of F'' have to be real. We provide a partial solution to this problem, showing that aF has at most $N-1$ points of extreme curvature, given that $a \in \mathbb{R}$ is smaller than a given bound. The conjecture that F has at most $N-1$ points of extreme curvature remains open.

Heather Williamson, Rice University
Physics of Springs: Systems with Error

Given a matrix A and a vector b, the problem of finding a vector x such that $Ax = b$ is well understood. However, if A and b have some error, the problem of recovering x is more subtle. We approach this problem by considering one particular case. We construct a planar network of interconnected springs and a system of linear equations: A is the adjacency matrix for the network, E is the diagonal matrix with the elongation for each spring, k is the vector of spring constants, and f is the force applied to each node. Hooke's Law states that the elongation of a spring is equal to the force applied to it times the spring constant, so our system is $AEk = f$. We first study how the structure of the network affects the recovery of the data, how different methods for calculating k compare, and how the condition number of AE affects the recovery of the data. Next, we run a large number of physical experiments and determine the probability distribution of the solutions, then compare the mean to the expected value of k.

Chengcheng Yang, Rice University
The Erdös Box Problem

Given an $N \times N \times N$ grid, let A be a set of vertices of the grid that does not contain the eight corners of any nontrivial box inside the grid. A few applications of Cauchy-Schwartz inequality give that the cardinality of A is at most $O(N^{\frac{11}{4}})$, and Erdös conjectured it to be sharp. The best known lower bound is on the order of $O(N^{\frac{8}{3}})$, which was shown by Katz, Krop, and Maggioni through the construction of bilinear maps in a finite field $GF(p^3)$, $p > 2$. By studying some special cases and then generalizing them, I will examine whether the bilinear map of katz's construction is actually unique up to isomorphism. This will help determine whether a similar construction might be used to improve the lower bound.

Jie Zeng, Michigan Technological University

Application of Functional Data Analysis in the Study of Aerosol light Absorption and Scattering

Aerosols play a key role in earth's climate changes and energy radiative balance. For this reason, it is important to study their levels and interactions with other atmospheric variables. One of the problems in the study of aerosols is the estimation of the aerosol levels due to instrumental variability. In this poster we use smoothing splines estimators to estimate background measurements of aerosol absorption and dispersion in Mexico City. The use of smoothing splines allows us to use well established standard criteria for estimation of the aerosol background functions, all necessary parameters, and their variability.