The Eighteenth Annual Nebraska Conference for Undergraduate Women in Mathematics

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TALK ABSTRACTS

PLENARY TALKS

Dr. Emina Soljanin
Professor of Electrical and Computer Engineering
Rutgers University
How Does Applied Math Become Applicable?

It has been widely acknowledged that research in mathematical sciences has been crucial in making communications devices, systems, and networks possible. But which research exactly? The one considered the most applicable at the time it was being conducted, the one cast in the best power point presentation, the one proving the most fundamental theorems, the one with the most dedicated owners, the one with the most charismatic proponents, or none, or all of the above? In this talk, I will tell you what, after more than two decades of working at Bell Labs, I think was hard, what was easy, and why I believe the toughest uphill battles for applying math to networking are still in front of us.

Dr. Abigail Thompson
Professor of Mathematics
University of California Davis
Knots and Low-Dimensional Topology

Low-dimensional topology is the study of 2, 3 and 4-dimensional spaces. Topologists are interested in the properties of these spaces that don't change much if the space is deformed a little; for example, even though the surface of the earth isn't perfectly round, topologists are content to call it a sphere. I'll talk about some of the ideas that drew me to low-dimensional topology in the first place, and about some of the questions, particularly in knot theory, that keep me there.

Talks by Undergraduate Students

Shuchi Agrawal, Brown University
On the Topology of the Space of Coverings

We will discuss original results regarding the topology of configuration spaces of coverings. For our purposes, a configuration space of k-coverings of an object by closed disks is the space of all points where each point represents a valid k-covering of our object. First, we deduce the homotopy type of the space of k-coverings of the unit intervals with 1 excess ball (i.e. using $kn+1$ balls of uniform radii). Then, we deduce the homotopy type of the space of k-coverings of the circle, with no excess balls (i.e. exactly k balls). Many open questions relating to both problems also arise.

Esther Banaian, College of Saint Benedict
Generalization of the Eulerian Numbers and Multiplex Juggling Sequences

We consider a generalization of Eulerian numbers which count the number of placements of cn "rooks" on an n by n board where there are exactly c rooks in each row and each column, and exactly k rooks below the main diagonal. The standard Eulerian numbers correspond to the case $c = 1$. We provide a method for counting these objects, compare their properties to standard Eulerian numbers, and show how they relate to juggling sequences!

Erin Brine-Doyle, University of St. Thomas
Emily Vecchia, University of St. Thomas
Comparing Methods of Identifying Knotting Behavior in Open Chains

The recent discovery of open arc knotting in physical systems such as polymers, proteins, and DNA has motivated studies aimed at classifying knotting in open chains. Knotting is trapped in closed knots making it possible to study the knotting in closed curves mathematically. By using different schemes to close the endpoints of an open arc knot, one can define the knotting of open chains in a number of different ways. The purpose of this project is to analyze and compare five different methods used to classify knots in open chains. These methods are known as the Infinite Method, the Random Equilateral Arc Method, the Straight Line Method, the Center of Mass Method, and the Convex Hull Method. The knotting in open chains is classified with these five methods and then the results are compared and analyzed statistically.

Monica Busser, Youngstown State University
Unique Hamiltonicity and Computational Algebraic Geometry

A Hamiltonian cycle is defined as a path through vertices and edges where every vertex is passed through only once. Graph theorists have long considered questions of unique Hamiltonicity, as there is no easy way to determine how many Hamiltonian cycles a graph has. One conjecture of particular interest is Sheehan's Conjecture (1975), which remains open and states that there are no uniquely Hamiltonian 4-regular graphs. Recent methods put forth by De Loera et al use computational algebraic geometry (and in particular Gröbner bases and standard monomials) to determine the amount of Hamiltonian cycles in a graph. We will discuss the development of our algorithm which is based on these methods and determines unique Hamiltonicity. We will also discuss our results regarding Sheehan's Conjecture as well as other conjectures.

Kate Causey, Furman University
Collaboration: A Mathematical and Medical Partnership

I will be presenting on my experiences working under a statistician in a medical context. I will highlight the benefits and difficulties of interdisciplinary communication with specific examples of statistical evaluations of medical research projects. In these examples, I aim to emphasize the importance of clear communication between all involved researchers at all stages: data collection, analysis, and results.

Sarah Chehade, University of Houston
Ranking Methods for Multi-Player Competitions

Ranking methods are used to rate sports teams, webpages, and preferences for Netflix movies. One well-known ranking method, which is used by the Bowl Championship Series in NCAA college football, is known as Massey's method. Massey's method considers a tournament (or a season) of games in which two players (or teams) compete, and for which there is one winner and one loser in each game. Using the scores from all of the games, Massey's method assigns a rating to each team allowing one to describe which teams are better than others. In this talk, I will discuss a generalization of Massey's method to tournaments of multi-player games. For a fixed number p, each game in the tournament will have p players compete and will end with 1 winner and $p-1$ losers. I'll discuss a way to assign a ranking to teams in this situation, and discuss applications of this ranking method to surveys and determining people's preferences in situations where multiple options are available.

Jiarui Chu, Davidson College
Random Visibility in Unit Bars

Two unit bars are visible to each other if an unobstructed vertical sightline can be drawn between them. The study of visibility in bars is motivated by Very-Large-Scale-Integration (VLSI) layout problems, and has applications in robot navigation, hidden-surface removal, and computer-aided software-engineering (CASE) tools. Although there is a rich body of research on visibility in bars, the existing research is mainly done in fields of computational geometry and graph theory. No result has been published on the probability aspects of visibility problems. Our research focuses on three major problems. Assuming n unit bars have uniformly distributed locations within width w, we first conjecture and prove the probability of having zero visibility among the n bars. Then we conjecture the probability density function and expected value for the number of bars required to cover the top bar. Finally, we derive the expression for the maximum number of visible pairs among the n bars.

Courtney Cochrane, Davidson College
K-forcing in Neurodegenerative Disease Spread

Neurodegenerative disease spread, both on a microscopic and macroscopic level, has been the subject of much previous study. Successfully modeling the spread of disease will allow for a more informed understanding of the disease, factors which influence progression, and possible treatment options. Graph Theory allows us to produce artificial neural networks that simulate connections between regions in the brain, and model changes in the brain, including those associated with brain diseases. Using this graph theoretical framework to model the brain enables application of a technique called k-forcing which uses graph coloring to indicate disease spread across the regions of a neural network. We use an adapted version of k-forcing to model the spread of neurodegenerative disease throughout the brain, and analyze the subgraph containing the healthy nodes. We examine the effects of k-forcing with different disease spread patterns and glean some interesting results which can inform future study in this area.

Angie Davenport, James Madison University
A Seasonal Matrix Model for Growth of Lycium carolinianum in Coastal Marshes

In this presentation we will discuss a proposed stage-based matrix model of the Carolina Wolfberry Lycium carolinianum that can provide insight into the ecosystem that encompasses the Aransas National Wildlife Refuge and the migrating Whooping Crane, or Grus americana.

Sara DeBrabander, University of Wisconsin-Eau Claire
Michelle Gebert, University of Wisconsin-Eau Claire
Lattice Point Visibility on Generalized Lines of Sights

Integer lattice point visibility has been studied since 1971 on straight lines through the origin with rational slopes. Harris, Kubik, and Mbirika generalize this notion of lines of sights to include all curves through the origin given by functions of the form $f(x) = \frac{a}{b}x^n$ where $\frac{a}{b} \in \mathbb{Q}$ and $n \in \mathbb{Z}^+$. Many questions remain open in this new setting of generalized lines of sights. In the classic setting where $n = 1$ a lattice point is visible if there exists no other lattice point between the origin and the point. The visible points are the points (x, y) where $\gcd(x, y) = 1$. We explore the process of identifying the first visible lattice point on a given curve $f(x) = \frac{a}{b}x^n$ in this new generalized setting. Also we explore the form of any given lattice point on f in this setting. This allows us to find the number of lattice points on f between the origin and a given lattice point (x, y). We compare these findings to the classic setting.

Rachel Domagalski, Central Michigan University
Dana Lacey, North Central College
On the Catenary Degree of Numerical Monoids Generated by a Generalized Arithmetic Sequence

We give a closed form for the catenary degree of any element in a numerical monoid generated by a generalized arithmetic sequence in embedding dimension three. While it is known in general that the largest and smallest nonzero catenary degrees are attained at Betti elements, the current literature contains no information about the other realizable catenary degrees. By classifying each element in terms of its Betti element divisors, we identify all the catenary degrees achieved and where they occur. In addition, our research provides the dissonance number and the period value, even though previous works have shown only that the catenary degree is periodic using a non-existential proof.

Marissa Eckrote, University of Wisconsin-La Crosse
A Permutation Test for the Spread of Three-Dimensional Rotation Data

Statistical inference procedures that require no distributional assumptions make up the area of nonparametric statistics. The permutation test is a nonparametric test that can be used to compare measures of spread for two data sets, but it is yet to be explored for three-dimensional rotation data. A permutation test for such data is developed and the statistical power of this test is considered under various scenarios. The test is then used in an application comparing movement around the calcaneocuboid joint for a human, chimpanzee, and baboon.

Sarah Fleming, Williams College
Nina Pande, Williams College
The Relationship Between a Ring and its Completion

If R is a Noetherian ring with exactly one maximal ideal, we can define a metric on R based on its maximal ideal and complete R with respect to that metric. The relationship between a ring R and its completion can be studied through the natural map from the prime ideals of the completion of R to the prime ideals of R given by intersecting ideals of the completion with R. If p is a prime ideal of R, the inverse image of p under this map is called the formal fiber of R at p. In this talk, we show that there are rings whose formal fibers have unexpected properties. All relevant concepts beyond basic ring theory will be defined during the talk.

Nina Galanter, Grinnell College
The Territorial Raider Model with Strategic Movement and Multi-Group Interactions

We analyzed the territorial raider game, a graph based competition for resources, with strategic movement. First we investigated the game in which players are individual organisms. Using a machine learning algorithm, we discovered that strict Nash equilibrium strategy sets only occur when all players raid one another and raiders do not compete. This indicates equilibria are generated by derangement functions of graphs. Thus, we found that a graph will permit a derangement if and only if it permits a strict Nash equilibrium. We then extended the game to the case where players are divisible "hives" or "armies". We examined both discrete and continuous division of armies. Our results include Nash equilibria for regular graphs and regular bipartite graphs in both cases. We found that while group entities defend in more situations than in the individual organism game, the portion of a group defending varies based on the degree of vertices and the advantage given to owners in protecting resources.

Michelle Gebert, University of Wisconsin-Eau Claire
see **Sara DeBrabander**

Cassie Hartley, James Madison University
Analysis of a Metapopulation Model with an Allee Effect

A metapopulation is a collection of subpopulations of the same species living in separated habitats (called patches) coupled by migration. We will consider a metapopulation for which each subpopulation has a carrying capacity and an Allee threshold. An Allee threshold for a patch is a population under which the species is not viable in the patch. We develop a model for such a metapopulation in an arbitrary number of patches, and study the dynamics in two patches in detail. We are especially interested in conservation, so we study which combination of parameters and initial populations lead to persistence of the population. Using detailed simulations in MATLAB, Python, and Sage, we describe the basin of attraction for the zero population, that is, the range of initial conditions for which the population goes extinct; these are the initial conditions we want to avoid, and if there are too many of them, the population is more likely to go extinct.

Sarah Hilsman, Hope College
Level Curves of a Real Algebraic Function: A Generalization of a Theorem of Pólya

We consider an old theorem of George Pólya's which looks at the level curves of certain polynomial functions and the intersection of such curves with lines of positive slope. We extend Pólya's theorem, relaxing conditions on the polynomial functions and considering intersections with lines of negative slope. The degree two case gives us hyperbolic paraboloids, leading to a brief visual demonstration of solid analytic geometry (the algebraic study of the real vector space $\mathbb{R}^3$).

Jordan Hunt, Northern Arizona University
Perfect Numbers in the Eisenstein Integers

Perfect numbers are positive integers equal to the sum of their proper positive integral divisors. Mathematicians from Euclid to Euler investigated these mysterious numbers. We present results on perfect numbers in the imaginary quadratic field of Eisenstein integers.

Yilin Jiang, University of Oklahoma
Applying Finite Element Method in Reservoir Simulation

Partial differential equations (PDEs) are extensively applied in oil industry, such as the flow of fluids through porous media and reservoir simulation. However, due to complicated boundary conditions and pragmatic constraints, analytic solution of corresponding PDEs is hard to find. Therefore, numerical methods, such as finite difference method (FDM) and finite element method (FEM) are introduced to solve these problems. Our project explores a more efficient finite-element procedure via Galerkin-based rule and distinct test functions to solve a specific equation that describes the two-dimensional, three-component, and single-phase flow problem, compared to analytical solution.

Ratna Khatri, George Mason University
Consensus vs. Fragmentation in a Model of Opinion Dynamics

We consider a continuous version of the Krause model of opinion dynamics. Interaction between agents either leads to a state of consensus, where agents starting out with random initial opinions converge to a single opinion as time evolves, or to a fragmented state with multiple opinions. We linearize the system about a uniform density solution and predict consensus or fragmentation based upon the most unstable mode of the dispersion relation. Analytical predictions are then compared to numerical simulations.

Dana Lacey, North Central College
see **Rachel Domagalski**

Rayanne Luke, State University of New York at Geneseo
Pushing the Bounds of Numerical Ranges

The numerical range W of an $n \times n$ matrix M with complex entries is the compact and convex subset of $\mathbb{C}$ defined as $W(M) = \{x^*Mx : x \in \mathbb{C}^n, ||x|| = 1\}$. An integer lattice point is of the form $a + bi$, where a and b are integers. Seeking invariant upper bounds for the area of and number of lattice points contained within the numerical range, we begin by finding the exact area of the numerical range of a 2×2 matrix, whose shape is an ellipse. Generalizing to upper area bounds for any size matrix, we circumscribe the numerical range by a circle. To provide a universal bound, we define a translation to ensure that the numerical range contains the origin. Thus, we arrive at the author's new proof of an upper bound for the area of the numerical range of any matrix, where the formula is expressed in terms of the trace of the matrix. We also use the trace of the matrix to bound the number of lattice points contained within the numerical range.

Crystal Mackey, Youngstown State University
Numerical Results for the IVP to the Burgers Equation with External Forces

In this project, we use Burgers equation to study traffic flow, including shock and rarefaction waves, where traffic density, traffic flow, and velocity are the main variables expressed as functions of position and time. The derivation of the conservation law from physical principles can be reduced to Burgers equation. The initial value problem (IVP) of Burgers equation is a partial differential equation with an initial condition. Our objective is to numerically approximate solutions to the IVP for Burgers equation with external forces. After deriving the Lax-Wendroff method and modifying it to improve numerical approximations, adaptations were made to include an external force term. External forces may help to capture physical traffic interpretations such as traffic lights, driver interactions, multiple lanes, or on and off ramps on a highway. Our goal is to approximate solutions to the IVP for Burgers equation with external forces and compare our numerical simulations to real data.

China Mauck, Grinnell College
Integrating Fish Movement in Multispecies Population Modeling

A major issue with modeling fish population dynamics is tracking movement of species between regions. Two different veins of models have been explored: data-driven and partial differential equations. A discrete model is formulated that incorporates population growth, predation, and movement based on the relative proportions of a species population. For any population growth/predation model posed, the choice of a transition matrix is non-unique within a family. Additional constraints are needed to close this model. Further, a variety of different PDE formulations is considered, which take into account fish movement, seasonal and long-term temperature fluctuations, and spatial dependence on nutrients. A comparison of these models is discussed.

Kathleen McLane, George Mason University
Mathematical Modeling, Dynamics, and Simulation of Search and Rescue Operations through UAVs

The use of unmanned aerial vehicles (UAVs) to accomplish tasks is a fast growing field in technology today for search and rescue operations. This multidisciplinary area requires precise mathematical modeling, description of associated mechanics, and evolution of probabilistic algorithms. We consider the development of a UAV model that incorporates the dynamics along with a decision-making framework using probabilistic search algorithms. The governing differential equations describing the dynamics are solved via numerical algorithms, and its performance compared for our model. Bayes filters are implemented to detect the presence of targets in the search area through calculations of belief functions. The proposed models are validated computationally for benchmark applications including searching a savannah in Africa for poachers to identifying residues of pesticides in crops. The computational results will be compared against experimental results obtained via drones that are built as a part of this research.

Shambavi Natarjan, Westminster College
Kramers-Kronig Relations in Spectroscopy

In spectroscopy, researchers study the interactions that a beam of particles has with a matter target in order to produce spectra, which are functions of properties that vary with the energy of a particle. The Kramers-Kronig (KK) relations obey the "principle of causality" and were found to link certain pairs of spectral properties, such as particle speed and absorption rate in a sample material. I will explain the mathematical foundations of the KK relations and use them to extract the phase shift spectra of a beam of photons of light from its reflection spectra obtained from isotopic species of water.

Stina Nyhus, Utah Valley University
The Math Behind Art Designs

In this presentation it will be shown how math, together with simple origami folds and the free software GeoGebra, can be used to construct amazing math-art designs. Many authors (T. Hull, D.P. Scher, S. Smith, etc.) have researched origami folding in connection with the conic sections and used dynamic software to demonstrate those folds. Work done by V. Vasilevska has explored and animated segments of tangents to parabolas in creating math-art designs. We expand on those methods by animating segments of tangent lines to ellipses and hyperbolas. First, the math behind these construction methods will be discussed. Then it will be demonstrated how geometry was used to construct several GeoGebra tools that take a constraining polygon/curve to find a best-fit conic section within it. Using GeoGebra we then animate those tangent segments which results in beautiful works of geometric art featuring the best-fit conic. Furthermore, we showcase those constructed math-art designs and discuss possible applications.

Ashley Orr, Youngstown State University
A Study of Youngstown Public Housing Program Participants' Preferences

Public housing programs are among the most costly public assistance programs in the United States and yet still only serve one in four eligible households. The Department of Housing and Urban Development (HUD) promotes affordable housing to low income households through a variety of programs administered by local and regional public housing authorities (PHAs). Although much research has focused on the superiority of one program over another, this paper takes a different approach and analyzes the preferences of public housing participants. Using a unique cross section of households served by the Youngstown Metropolitan Housing Authority, logistic regression is used to predict the likelihood that low income program participants prefer Section 8 vouchers over HUD owned and maintained public housing units in the Youngstown metropolitan area. Surprisingly, Youngstown households' preferences lie with public housing units.

Adele Padgett, University of Chicago
An Investigation Into Some Covers of Finite Spaces

Covering spaces are important objects in a variety of areas of mathematics. As the investigation into finite spaces and their properties continues, information about what covers of these spaces look like and how to construct them could become useful. One way of searching for this information is to look for similarities between covers of finite spaces and covers of spaces we are accustomed to working with. In this paper, we will investigate the relationship between the wedge of two circles and the 5-point space weakly homotopic to it. Afterword, we will suggest an intuitive way to find covers for any height-2 poset by looking at other wedges of circles.

Nina Pande, Williams College
see **Sarah Fleming**

Priyanka Prasad, Butler University
Row Standard Young Tableaux: the Two-Row Case

Young diagrams are combinatorial objects with multiple applications in representation theory first introduced in 1900 by Albert Young. They are formed from simple arrangements of a fixed number of square boxes placed in left justified rows. A Young diagram in which each box is labeled with a number following a prescribed set of rules is referred to as a Young tableau. A diagram labeled using the most well-known set of rules becomes a standard tableaux. The number of distinct standard tableaux of a given shape and size can be calculated using the hook length formula. Row-standard tableaux are formed using another less studied set of labeling rules. No formula exists to determine the number of row-standard tableaux of a given shape and size. This talk will explore a formula to count two-row row-standard tableaux. It will discuss a standardization function which groups tableaux into equivalence classes. This work is connected to current research on closures of irreducible components in Springer varieties.

Sruti Prathivadhi, Creighton University
Mathematically Modeling Cancer Metastasis Through Mechanical Properties

Accounting for over 90% of cancer deaths, metastasis is a complex process by which cancer translocates to organs away from the primary tumour site. Unfortunately, existing cancer drugs do not target metastasis as our understanding of the field is limited. In our project, we consider the fluid dynamics of the microcirculation using a microfluidic platform which mimics capillary constrictions of the pulmonary and peripheral microcirculation. Using the Navier-Stokes equation, finite element analysis and COMSOL Multiphysics® simulations, we extract the elastic and viscous properties of the cancer cells, subjected to various chemotherapeutic drugs. The mechanical properties enable us to assess, in a non-invasive manner, the pro- and anti- metastatic effects of these cancer drugs. Our work is a first step towards establishing cell mechanics as a readout to assist in effective anti-metastatic drug development.

Hannah Prawzinsky, Northern Arizona University
New coprime vertex labelings

A prime vertex labeling is an injective assignment of the labels $\{1, 2, \ldots, n\}$ to the vertices of an n-vertex simple connected graph such that adjacent vertices receive relatively prime labels. I will present new labelings for several infinite families of graphs. No prior knowledge of graph theory will be assumed.

Lattie Reddoch, Furman University
Optimizing School Zones

Evidence suggests that the socioeconomic status of a students classmates directly correlates to that students academic performance (Kahlenberg, "From All Walks of Life: A New Hope for School Integration," American Educator, 2012). However, many school districts neglect socioeconomic status when creating their attendance zones. In this work, we seek to assign students to high schools in Greenville County, South Carolina – one of the largest school districts in the country by area and by population – so as to balance the distance travelled and socioeconomic factors. The methodology of this work highlights how this assignment might be achieved for other school districts.

Majerle Reeves, California State University, Fresno
Optimizing An Immunization Scheme for Influenza

In its efforts to combat seasonal influenza, for years the CDC has advocated distributing the flu vaccine in such a way that children and the elderly are prioritized. In this research, we seek to determine whether or not the current flu vaccination scheme is optimal and if so, what is the best way to immunize a population. We use data from recent flu activity in the United States and inter-regional travel to create a model of flu activity within California. The model is then used to optimize the distribution of vaccines. Our experiments show that the current vaccination scheme is correct in prioritizing children and elderly, but that a more concerted effort should be made to vaccinate children and the elderly. The conclusions reached give public health authorities a strategy to keep levels of influenza infections to a minimum given cost and supply limitations in distributing the flu vaccine.

Zoe Rehnberg, Washington University in St. Louis
ETF-Based Models for Liquidity Risk

An exchange-traded fund (ETF) is a security that represents a collection of assets and provides a more liquid market for positions dependent upon those assets. Liquidity in ETF markets is of interest to many financial institutions that must manage the risk of buying and selling assets in these markets. Under illiquid conditions, large transactions can result in high trading costs or an inability to sell a position. To accurately assess liquidity in the underlying basket, financial institutions rely on metrics that model and track changes in liquidity over time. A metric developed in 2014 exploits the difference between the ETF share price and the net asset value (NAV), or price per share of the basket of underlying assets, to quantify liquidity. Because these two values are based on the same securities, the difference between them can be attributed to a liquidity difference. In our work, we expand this model beyond simple use of ETF price and NAV to include the effects of market depth and time-to-liquidation.

Alanna Riederer, University of Central Oklahoma
Modeling in Ecology: Simulating the Reintroduction of the Extinct Passenger Pigeon

The Passenger Pigeon was an iconic species of bird in North America that comprised 25-40% of North American avifauna. Passenger Pigeons went extinct in 1914 due to excessive hunting. Current research aims to de-extinct the Passenger Pigeon. To determine under which conditions a Passenger Pigeon could survive a reintroduction into a natural habitat, we used an agent-based model. The model incorporates logistic population growth, an Allee effect, and a Holling Type III functional response. The model is spatially explicit to simulate the population dynamics of the Passenger Pigeon in a number of present-day forest environments. It incorporates the following stochastic processes: varying availability of food sources, reproduction, and natural death of the Passenger Pigeon. Bio-energetics, tree distributions, and other ecological values were obtained from literature. Results from our simulations suggest that the Passenger Pigeon could survive a reintroduction into a natural environment.

Emily Roberts, Coe College
Differential Outcomes by SES in Children Undergoing Treatment for Acute Lymphoblastic Leukemia

The most common pediatric malignancy is acute lymphoblastic leukemia (ALL). This research focused on identifying differential outcomes for treatment-related toxicities by different socioeconomic status of patients. Two protocols of clinical trials for ALL at the Dana-Farber Cancer Institute were analyzed under mentor Dr. Donna Neuberg. Patients in the clinical trials were children and adolescents newly diagnosed with ALL. Survival analysis was used to compare relapse free survival. Logistic regression used to create a model to explain the incidence of toxicities. There are some differential toxicity outcomes by socioeconomic status for patients with ALL. Prospective studies to investigate potential causes are necessary.

Megan Roddie, Sam Houston State University
The First Subconstituent of a Strongly Regular Graph

We search for strongly regular graphs using the first and second subconstituents of the graph, making an assumption about automorphisms acting on those constituents.Assuming an abelian group acting on the first constituent, we find the linear representations of the group, a sum of roots of unity lying in a cyclotomic extension of the rationals. We examine parameters (v, k, λ, μ) where primes 5 or 3 divide the valency k. Three examples of this case are $(121, 40, 15, 12)$, $(196, 65, 24, 20)$, and $(64, 21, 8, 6)$. In the first two cases we use a 5th root of unity to determine the possibilities for the trace of the representation. Then using different methods, such as bounds for certain matrix entries and knowledge about Galois automorphisms, we eliminate some of the possibilities that survive the first test. The same process is used for the parameter set $(64, 21, 8, 6)$ but instead uses a cube root of unity.

Huei Sears, Michigan State University
Properties of the Roots of Tribonacci-type Polynomials

Consider Tribonacci-type polynomials defined by the following recurrence relation $T_n(x) = \alpha(x) \cdot T_{n-1}(x) + \beta(x) \cdot T_{n-2}(x) + \gamma(x) \cdot T_{n-3}(x)$, where recurrence coefficients $\alpha(x), \beta(x)$, and $\gamma(x)$ and initial conditions $T_0(x), T_1(x)$, and $T_2(x)$ are arbitrary functions of x. In this talk, we present matrix representations of $T_n(x)$, namely $M_n(x)$, such that $\det |M_n(x)| = T_{n-1}(x)$. Using this determinant representation, I discuss the nature of all roots of all polynomial sequences of this form using an alternative method of Gerŝchgorin's Circle Theorem, Laguerre's application of Samuelson's Inequality, and an application of Rouché's Theorem. Special cases of $T_n(x)$ mentioned include a recurrence with only real roots and a recurrence with only complex roots. I conclude with a presentation of ordinary generating functions for all polynomials mentioned.

Emily Stark, Austin Peay State University
A Game Theory Approach to the Cost-Benefit Analysis of a Public versus Private University Degree

The purpose of this research is to look at the legitimacy of the signaling capabilities of a university degree from a public or a private university to the employer. The project will be addressing the article Job Market Signaling by Dr. Michael Spence from 1973 and modeling his analysis with an extensive-form game. Spence's article is set from the viewpoint of the employer so for comparison, the applicants viewpoint will also be modeled with an extensive-form game. It is expected that, in the context of the economy, at some point the signaling ability of a more prestigious university will be compromised due to the price of a private institution. In other words, these models support that at a certain point the cost of a private institution is greater than the signal the employer receives pertaining to the applicants work effort and skill level.

Sara Stover, Mercer University
Classification of Skew Sturmian Sequences

Sturmian sequences are a class of bi-infinite sequences defined by Morse and Hedlund in 1940. In our research, we examined a less-studied subclass of these called skew Sturmian sequences and tried to understand the shift spaces they generate. We classified these shift spaces up to conjugacy, an important equivalence relation in symbolic dynamics.

Melissa Theobald, Northern Arizona University
Cycles in Various Nonlinear, Age-Structured Population Models

We consider N-dimensional, age-structured models of the normally 1-dimensional Beverton-Holt, Ricker, and Pennycuick population models. Our particular interest is in the impossibility of certain p-cycles in models of corresponding dimension as well as the impossibility of certain q-cycles in p-dimensional models where q divides p.

Claressa Ullmayer, University of Alaska Fairbanks
Survival Analysis Dimension Reduction Techniques: A Comparison of Select Methods

Formal studies across many fields may obtain copious amounts of "redundant" data to explain pertinent outcomes. Thus, dataset dimensionality reduction becomes imperative for facilitating the explanation of phenomena given abundant covariates. Principal Component Analysis and Partial Least Squares are established methods used to obtain components, such that the covariance and correlation is maximized between linear combinations of predictor and response variables. The performance of Johnson-Lindenstrauss Euclidean random matrices were also investigated. The performance of these techniques was explored by simulating 5,000 datasets using R statistical software. The semi-parametric Accelerated Failure Time model was utilized to obtain predicted survivor curves. Bias and mean-squared error between true and estimated survivor curves was ascertained to find the error distributions of all methods. The results indicate that PCA outperforms PLS, and the three random matrices outdo both PCA and PLS.

Gabrielle VanScoy, Youngstown State University
A Bone Eat Bone World: Math Models of Bone Metabolism

Bone mass and density are regulated by bone cells (osteocytes, osteoblasts, and osteoclasts) in response to stress on the bone. It is understood that micro fractures within bone increases communication among cells, which allows new bone to replace damaged cells. A biomedical engineering lab at the University of Akron is developing experiments to better understand the ways and methods of bone metabolism (resorption and formation) in response to stress on the bone. Discrete Stochastic Mathematical models are constructed to aid in the understanding of the bone resorption and the bone replacement processes. These models are ideal because they allow for the tracking of the decisions made by each individual bone cell as opposed to the average activity for a large group of bone cells. They are also very flexible to new or changing information which tends to be the trend in biological experiments. Progress on the above described mathematical models and spatial statistics will be presented and future work mentioned.

Emily Vecchia, University of St. Thomas
see **Erin Brine-Doyle**

Chuyue (Monica) Wang, North Carolina State University
Sensitivity Analysis: Sensitivity Equations vs. Complex-Step Method

Sensitivity analysis provides valuable insights about how robust a system's responses are with respect to changes in parameters and data. Moreover, it shows what parameters or data are most influential in the system and can effectively be used as active controls. In our work, we numerically estimate sensitivities for various DE models using the classical method with sensitivity equations and the complex step method, based on the Cauchy-Riemann equations. The talk will provide a comparison of the two numerical methods and a discussion of their pros and cons.

Lilly Webster, Grinnell College
Involution Subword Complexes in Coxeter Groups

Let W be a Coxeter group with generators S. An element in W and a word in the elements of S define an interesting simplicial complex, called a subword complex. We define an operation on the involutions in W that functions analogously to the usual product in Coxeter groups. This operation allows us to define an involution subword complex, given an involution in W and a word in the elements of S. We will show that involution subword complexes are structured very similarly to subword complexes defined under the usual product. We will discuss a special class of involution subword complexes in S_n and demonstrate they are isomorphic to the dual associahedron.

Christine Wiersma, Alma College
Characterizing the Geometry and Topology of RNA Junctions

Ribonucleic acid (RNA) is one of the least studied molecules in the body. There are many different types of RNA, each with specific structures and functions, which are directly related. Many RNA molecules have one or more closed loops, or junctions, that are central to the structure of the entire molecule. This project attempts to characterize the geometry and topology of RNA junctions using three values: the linking number, total twist, and writhing number. We model the loops using a curve consisting of linked edges. The linking number describes the entanglement of the two edges of the curve. The twist of the edges around each other is denoted by the total twist, and the folding of the centerline is indicated by the writhing number. These values were computed using a discrete model of RNA created in Wolfram Alpha's Mathematica. The initial calculations were completed with tRNA. A survey of the junctions in other types of RNA will continue to reveal more about the structure of these molecules.

Qi Yang, University of Southern Califronia
Detecting Foot-Chases from Police Body-Worn Video

Existing methods to record interactions between the public and police officers are unable to capture the entirety of police-public interactions. In order to provide a comprehensive understanding of these interactions, the Los Angeles Police Department (LAPD) intends to utilize *Body-Worn Video* (BWV) collected from cameras fastened to their officers. BWV provides a novel means to collect fine-grained information about police-public interactions. The purpose of this project is to identify foot-chases from the videos using machine-learning algorithms. Our proposed algorithm uses the *Bag-of-Intrinsic-Words* algorithm followed by classification via support-vector machines. Our training dataset consists of 100 training videos (20 foot-chase & 80 non-foot-chase), and a test dataset of 60 LAPD videos (4 foot-chase & 56 non-foot-chase). We achieved results of 91.6% testing accuracy.

Qianru Zhu, Penn State University
Fairness in an Agent-Based Evolutionary Game

In the ultimatum game, two players (proposer and responder) decide how to divide a sum of money. Based on traditional economic theories, a rational proposer should offer a minimal value and the responder should accept any offer greater than zero. However, empirical evidence shows that people behave more fairly. In our model, we assign two players two numbers randomly, an acceptance level number and an offer number. Players care about winnings and they learn from each interaction. Unlike providing a fairness function directly to analyze the game, our model exhibits the emergence and evolution of fairness in ultimatum games.