The Twenty-Seventh Annual Nebraska Conference for Undergraduate Women in Mathematics

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POSTER ABSTRACTS

Posters by Undergraduate Students

Fatima Abbas, Denison University
Numerical Methods for Quasi-Stationary Distributions

Given a Markov chain evolving in a domain S, a state i in S is considered absorbing if, once entered, the chain remains in i indefinitely; i.e., the probability $P(i,i) = 1$, and for any other state j in S, $P(i,j) = 0$. In the case where i exists, the Quasi-Stationary Distribution (QSD) represents a probability distribution over the transient states of the chain. Previously, several approximation schemes have been proposed for computing the QSD in both discrete-time and continuous-time Markov chains. This research aims to analyze and compare five proposed approximation schemes: four regenerative schemes for finite-state, discrete-time Markov chains, and one regenerative scheme for continuous-time chains. Each scheme is defined by interacting chains characterized by the total time occupation of all particles within the system, which in turn influences and reinforces the transition dynamics. The study evaluates the performance of these schemes in approximating the QSD under various conditions, particularly examining how added complexities to the underlying dynamics of the chain impact the performance of the approximations.

Keerthana Avvaru, United States Air Force Academy
Dani Bryan, United States Air Force Academy
Honey, I Shrunk the F-22 (Image compression using SVD and FFT)

We will explore the various applications of different image compression methods with a military focus. Specifically, we will analyze the characteristics and benefits of using both Singular Value Decomposition and Fast Fourier Transform to compress images.

Lenox Baloglou, University of Arizona
Time Series Generative Modeling for Algorithmic Trading: Strategic Optimization of GAN for Intraday Trading in the Stock Market

Day trading (also referred to as intraday trading) within the stock market refers to the process of buying and selling assets within a single trading day, and holding nothing overnight. This is to avoid any social and political factors unrelated to the actual stock market state affecting the prices too much. Trading only during open hours allows for a more predictable environment for analysis. As the data associated with this process is significantly more volatile than that associated to inter-day trading, understanding patterns is crucial to the success of the trader. Building off of previous work that generates artificial data using TimeGAN, we will tailor the current code to align with the most important aspects of intraday trading. To test our results, we will use the TSGBench model that is currently available and fit the code with an extra parameter to quantify the speed, precision, and accuracy of our newly generated day trading data. We will then create an interface to combine the two models. Our ultimate goal is to be able to forecast stock market features to inform better day trading decisions, which need to be made at a moment's notice.

Ellyssa Bartels, Augustana University

Exploring Student Outcomes Across Diverse REU Sites: A Comparative Analysis and Comprehensive Examination Using PSM Nearest Neighbor and Optimal Methods

STEM education offers diverse career opportunities and spans various academic levels, from Bachelor's to PhD degrees. Despite its significance, there has been a documented shortage of STEM PhDs in academia and professionals in the industry, prompting increased support and investment in STEM programs. This study re-examines the impact of National Science Foundation Research Experiences for Undergraduates (NSF REU) on STEM career success using propensity score matching techniques, nearest neighbor and optimal matching. The study compares students selected for five REU sites in ecology (2009-2011) with those who applied but were not selected. Data on 178 students, including demographics, educational background, and post-REU achievements, were analyzed. Propensity score matching created comparable groups for analysis. The Friedman test was then used to compare outcomes. Results indicated that while REU participation did not significantly affect publication rates, it was associated with a significant increase in presentations and awards. These findings underscore the value of REU programs in enhancing certain aspects of STEM career success.

Gemma Bertain, University of Puget Sound

Reduced Trip Permutations of Plabic Graphs

The decorated trip permutation of a reduced plabic graph tells us what cell in the Grassmannian the graph parameterizes. This research studies the trip permutations of unreduced plabic graphs and how they change when the graphs are reduced. If the output is a permutation with no fixed points, this tells us what cell in the Grassmannian an unreduced graph parameterizes without actually reducing the graph.

Rose Bittle, DePaul University

Modifications to the Spiral Array: a Computational Approach to Music Analysis

The Spiral Array is a geometric model of musical tonality, similar to the Circle of Fifths, and exists as a tool in computer-aided music analysis. This project aimed to restructure the spiral array, limiting user ambiguity and optimizing the application of musical key analysis. The existing model defines pitch, chord, and key location to form a series of spirals dependent on a set of flexible weights. In our research, we were able to improve the model's potential for musical key analysis by modifying these weights through gradient descent, given parameters derived from the Harmonic Series, and observations of common tonal practice. Additionally, we were able to identify potential issues with the pitch definitions themselves and experiment with methods of addressing concerns by modifying existing pitch definitions and key algorithms produced by the model's original creator, Dr. Elaine Chew. Our current model and algorithm allow users to analyze the key center of a musical excerpt in a way that is consistent with the harmonic series and common tonal practice. This talk will highlight the journey of troubleshooting an existing model and demonstrate the power of mathematics in the field of Music Information Retrieval. This research was made possible by the DePaul Undergraduate Summer Research Program (DePaul USRP), in collaboration with Dr. Karl Liechty.

Elise Bormann, University of Wisconsin-Eau Claire
Communication in the Claw Network

Adversarial networks model communication through a graph of edges where information is sent from sender to receiver using a code. This presentation discusses the scenario in which a hostile adversary can corrupt along a restricted subset of edges within a "claw" network structure. In particular, we examine claw networks in which the sender sends a single symbol along $2n$ edges, with n edges in each claw. We examine the families of claws with varying n and give results on the communication capacity.

Cayla Bovell, Denison University
Blah Blah Blah: Understanding the Shift from Lecturing to Active Learning in Undergraduate Mathematics

Mathematicians have opinions on how mathematics should be taught. Sometimes, they will reference a study or two to support their beliefs. Over the past 15 years, references to "active learning" have come up in these conversations, usually referenced in opposition to lecturing. Research in Undergraduate Mathematics Education (RUME) seems quite resolute in its support for active learning, but it has yet to reach wide-scale implementation in these classrooms. Our research was a literature review surrounding active learning and lecturing in undergraduate mathematics. The researchers for this study consisted of three undergraduate mathematics majors with no background in RUME but a passion for mathematics education. The literature we found explored the benefits and impacts of lecturing versus active learning, varied pedagogical approaches, barriers to implementing student-centered classrooms, how to promote student-centered instruction, and what is missing from the research in this area. The goal of this study is to make the discussion about active learning versus lecturing more digestible to a broader audience (i.e., students, prospective instructors, and current instructors in mathematics) who may or may not be well-versed in RUME; and to encourage mathematicians, math educators, and teacher educators to revisit their teaching approaches and beliefs.

Eve Bradley, University of Utah
Josie Marshall, University of Utah
Deborah Wooton, University of Utah
Enumerating Equivalence Classes within Fibered Barcodes of Tame Bipersistence Modules

In topological data analysis, the persistent homology pipeline allows us to understand topological information about a data set in the form of a barcode–a summary of persistent homological features ("holes") across a one-dimensional filtration of simplicial complexes on our data. Some data warrant investigation across multiple dimensions, requiring the use of filtrations indexed by more than one parameter. Key information about these multidimensional filtrations cannot be completely described by one barcode; instead, summarizing the data requires a collection of barcodes, where each barcode corresponds to a one-dimensional filtration of our data. Critical points, points in the filtration where the simplicial complex undergoes a change in homology, partition such one-dimensional filtrations into equivalence classes by barcode. Our research aims to enumerate and describe these equivalence classes. Equivalently, in two dimensions, we want to understand how many ways a line with positive slope can partition a set of points in the plane. We present preliminary findings, which partially classify when pairs of points cannot be separated by a line of positive slope, as well as precise definitions of the words "left" and "right."

Karme Brame, Howard Univesrity
Entropic Optimal Transport Approach to the Far-Field Reflector and Refractor Problem

The reflector and refractor design problems in geometric optics involve creating surfaces to direct light from a source to a target with a specific intensity distribution. This research applies the entropic optimal transport framework proposed by Benamou et al. to regularize and simplify the associated PDEs, enabling efficient numerical solutions using the Sinkhorn algorithm introduced by Cuturi. By incorporating entropic regularization, this study enhances the stability and smoothness of solutions for the far-field reflector and refractor problems. Matlab is utilized to model these problems, projecting light from square patches onto unit spheres and coding cost functions to optimize light transport. The approach effectively addresses critical challenges such as boundary conditions and geometric constraints while providing accurate visual and numerical results. This work demonstrates the advantages of entropic optimal transport in geometric optics, offering a computationally efficient and robust method to solve complex design problems.

Cristin Brown, California State University, Dominguez Hills
Jazmyne Vargas, California State University, Dominguez Hills
Kyara Wise, California State University, Dominguez Hills
Unlocking Voter Dynamics: Exploring Piercing Numbers in Discrete Societies

This study focuses on the topic of the mathematics behind approval voting, with a specific focus on piercing numbers. Piercing numbers represent the minimum subset of candidates required to ensure unanimous agreement among voters, derived from the agreement number which indicates the maximum number of choices that voters collectively approve. Through approval voting, our aim is to identify situations where the majority of voters are satisfied with the final selection. By focusing on piercing numbers, this study will monitor various influencing factors, such as the number of voters, the size of the ballot, and the number of candidates. We found that by using the ideas of Pascal's Triangle, the Hockey-Stick Identity, the Pigeonhole Principle, and combinatorics helps us formulate equations to further simplify the possible piercing numbers and agreement numbers given various factors. These variables will shed light on the differences of agreement numbers, offering deeper insight into the mechanics of consensus in voting systems.

Dani Bryan, United States Air Force Academy
see **Keerthana Avvaru**

Raelynne Burns, University of Central Oklahoma
Getting to the Heart of it: A Mathematical Model of Canine Heartworm Infections

More commonly known as the canine heartworm, Dirofilaria Immitis, is a vector-borne parasite transmitted through members of the canine family (e.g., dogs, coyotes, jackals). A particularly interesting interspecies transmission, or spillover event, exists between the domestic dog (Canis lupus familiaris) and wild coyotes (Canis latrans) within the southern United States. Domestic dogs have owners that can treat the parasite and even prevent the initial infection, while wild coyotes do not typically have access to veterinary care. This transmission occurs when an infected dog or coyote is bitten by a female mosquito, which then becomes the host of the parasite. This mosquito travels to other uninfected canine, bites to feed, and deposits microfilaria into the uninfected canine. We develop and analyze a differential equations model describing the coyote-mosquito-parasite system and present results of a variety of numerical investigations aimed at understanding the risk to domestic dogs.

Rachel Castro, Colorado School of Mines
Rhizomes of Ranked Posets

We introduce and study the notion of a *rhizome* for a ranked, partially ordered set (or poset) where each set of fixed rank is finite. A rhizome is defined as a minimal size subset of the elements of rank n such that each of the elements of rank $n+1$ covers at least one element of the rhizome. Given a poset $\mathcal{P}$ with ranked parts $\mathcal{P}_n$, we consider the function $r_{\mathcal{P}} : \mathbb{N} \to \mathbb{N}$ which gives the size of a rhizome for $\mathcal{P}_n$, and study this function for examples like the Boolean lattice and Young's lattice.

Kayla Chandler, University of Michigan-Ann Arbor
Gravitational Lensing of a Naked Singularity

How does a black hole deflect light and warp a trajectory? In this project, we will compute the bent trajectories of light through the numerical integration of the geodesic equation. Our ultimate goal is to visualize how astronomical images are distorted by gravitational lensing. We delve deeper into two cases: a black hole with constant mass and another where the mass is an increasing function. In some cases, depending on the increasing function, this metric can yield a naked singularity. We further investigate whether any unique lensing characteristics are linked to these naked singularities– as their existence would have significant implications for the field of gravitational relativity and its foundations. The project relies heavily on concepts and equations from multivariable calculus, differential equations, and differential geometry.

Eden Cook, Cedarville University
Strange Sets: A Look at the Role of Scale in Mathematical Pattern

For the purpose of this presentation, we define a Strange Set as the image of a finite set of discrete points under a continuous, periodic function and a Strange Figure as the graph of a Strange Set. In this presentation, We will look at Strange Figures of different trigonometric functions and over different sets of integers to demonstrate the role that scale plays in visual pattern recognition, as well as explore patterns produced by integer approximations of multiplies of 2. We will also present our findings on how adjusting the periodicity of the function and the sampling interval impacts the patterns in the Strange Figures.

Victoria Corcimaru, University of Montevallo
New Methods to Tile a Square Using the Fibonacci Sequence

To tile an object is to completely fill it with non-overlapping similarly shaped objects. We call a tiling visible if at least one side of each tile occupies at least one boundary of the tiled object. In this poster, I will discuss various structured methods for tiling squared. Several of these techniques will be analyzed, including a process that utilizes the Fibonacci sequence. This particular process reveals an interesting property of Fibonacci numbers and results in a theorem that I will prove.

Kassidy Crockett, University of Central Oklahoma
Autumn Langer, University of Central Oklahoma
Subset Selection Methods for Multi-Lead ECG Data

The presence of anomalous heartbeat morphologies in the electrocardiogram (ECG) can signify serious heart health complications. Unfortunately, the unassisted review of ECG data often relies on limited real-time observations. Thus, the automated summarization of this data can aid clinicians in moving forward with patient care and promote a more comprehensive assessment. Since ECG data can be presented using a variety of signal lead systems, we investigate the use of different CUR matrix decomposition algorithms in generating summaries of single-lead ECG, twelve-lead ECG, vectorcardiogram (VCG), and VCG magnitude data derived from the St. Petersburg INCART 12-lead Arrhythmia Database. Also considering a few different normalization schemes, subsets for each data type are identified using the discrete empirical interpolation method (DEIM), leverage scores, Q-DEIM, and QR with pivoting. We also include subset selection using oversampling algorithms that build off of DEIM results using leverage scores (L-DEIM), random oversampling (R-DEIM), and extended DEIM (E-DEIM). The presented results aim to provide insight regarding appropriate methods to summarize different ECG data types for clinical support.

Kaley Crosley, University of Central Oklahoma
Agent-Based Modeling of the Polymerization of Fibrin Fibers

Blood clots are held together by a network of fibrin fibers. It is widely accepted that fibrin forms through lateral aggregation (forming parallel, chain-like networks of fibrin). However, new imaging is showing a potentially different formation mechanism, one that depicts fibrin fibers forming a "criss-cross" structure when one fibrin fiber comes into contact with another. Our agent-based model aims to render accurate fibrin interactions to better understand polymerization of fibrin molecules. By using vector agents diffusing in a 2D or 3D space, we can better visualize this formation process. The model is used to test various physiological conditions to see which produce results most like experimental output. Future models will include vertex angles, fluid flow, growth factor probabilities, and more.

Michelle Jing Dong, University of California, Berkeley
Category O, Superpotentials, and Koszul Duality

Through Beilinson-Bernstein localization, we can define Category O for D-modules, and via the Riemann-Hilbert correspondence, we can relate Category O to perverse sheaves. Perverse sheaves can be connected to the Fukaya category on cotangent bundle through the Nadler-Zaslow correspondence and further related to superpotentials in Fukaya-Seidel categories. The Lie algebra and corresponding superpotentials of the Higgs and Coulomb branches can be related through Koszul duality. In this project, we calculate specific examples of different Lie algebras to better understand these connections, explore different superpotentials, and further the understanding of 3D mirror symmetry.

Zoe Erpelding, Gonzaga University
Diana Hoppe, Gonzaga University
A Combinatorial Study of the Game Triominoes

Triominoes are a variant of dominoes using equilateral triangular tiles. The corners of each tile are labeled by integers from the set $\{0, 1, 2, 3, 4, 5\}$ following certain rules. Each allowed tile appears exactly once in the game set. In this presentation, we discuss why these rules and game size are important, as well as present several combinatorial properties of generalized triominoes games on the set $\{0, 1, \ldots, n\}$, with and without an orientation restriction.

Delaney Finley, United States Air Force Academy
A Investigating Bipolar Disorder with Differential Equations

Approximately 40 million individuals across the world are affected by bipolar disorder, which is a mental condition characterized by reoccurring episodes of mania and depression and it can be classified into three categories: type one, type two, and Cyclothymia. Each type presents unique challenges for patients, with different patterns and durations of manic and depressive episodes. This research seeks to better understand the dynamic nature of these emotional states through mathematical modeling. Specifically, we employ a Liénard family of ordinary differential equations to capture the cyclical behavior. We focus on analyzing the stability of special solutions, which represent potential equilibrium states or recurring emotional cycles in the system. We also conduct a bifurcation analysis to understand how small changes in the system's parameters might lead to qualitative shifts in the behavior of the emotional states, potentially leading to more severe manic or depressive episodes. Furthermore, we use computer simulations to visualize these patterns and explore the range of possible scenarios that could correspond to the experiences of individuals with different types of bipolar disorder. These simulations provide valuable insights into the nonlinear dynamics of the disorder and offer a framework for future investigations into its underlying mechanisms. Ultimately, we aim to contribute to a deeper understanding of bipolar disorder through mathematical modeling.

Emily Fowler, Furman University
Predictive Delivery Time Model of BMW Paint Shop Stations

Car manufacturing paint shops are a complex system of independent stations where time management is crucial to productivity. Stations consist of various processes including hands-on work, robots, ovens, and inspection lines. Occasionally, stations may temporarily pause operation. One critical challenge is properly allocating workforce during unexpected station downtimes. When unexpected downtimes occur, station managers must make decisions: whether to have employees wait for the station to resume operation, to send employees to other stations, or to stop operations for the day. This decision process is complex, relying on extensive knowledge of station maps, unit transfer times, average station downtime, and inventory capacity. We used Little's Law, a well known result from queuing theory, to predict delivery times to stations, helping station managers with their workforce allocation decision and, thus, optimizing paint shop productivity.

Saja Gherri, University of Michigan-Ann Arbor
Optimal Design Problem with Cost Function: Regularity of Minimizers and Free Boundary Analysis

We investigate optimal design problems with non-constant cost functions, where certain regions are more costly to occupy than others. This leads to the analysis of a complex free boundary problem of the Alt-Caffarelli type. We show the existence of solutions u to the cost problem and establish the regularity of minimizers and their free boundaries. In particular, we show u is universally Hölder continuous if the cost function $c(X) \in L^p$, with $p > \frac{n}{2}$. For $p = \infty$, we achieve Lipschitz continuity of minimizers. A free boundary condition is proven to hold via a geometric measure Hadamard's variational formula. Finally, we establish the uniqueness and stability properties of the solution when the body to be insulated is star-like.

Megan Gilbert, Gonzaga University
Malia Recker, Gonzaga University
Hexagons Are the Bestagons: Comparing Hexagonal and Square Grid Representations of Knots

There are many types of tiles that can be used to represent projections of knots onto small grids, namely mosaic (square) tiles and hexagonal tiles. We aim to show that there is a relationship between the tile numbers on these grids. Efficiency can sometimes be improved using simple shifts of crossings.

Susanne Goldstein, Oberlin College
Christina Hoff, Kutztown University
On Algebraically Defined Edge Colored Graphs

An algebraically defined edge-colored graph $(K, \Gamma^c_{\mathbb{F}}(f(X,Y)))$ is constructed using a field $\mathbb{F}$, a complete bipartite graph K where each partite set is a copy of $\mathbb{F}^2$, and a function $f(X,Y)$. We denote the vertices of the first partite set by (a_1, a_2) and of the second by $[x_1, x_2]$. We color the edge $(a_1, a_2)[x_1, x_2]$ blue if their coordinates satisfy the equation $a_2 + x_2 = f(a_1, x_1)$, otherwise we color the edge red. These graphs are properly connected, meaning that there exists a path with alternating edge colors between any two vertices. We will discuss properties of algebraically defined edge-colored graphs including: proper diameter, the length of the longest minimal proper path length between any pair of vertices; proper girth, the length of the shortest properly colored cycle; and proper vertex cuts, the minimum number of vertices that can be cut to make the graph not properly connected. We motivate our work by a link to incidence geometry.

Zoe Harrington, Colorado College
Implementing Maximum Likelihood Estimations in Calculus Classrooms

Applications of optimization in calculus classes often follow a similar bland script; for example, calculating the maximum area for a farmer given fencing restrictions. In contrast, the ideal guided inquiry or application problem generates curiosity, extends the relevance of calculus to the student, all while meaningfully integrating the intended learning goals. This project suggests opportunities in the calculus curriculum to broaden knowledge and highlight the interdisciplinary applications of mathematics for students with any level of investment in calculus by introducing the method of Maximum Likelihood Estimation (MLE). MLE is an upper-level statistical method used to estimate the parameters of a statistical model, which uses the method of optimization learned in calculus to compute the “best fit” parameters. Implementing MLE for optimization problems in univariate and multivariate contexts seamlessly explores the process of model fitting and demonstrates how calculus fits into a diverse set of interests. Due to the generality of the MLE method, these problems can be tailored with different datasets to target the instructor’s audience. This project utilizes pedagogically sound and equity-based teaching practices and provides a repository of worked examples, teacher materials, a bank of guided-inquiry problems, and answer keys.

Kate Harvey, Colorado School of Mines
Hailey Puglia, Colorado School of Mines
How Noise Affects Sound Perception: Exploring Age, Listening Habits, and Preferences

This study explores how varying levels of noise in audio impact sound perception and preferences across different age groups and individual preferences. Using a combination of Fourier transformations and Python-based audio processing, audio signals from a sample audio were transformed into the frequency domain, and controlled noise was added to create several modified audio samples with varying levels of noise. These samples were then assessed by surveyed participants for perception and enjoyment. Examining how different noise levels influenced the acoustic interpretation of the audios highlighted age-related differences in noise tolerance and the ability to detect noise. Statistical models were used to evaluate the relationship between audio quality, enjoyment, and listener characteristics. This work provides valuable insights into how noise influences auditory experience.

Maley Her, California State University, Fresno
Turnip the Future: NLP in BioTech

Genetically modified crops have the potential to address critical issues such as food security, climate change, and environmental sustainability. However, despite nearly 30 years of research on genetically modified crops on the African continent, very few crops have transitioned from development stages to implementations by farmers, especially on a commercial scale. With over 2 million text data gathered from various African media outlets, our research aims to determine the overall sentiment of the actors shaping the future of genetically modified crops. This is done by creating a pipeline that analyzes the text data using various Natural Language Processing (NLP) methods such as Named Entity Recognition (NER), Aspect-Based Sentiment Analysis, Prompt Engineering, and Speaker-Quote Text Classification. After training, improving, and evaluating the various NLP models using accuracy, model agreement, and F1 scores, the research resulted in a collection of high-performing models, such as the BERT-large model for NER, used in the pipeline to utilized the NLP methods to cohesively analyze large text datasets. We hope that our results will contribute to the understanding of the current state of genetically modified crops on the African continent and used to help push implementations of biotechnologies to combat large scale social issues such as food security.

Fatima Hernandez, University of the Incarnate Word
Modeling Financial Losses in Aviation Due to Severe Weather: A Time Series Analysis Approach

This research uses Time series analysis to model airline financial losses caused by severe weather disruptions like tornadoes, wind shear, lightning, high winds, and large hail. By analyzing data collected over the last 5-10 years for Dallas-Fort Worth, Texas to Chicago, Illinois, and applying mathematics, the impact of severe weather in aviation is determined. The graphical representations highlight the patterns in severe weather disruptions associated with financial losses for the airline. These losses include the following: passenger accommodation, rebooking fees, hotel expenses, transportation for affected customers and damage/repair to aircraft. With this study a relationship between weather conditions and aviation is established.

Nuvia Hernandez, Lewis University
Mackenzie Welsh, Lewis University
Development of Agent-Based Models for Evaluation of Precision Nutrition Interventions through a Socioeconomic Lens

An individual's overall health is dependent upon many characteristics such as demographics, physical activity, body-mass index (BMI), underlying health conditions, and socioeconomic status. To date, many guidelines to promote healthier eating have been targeted at the population level rather than focusing on the individual. Our work aims to investigate the role of an individual's socioeconomic status on both their overall health and total population health through agent-based models (ABMs) of two Chicagoland villages: Broadview and Clarendon Hills. Using Google Maps as a guide, we developed a graphical user interface of Broadview that includes detailed information about the village, including houses, schools, restaurants, and grocery stores. Additionally, residents were assigned individual characteristics based upon data from the Chicago Metropolitan Agency for Planning including age, sex, race and ethnicity, income, BMI, and medical information. The model simulates a daily routine for residents that involves interacting with both others and their surroundings, such as grocery stores and restaurants (or lack thereof), and it dynamically updates individual characteristics and decision-making along with daily behaviors in order to determine a health score for each resident. Through model simulations, we aim to assess how an individual's social network and resources affect their overall health score and what interventions would be most impactful in improving population health.

Lanorah Hobbs, Francis Marion University
Alternative Probability Density Estimators for Navies Bayes Nearest Neighbor Machine Learning Method for Accuracy and Explainability in Wound Image Classification

We investigate classifying the stages of wounds from a dietetic wound imaging dataset with alternative machine learning algorithms to the standard approaches like Convolutional Neural Networks (CNN) and Support Vector Machines (SVM). Although these methods usually classify with high accuracy, we search for more explainable methods for clinician and patient interpretability. One approach previously studied in the literature is using a Bayesian Network model, specifically Naive Bayes Nearest Neighbor (NBNN). The goal of the authors was to make a computationally simple method while being competitive in image classification. We make some alterations to their method by trying alternative estimates of the probabilities in NBNN to improve the model's performance and equally important, its explainability. In particular, we consider K-Nearest Neighbor (KNN) for probability density estimation without using a kernel and then compare their classic NBNN to our approach using k-fold cross-validation. Ultimately, we address whether Bayesian Networks can be competitive in performance but also provide explainable wound imaging predictions.

Christina Hoff, Kutztown University
see **Susanne Goldstein**

Diana Hoppe, Gonzaga University
see **Zoe Erpelding**

Mia Hudson, Saint Mary's College and the University of Notre Dame
Quadcopter Using Sensors and PID Control

This project is about building a Quadcopter from scratch using different sensors, code, and electrical connections to find the PID control (type of feedback control) to maintain a stable flight. Arduino IDE is the software being used for the code, and Teensy is the "breadboard" for the different connections, which is our microcontroller. The drone is flown by a controller, and uses a MPU6050 and a BMP280 (the sensors) to control and collect the data from the drone. By collecting data, and controlling the drone, equations are used the solve for the PID in the PID control. A Kalman filter will be added on top of everything in the code to help achieve the goal of a stable flight.

Elizabeth Iaryguine, Kennesaw State University
Variational Characterization of Fractal Neumann Eigenvalues

A fractal is a self-similar, infinitely repeating geometric object. These exhibit many counterintuitive mathematical properties. One such property is a fractal dimension, where the dimension of an object does not necessarily need to be an integer. A method called dimensional regularization can be used to transform fractional integrals into integrals in the more intuitive Euclidean space. We have shown that in this fractal space, many properties of solutions to partial differential equations continue to hold. In particular, we have shown that in the Neumann problem for a fractal version of the Laplace equation, there is a variational characterization of the Neumann eigenvalues via a corresponding notion of the Rayleigh quotient. This enables easier computation of eigenvalues, either by numerical methods or by hand.

Taylore Keesler, University of Central Florida
Investigating the Dimensional Effects on Thomas Cyclic Systems

The Thomas Cyclic System (TCS), proposed by René Thomas, is a system of ordinary differential equations often used to describe the movement of a frictionally dampened particle in a 3D lattice. Despite its relevance in biological diffusion, cell morphology, and other sciences, the TCS may be too complex to study as a direct application. To reduce this complexity, we aim to perform a comparative analysis of a one-dimensional (1-D) system and a two-dimensional (2-D) system, along with the original Thomas Cyclic System (3-D). We employ both numerical and analytical methods to compare the behavior of the Thomas Strange Attractor to its variations. We further explore this behavior using linear stability and Hopf bifurcation analysis and hope to understand these dynamics in n-dimensions.

Fanni Kertesz, Bellarmine University
Circles Are So Euclidean: Exploring Convex Bodies, Norms, Symmetries, and Isometries via the Minkowski Functional

In a real vector space, a symmetric convex body containing the origin and compact under the Euclidean norm uniquely defines a norm via the Minkowski functional, where the closed unit ball of this norm is the convex body. This establishes a one-to-one correspondence between convex bodies and norms. The norm derived from the convex body allows for the definition of a metric, enabling the study of isometries within the space. However, the symmetries of the convex body itself do not completely determine the isometries of the associated Minkowski space. Instead, the symmetries of the most symmetric shape a convex body can be linearly deformed into correspond to newly defined non-Euclidean isometries of the space. This thesis will provide an accessible review of the connection between convex bodies and norms via the Minkowski functional and explore how the symmetries of convex bodies help predict the Euclidean and non-Euclidean isometries of the associated Minkowski space.

Sloane Kinley, Converse University
Dynamic Flexible Tile Modeling of DNA Self-Assembly

Deoxyribonucleic Acid (DNA) has been proven to be a valuable building block for constructing nanostructures capable of targeted drug delivery. DNA is also characterized as self-assembling; when a sticky end is introduced to complementary unbonded base pairs, they will hydrogen bond without any mechanical assistance. Graph theory can be implemented to model this phenomenon, and one such framework is referred to as the flexible tile model of DNA self-assembly. This model allows for symmetry and predicted bonding where it may not exist in the lab setting. We add to the flexible tile model in order to calculate the probability of self-assembly of certain graphs. This theoretical experiment explores the possibility and probability that the cohesive end types, in the flexible tile model, can bond to other end types when exposed to one another in the lab setting. Markov chains are used to calculate steady states of bond probabilities. This exploration specifically focused on small cycle graphs of orders three and four.

Licia Lamb, Metropolitan State University of Denver
Factorial Frenzy

Factorials have been a topic of fascination and study for millennia, serving as the quiet foundation for a plethora of mathematical concepts. While complicated at first glance, there are distinct and reliable patterns given by factorials. For example, each factorial greater than 1! is an even number. Approaching factorials through this lens of pattern recognition, we observe that for $n \geq 5$, $n!$ has at least one trailing zero. In this presentation, we give a formula that predicts the number of trailing zeros on $n!$ and proceed to further generalize this idea to determine the maximal k for which $n!$ is divisible by mk. The process of deriving this function and our results highlight the impact of prime factorizations within large numbers. As we explore the continuously expanding world of factorial patterns, we can utilize them to demonstrate the value and applications of theoretical mathematics.

Autumn Langer, University of Central Oklahoma
see **Kassidy Crockett**

Lorelei Linkel, Georgia Institute of Technology
Physics-Informed Neural Networks for Particulate Matter Diffusion

We model the dispersion of Particulate Matter 2.5 (PM2.5) using a Physics-Informed Neural Network (PINN) to develop efficient and accurate air quality predictions and gain a deeper understanding of the mechanisms driving PM2.5 dispersion. PINNs, introduced by Raissi et al are a class of deep neural networks that integrate physical laws during training, making them well-suited for solving both forward and inverse problems involving Partial Differential Equations (PDEs). Using citizen data from Purple Air sensors in California, we trained PINNs on diffusion and advection-diffusion PDEs. While theoretical research on PINNs is extensive, our work applies these methods to sparse, real-world data from a nonlinear dynamical system with complex boundary conditions. Our findings indicate that although the network and PDEs were not sufficiently complex to fully capture all data features, they successfully modeled the general movement of PM2.5. Through this project, we aim to contribute to the growing body of PINNs research and provide a foundation for future particulate matter dispersion models.

Carlye Larson, Augustana University
Finding Different-Sized Dice with the Same Frequencies as Standard Dice

We generalize a question of dice relabelling posed by Gallian and Rusin: Given n dice, each labeled 1 through m, how many ways are there to relabel the dice without changing the frequencies of the possible sums? We explore a method for decomposing two m-sided dice into two dice of different sizes and give some preliminary results on relabeling two dice of different sizes. In particular, if $m = ab$, we describe labels for dice of sizes a, ab^2.

Lena Little, University of Colorado Boulder
Andraine Sinaga, University of Colorado Boulder
Understanding Indecomposable Modules for the Universal Virasoro Vertex Algebra

The Virasoro vertex operator algebra is an infinite-dimensional vector space with additional algebraic structure that has several applications in conformal field theory. While irreducible modules are well-understood for the Virasoro vertex operator algebra, we are interested in better understanding some of its indecomposable modules.

Margaret Luo, University of California, San Diego
Non-Intrusive Parallel-in-Time Solvers for Partial Differential Equations

Recently there has been a stagnation in efficiency of serial algorithms as they bottleneck on single-thread performance, leading to a push for parallel algorithms to take advantage of exponentially growing core counts in computer hardware. The Center of Applied Science and Computing (CASC) at Lawrence Livermore National Laboratory (LLNL) does extensive research in this area. In particular, they want to design non-intrusive algorithms which can generalize to various problems and sizes without requiring additional information from or modification of the original problem. Our project during the Research in Industrial Projects for Students (RIPS) program, supported by the Institute for Pure and Applied Math (IPAM) and in collaboration with LLNL, focuses on approximating the coarse-grid operator in the Multigrid reduction-in-time (MGRIT) algorithm through Machine Learning approaches in hopes to get the most general solution. This research introduces a Feedforward Neural Network that yields the generalization of a linear system in the form of a stencil and is supported by loss functions built from the matrix's spectral norm. Through observing many characteristics and metrics of the network with different loss functions, we assessed how well the loss function aligned with convergence in PyMGRIT, a python implementation of MGRIT algorithms. Our results suggest that the neural network approach has the potential to be used for a wide variety of partial differential equations.

Kaylen Maat, Saint Mary's College
Statistical Analysis for the Community Learning Center of St. Joseph County

The St. Joseph County Public Library is home to the Community Learning Center (CLC), which opened in January of 2022. The CLC was a $38 million investment, including the St. Joe Coffee Co., a cafe that opened in April 2022, and other venues available for rent. The CLC's venues can be used for meetings, seminars, and personal events such as parties or showers. This project analyzed data about cafe sales and room bookings in the CLC since its opening in 2022 with hopes of improving the operation and maintaining inclusivity.

Revathi Mandava, Carleton College
Modeling Language Shift: What Keeps a Language Alive?

When languages come in contact they have varied impacts on each other. For instance, a population could abandon one language for another, in a process called language shift. One way of modeling language shift, the Abrams and Strogatz model, sees languages as fixed, and competing for monolingual speakers, where the probability a speaker switches from one language to another depends on between the number of speakers of a language and a language's perceived social status. The purpose of this research is to analyze the effect of the number of speakers of a language and a language's perceived social status on the rate of language shift within a given geographical region using the Abrams and Strogatz Model for language change. Given a language, there is a threshold T such that if the number of speakers is larger than T then the language can coexist with another dominant language.

Josie Marshall, University of Utah
see **Eve Bradley**

Zoe Marshall, Vanderbilt University
Cardiac Septal Thickening Model Evaluated through Univentricular and Biventricular Processing using cineCT

As heart disease becomes evermore present in our population, more mathematical tools are necessary to aid with diagnosis and proper understanding of cardiac function. Many heart diseases take root in one ventricle, but impact the function of the connecting ventricle due to ventricular interdependence through the septum. To quantify the septum's interdependence, I developed a septal thickening model using finite element visualization of the interior blood pools derived from cardiac cineCT images. Building on a coherence-based point-tracking algorithm termed SQUEEZ, we analyzed the septal thickening and surface strain that occurs between the filled (end-diastole) and contracted (end-systole) states by matching points across the septum at end-diastole and tracking the points to end-systole. This mathematical model was retrospectively applied to a cohort of right and left ventricle heart disease patients (CTEPH, pre-LVAD, and rTOF) and non-disease patients to quantify their septal thickening values compared to their expected heart function. We analyzed these values through single and both ventricle processing to determine the effect of the coherence point drift calculation on the model. We compared this model to blood pool surface strain which suggests new information regarding cardiac contraction assessment was found with this thickening model.

Tabitha Merrithew, Converse University
Optimal Designs for DNA Self-Assembly of Select Archimedean Solids in the Flexible Tile Model

This project mathematically models the self-assembly of DNA nanostructures in the shape of select Archimedean solids using the flexible tile model. Under three different sets of restrictions called scenarios, we employ principles of linear algebra and graph theory to determine the minimum number of different DNA branched molecules and bond types needed to construct the desired shape. Our goal in finding these values is to theoretically reduce laboratory costs and the waste of biomaterials. Five graphs were studied, and we provide full results for all in Scenario 1. We propose full Scenario 3 and partial Scenario 2 results for the order 12 graphs, as well as partial Scenario 3 results for the order 24 graphs.

Isabella Mohren, University of Richmond
Using Stranding to Detect Leading Terms for $\mathfrak{sl}_3$ webs

Webs are graphs that represent algebraic data in diagrammatic form. Our research is centered around $\mathfrak{sl}_n$ webs - trivalent, planar graphs with edge orientation and weighting conventions that come from the representation theory of the Lie algebra $\mathfrak{sl}_n$. In our current project, we focus on using combinatorial features of an $\mathfrak{sl}_n$ web to compute the leading term of its corresponding vector. There are many results in the literature that study these leading terms for so-called reduced $\mathfrak{sl}_3$ webs. Our work, which incorporates the concept of stranding recently developed by Russell and Tymoczko, seeks to generalize these results to all webs.

Kennedy Munz, United States Military Academy
AI Assisted SEM Image Analysis for Enhanced Characterized of Cobalt Nanowire Aerogels

Nanomaterials have diverse applications, including sensing, energy storage, and tissue engineering. Accurately characterizing nanowire materials is extremely valuable to design considerations and applications. SEM image analysis of these structures is incredibly difficult due to the complex, asynchronous aspects of the mesh network, in addition to technical limitations of the image capturing process. Existing image processing tools use methods like blurring, edge detection, binarizing, contouring, and skeletonization, but no method currently exists to reliably determines nanowire length. Leveraging CNN-based methods coupled with existing image processing techniques, a procedure is presented to analyze and characterize the average length of nanowires in nanowires networks, specifically cobalt nanowire aerogels.

Kylie Nolting, University of Central Oklahoma
A Mathematical Model to Understand Why Hibernating Bears Don't Get Blood Clots

Did you know that hibernating bears don't get blood clots? A possible reason for this is significantly lowered levels of heat shock protein 47 (HSP47) during hibernation. HSP47 is a protein that allows activated platelets to clamp to exposed collagen in the blood vessel walls. This HSP47 allows for an initial layer of platelets to be clamped on top of the collagen, which then causes more activation in platelets to finally form a blood clot. The purpose of this research is to model the relationships between unactivated platelets, activated platelets, and the rate of collagen being used up during blood clotting. By building a set of ordinary differential equations, we can better understand the difference between blood clotting during hibernation and non-hibernation.

Julia Osmun, Grand Valley State University
Guessing Games to Determine 1 of Several Secret Numbers

A guessing game is a game where the Responder is thinking of at least 2 secret numbers x in a set S of size n. The Questioner is tasked with asking questions of the form: "How many numbers are in Q?", where Q is a subset of S, until the Questioner knows at least one of the Responder's secret numbers. We investigate to find a game-winning strategy for the Questioner with minimal possible questions.

Molly Paez, Lewis University
Tile-based Graph Theoretical Modeling of Self-Assembling DNA of the Kayak Paddle Graphs

Self-assembly is a term used to describe the process of a collection of components combining to form an organized structure without external direction. The unique properties of double-stranded DNA molecules make DNA a valuable structural material with which to form nanostructures, and the field of DNA nanotechnology is largely based on this premise. By modeling nanostructures with discrete graphs, efficient DNA self-assembly becomes a mathematical puzzle. These nanostructures have wide-ranging applications, such as containers for the transport and release of nano-cargos, templates for the controlled growth of nano-objects, and in drug-delivery methods. This research project centers around exploring graph theoretical and combinatorial properties of DNA self-assembly to optimize the nanostructure construction for laboratories. This talk shares our results in determining optimal design strategies for the Kayak Paddle Graph Family.

Olivia Payne, Stephen F. Austin State University
Exploring Graphs and Chromatic Symmetric Functions

We consider graphs with a small number of vertices and analyze the coefficients of their chromatic symmetric function, which is a generalization of the chromatic polynomial of a graph. Some of these coefficients can hold information about the graphs themselves and, in this research, some interesting combinatorial formulas arise for some of the coefficients. This research is motivated by Stanley's Tree Conjecture.

Nyah Pee, Francis Marion University
Leveraging SIFT for Explainable AI: A Naive-Bayes Nearest Neighbor Approach

The increasing use of AI in all disciplines has highlighted the necessity for transparency and results that can be understood. This research utilizes the Scale-Invariant Feature Transform (SIFT) algorithm, Naive-Bayes Nearest Neighbor (NBNN) Classifier, and provides explainability through the use of a probability density function (PDF). The SIFT algorithm extracts essential features, known as keypoints and descriptors, from a query image. The notable features are then classified based on the likelihood of the feature occurring in each class, due to the Naive-Bayes Nearest Neighbor method. Lastly, a probability density function is applied to provide an estimation of feature relevance and to which class the image belongs to. Our model demonstrates that this approach provides transparency and proper explanation of the AI model's decision making. Final results provide a clear and concise analysis of how each feature of the query image ultimately affects the classification of this image into a class. The forthcoming objective of this project is to be implicated in the discipline of healthcare through way of wound imaging.

Hailey Puglia, Colorado School of Mines
see **Kate Harvey**

Tahda Queer, Hunter College, City University of New York
Stable Tamari Posets on Length-Three Sequences with One Peak

The Tamari poset, introduced by Dov Tamari in the 1960s, is a fundamental structure in combinatorics, particularly known for its connection to binary trees, Catalan numbers, and associative operations. This poset not only serves as a combinatorial model for various algebraic and geometric structures but also plays a significant role in the study of lattice theory and planar triangulations. Building on this classical framework, we expand the poset to all non-negative integer sequences of the same length and explore further properties and structures. In this presentation, we will focus on the lower order ideal of sequences of the form (a, b, a) where $a < b$. We will explore surprising results regarding the size of these lower order ideals and the number of intervals they contain. Interestingly, these results lead to sequences that correspond to known entries in the OEIS, hinting at deeper connections to other combinatorial objects. We will also discuss open problems and potential directions for further research.

Malia Recker, Gonzaga University
see **Megan Gilbert**

Isabella Robinson, Southwestern University
Yasmine Soto, Southwestern University
Perimeter Minimizing Rectangles in two-dimensional Euclidean space with density $M|x| + N|y|$

We examine perimeter-minimizing rectangles in an ambient two-dimensional Euclidean space imbued with a nonnegative density function. More precisely: on top of two-dimensional Euclidean space, we define the density function $f(x, y) = M|x| + N|y|$, and use this density function to add weight to measurements of perimeter and area. Under this framework, we ask and answer the question: "Out of all rectangles with edges parallel to the x- or y-axis, for which the total weighted area A of the rectangle is fixed, which rectangle has an optimal (minimal) amount of weighted perimeter?" Using variations on area and perimeter, we find that an optimal rectangle must sit with one corner touching the origin, and the dimensions of the rectangle depend only on M, N, and A.

Naomi Rojas, Coe College
Exploring Matrix Structures with the Diamond Sampling Algorithm

Given a symmetric matrix, the Diamond Sampling algorithm is a probabilistic method for selecting the largest element in the squared matrix by comparing randomly chosen submatrices. With diamond sampling, we investigate a variety of matrix structures in an effort to understand the performance and accuracy of the algorithm. By studying selection probabilities and specific matrix configurations, we gain insight into how structural patterns impact the algorithm's outcomes, revealing key relationships between matrix composition and sampling results.

Bridget Rozema, Grand Valley State University
The Hunt for New Number Sequences in the Union of Path and Cycle Graphs

This study focuses on the sequence of numbers formed by counting the edge covers of specific graph families. An edge cover is a subset of a graph where each vertex is adjacent to at least one edge. Using the known sequences derived from the path and cycle graphs (Fibonacci and Lucas, respectively), we examine how combining these two graph families together at certain vertices lead to new number sequences. We will employ various methods to find the sequences that arise from these combinations of path and cycle graphs, such as rocket and bolo tie graphs, and determine their properties.

Caroline Schwengler, University of Arizona
Visualizations of Minute-by-Minute Data Collected from Clinical Trial: Sugammadex vs Neostigmine for Kidney Transplantation

The goal of our work was to find a predictor for respiratory failure following a kidney transplantation surgery. Additionally, an objective of our work was to create easily understandable data visualizations that could be used to simplify or better understand the complex trends in minute-by-minute ventilation data. The data used was originally collected for a double-blind, randomized, parallel study that sought to compare the efficacy of sugammadex versus neostigmine in the reversal of the neuromuscular blockade. The RedCap data includes many variables but for this work we largely focused on the vast amount of minute-by-minute data. We created segmented regressions, spline lines, and animated graphs that allowed us to observe trends over time and across patients. Near the end of our work we also used the segmented regression lines to predict a backslide in the quantitative train of four (qTOF), a measurement of the neuromuscular blockade of patients as they come out of anesthesia. We hypothesized this might allow us to better predict respiratory failure. We were unable to conclude that there is a significant relationship between the qTOF and respiratory failure universally. However, our prediction model did show promising results for some patients. Our work was limited due to time constraints and large amounts of missing data. In the future, we would like to use these same segmented regression models with other variables collected and continue our predictive work.

Malaika Shroff, University of North Carolina at Chapel Hill
Stability Classifications of Degenerate Hamiltonians

Our research group aims to classify degenerate Hamiltonian systems into weakly stable and weakly unstable cases, focusing on real analytic Hamiltonians with nonzero degenerate quadratic terms. While the stability characteristics of nondegenerate Hamiltonians are well established, our study investigates Hamiltonians with a critical point at the origin, specifically examining systems where $H(x, \xi)$ includes both quadratic and higher-order terms. We work with Hamiltonians expressed as $H(x, \xi) = \xi^2 + H_3 + H_4 + \dots$, using symplectic transformations to analyze the system's behavior and derive conditions for weak stability and instability. Our results show that certain forms, such as $H = \xi^2 - x^{2m}$, exhibit weak instability. Additionally, we explore the geometric structures associated with these transformations, using Poisson brackets and higher-order expansions to trace the stability of solutions. This work contributes to the understanding of Hamiltonian dynamics near degenerate critical points, extending classical stability results to a broader class of systems. In future research, we are aiming to examine the quantum analogs of symplectic transformations to further understand weakly stable and unstable systems.

Andraine Sinaga, University of Colorado Boulder
see **Lena Little**

Yasmine Soto, Southwestern University
see **Isabella Robinson**

Molly Staples, Doane University
Economic Return on Investment on Higher Education

We examine the return on investment of higher education as measured by average salary of graduates and cost of degree for various levels of education attainment. We investigate the different types of degree granting institutions as well as the demographic makeup of graduates and geographic locations.

Kaelan Swallow, Cedarville University
Markov Chains and Their Applications in Soccer

Soccer is often described as a "player's game" due to the ever changing state of the game. No two soccer games will ever be the same, making it difficult to predict the outcomes of a soccer match. However, in recent years, mathematicians have used Markov chains to model and predict outcomes of different aspects of soccer, such as the passing probabilities, probability of getting a shot off based on skills, and evaluation of playing styles. A Markov chain is a stochastic process used to describe a sequence of events. For example, to determine the probability of getting a shot off, we can construct a matrix of transition probabilities based on the likelihood of a player shooting as a result of a set list of skills. This presentation looks at the various applications of Markov chains in the game of soccer, the benefits and limitations of Markov chains and what future areas of research might be.

Kaydence Throm, Doane University
Comparing Shortest Common Superstring and De Bruijn Genome Assembly Methods

The process of DNA sequencing produces many overlapping sequences of DNA bases (ATGC) called reads. The problem of genome assembly requires assembling these reads into a cohesive genome. Ideally, DNA sequencing and DNA assembly would accurately reproduce the original genome. Our project investigates two popular assembly methods - Shortest Common Superstring and DeBruijn Graphs. After providing an overview of each method, we illustrate the strengths and weaknesses of each technique through examples and Monte Carlo experiments. Our example "genomes" include lyrics from songs Barbara Ann and Pump Up the Jam, as well as the complete genome of Candidatus Carsonella ruddii, an obligate endosymbiotic Gammaproteobacterium that lives in all phloem sap-feeding insects. We found that for practical use, the DeBruijn method is superior.

Jazmyne Vargas, California State University, Dominguez Hills
see **Cristin Brown**

Breanna Wells, University of Montevallo
The Fibonacci Sequence

This poster will be focused on analyzing the Fibonacci sequence and its properties. Several papers, articles, and books relating to the sequence will be analyzed and relevant information will be noted. Then, theorems, lemmas, and corollaries that prove important properties of the sequence will be worked through. After that, we will begin our big theorems, proving that F_n can be represented by a formula, utilizing our knowledge of Calculus and infinite series. After that, we will show a formula for generalized Fibonacci sequences that uses Linear Algebra paired with eigenvalues and eigenvectors. The last thing covered will be the convergence relationship between the Fibonacci sequence and the Golden Ratio.

Mackenzie Welsh, Lewis University
see **Nuvia Hernandez**

Victoria Wiest, California State University, Fresno
Effective Weights of Numerical Semigroups of Small Depths

A numerical semigroup, S, is an additively closed subset of $\mathbb{N}_0$ with finite complement. The elements of the complement are the gaps of S, and the number of gaps is the genus of S. Every numerical semigroup S has a minimal generating set such that S is the set of all nonnegative linear combinations of its minimal generators. The effective weight of S is defined in terms of the minimal generators of S and the gaps of S. Motivated by the study of Weierstrass semigroups of algebraic curves, Nathan Pflueger conjectured that $\left\lfloor \frac{(g+1)^2}{8} \right\rfloor$ is an upperbound for effective weight, where g is the genus of S. The depth of a numerical semigroup, S, is an integer that indicates how large the largest gap is in terms of multiples of the smallest nonzero element of S. We present our proof of Pflueger's Conjecture for numerical semigroups of depth 2, and discuss our progress for numerical semigroups of larger depths.

Kyara Wise, California State University, Dominguez Hills
see **Cristin Brown**

Deborah Wooton, University of Utah
see **Eve Bradley**

Kewen Yuan, Mount Holyoke College
An Algorithm for Directly Forceable Graphs

A directly forceable graph is a graph that can be entirely colored with only vertices from an optimal zero forcing set. We prove bounds on the zero forcing number of a directly forceable graph, and we construct an algorithm to determine if a graph is directly forceable. In addition, we characterize graphs which are directly forceable for some extreme cases. We use the algorithm to conjecture that regular graphs are directly forceable.

Marisa Zarcone, Colgate University
Critical Groups: Exploring the Algebra of Chip-Firing Games on Graphs

The focus of this project is to study the critical groups of different families of graphs. The critical group of a graph is a finite abelian group defined using the graph's Laplacian matrix and can be described via chip-firing, a combinatorial game that involves distributing "chips" on the vertices of a graph and moving them according to specific rules. We will explore the critical groups of complete bipartite and circulant graphs. This research is motivated by a paper from Glass and Kaplan, who propose various open problems related to the computation of critical groups of graphs.

Sarah Zaske, Grand Valley State University
Cospectral Constructions for the Exponential Distance Matrix

The generalized distance matrix of a graph is a matrix in which every i, j entry is a function of the distance between vertex i and vertex j. Depending on the choice of j, this family of matrices includes both the adjacency matrix and traditional distance matrix. We present a Godsil-McKay switching cospectral construction for the generalized distance matrix. We also investigate a special case of the generalized distance matrix: the exponential distance matrix, which is a matrix in which every entry is a value q raised to the power of the distance between the vertices. We give an upper bound of the values of q needed to show a pair of graphs is cospectral for all values of q corresponding to the diameter of the graphs. We also give cospectral constructions for a unique value of q.