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

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POSTER ABSTRACTS

Posters by Undergraduate Students

Ridwan Abdi, Augsburg University
Dijone Mehmeti, Augsburg University
Ly Xiong, Augsburg University
Modeling Soil Carbon Rates of Change with Nearly-continuous Data from an Environmental Network

The goal of this project was to acquire and analyze environmental measurements from different ecosystems across the United States to model rates of change of soil carbon dioxide. Understanding soil carbon fluxes provides baseline metrics for monitoring changes in soil carbon for future climate scenarios. This project applied data from the National Ecological Observatory Network (NEON; neonscience.org) across a multi-year period using mathematical modeling, data science, and environmental science. After acquiring half-hourly data of temperature, soil moisture, and soil CO_2 concentrations, we then applied a numerical model to calculate the rate of change of CO_2 from the soil (the soil carbon flux) at different sites. We studied and processed code to make it more efficient and run faster using the R statistical software program and associated packages. One challenge we addressed was accounting for measurement gaps for the different input variables into our data science workflow. We developed an online interactive app (https://jmzobitz.shinyapps.io/NEON-soil-fluxes/) to visualize the environmental measurements at the different sites. Although additional model validation is ongoing, we had a good agreement between the different plots in the flux outputs.

Moriah Aberle, Denison University
Rivkah Moshe, Boston University
Decompositions of Cartesian Products of Cycles

We say a graph H decomposes a graph G if there exists a partition of the edges of G into subgraphs isomorphic to H. We seek to characterize necessary and sufficient conditions for a cycle of length k, denoted C_k, to decompose the Cartesian product of two cycles $C_m \square C_n$. We prove that if m is a multiple of three, then the Cartesian product of a cycle C_m and any other cycle can be decomposed into three-cycles of equal length. This extends work of Kotzig, who proved in 1973 that the Cartesian product of two cycles can always be decomposed into two-cycles of equal length. We also show that if k, m, and n are multiples of four, and k divides mn, then C_k decomposes $C_m \square C_n$.

Paige Allen, Lewis University
Laplacian Simplices Associated to Graphs

This research introduces the concept of a Laplacian simplex, which is given from a finite graph by taking the convex hull of the columns of that graph's Laplacian matrix. We define graph terminology along with how to construct the Laplacian matrix. Recently, there is a heightened interest in studying polytopes associated to graphs. It is of interest within the mathematical community to explore how the geometric properties of the polytope relate to the discrete properties of the graph. For instance, the volume of a Laplacian simplex is related to the spanning trees of its underlying graph. We analyze the fundamental parallelepiped of the simplex in order to describe a bijection between lattice points and labeled rooted spanning trees. Finally, we demonstrate the construction of lattice points and present new results regarding the form of lattice points for different families of graphs.

Iliana Alvarez, California State University, Stanislaus
Early Classification of Transients using RAPID

Vera C. Rubin Observatory will carry out a 10-year legacy survey of space and time, known as LSST. Data Preview2, DP02 for short, has helped us engage with the Rubin Platform. DP02 consists of simulated data that includes processed visited images, deep co-ads, the difference images along with catalog data of detections measurements and forced photometry. The work shown here will focus on objects in space that drastically change photometry over time known as transients. These transients include: Type 1a and Core collapse Supernovae, Tidal Disruption Events and more. Through previous work, it has been shown that Neural Networks (NN) can aid in the classification of transient objects in real time. We hope to further our understanding and replicate these NN to apply them to the Rubin database. By classifying the transients using automated methods we are able to investigate the extremely large number of transients we expect to see. Furthermore, we are able to determine an object's supernovae type along with distinguishing other transient types. We hope to determine the probabilistic classification of each transient using the DP02 database. This can be achieved using the RAPID supernovae classification code to determine how well Rubin light curves can be classified. The significance is to determine how many observations are required for reliable classifications in determining transients of interest, as opposed to waiting for annual releases of data to form classifications.

Isabella Asplund-Wain, Gonzaga University
Grace Dojan, Gonzaga University
Total Roman Domination in Kneser Graphs

In graph theory, the Total Roman Domination assigns every vertex in a graph with a 0, 1, or 2. The Total Roman Domination of a graph G is the smallest possible sum of the weights that also obey the following rules. Every nonzero vertex must be adjacent to another nonzero vertex and every vertex labelled '0' must be adjacent to at least one vertex labelled '2'. In this presentation we discuss Total Roman Domination of Kneser graphs. We give exact counts for some graphs and demonstrate bounds for other graphs.

Meryem Boumalak, Hobart and William Smith Colleges
Constructing Semi-Directed Level-1 Phylogenetic Networks Using Quarnets

Evolution is a process that results in changes in the genetic material of a population over time. It reflects the adaptations of organisms to their changing environments. In fact, there is a pattern of how several species evolved from a series of common ancestors. The study of evolutionary relationship among species is called "phylogenetics" and it teaches us how different organisms came to the way there are today and how they might change in the future. Phylogenetics can help to inform conservation policy when conservation biologists have to make tough decisions about which species they try to prevent from becoming extinct.We present two algorithms for constructing phylogenetic networks from their complete set of 4-leaf subnetworks (quarnets). The first algorithm is the sequential algorithm. It begins with a single quarnetand adds on one leaf at a time until all leaves have been placed and the second algorithm is the cherry blob algorithm, which functions by identifying exterior network structures from the quarnets.

Anna Center, Carleton College
Unraveling Knot Theory Through Knitting

Knot theory is an aspect of topology that studies closed curves in three-dimensional space. It is used to further our understanding of surfaces and their properties and is vital for understanding the formation and folding of DNA and enzymes. Knot theory is a subject that has only existed for 153 years, and we can discover so much in this field from the mathematics within knitting. A simple cotton knit fisherman's rib demonstrates the topological property of a relatively non-stretchy string being transformed into a shape that stretches significantly along the horizontal, minimally along the vertical, and proportionally as a combination of the two in any other direction. Knitting is historically overlooked and trivialized as "just" a woman's activity, but the true mathematical complexity and gorgeous art behind knitting has, in recent years, begun to receive recognition for the value it holds.

Katherine Chui, Rice University
Flexible Cone Metrics of the Genus-2 Surface

The set of metrics on surfaces is still mysterious, particularly that of cone metrics. There exist two classes of cone metrics, the well-understood rigid ones and the more slippery, flexible ones. We work to explore the latter by building off of Erlandsson, Leininger, and Sadanand's work which proved that flexible metrics are characterized by the existence of specific covering maps. Specifically, we'll study the covering maps from a genus-2 surface, using a mixture of techniques including geometry (comparing hyperbolic areas), topology (examining local degrees of cover maps), and group theory (relating symmetry groups and permutation representations). Ultimately, we find the complete and explicit list of all flexible cone metrics on a genus-2 surface—a result which helps deepen our understanding of surfaces and their hyperbolic cone metrics.

Madison Cox, Northern Arizona University
Applications of Google's PageRank Algorithm

Google's PageRank algorithm, originally created in 1998, is the dominant design for link analysis. PageRank's ranking scheme has been successfully applied to a wide range of fields including chemistry, biology, literature, and sports. The PageRank algorithm is most commonly used for sports that feature competitions between two teams or competitors, such as basketball tournaments or football games. Our research focused on a sport that does not feature this head-to-head competition style–snowboarding. We utilized PageRank principles to accurately predict the outcomes of the 2022 Olympic snowboard half-pipe competition. The two models that were developed, the Olympian Proportion Model and the Average FIS (International Ski and Snowboard Federation) Model, both outperformed the industry standard ranking system. This research was conducted as part of the 2022 Youngstown State University BUMP REU program.

Grace Dojan, Gonzaga University
see **Isabella Asplund-Wain**

Ellynor George, Washburn University
A Closed-Form Formula to Fibonacci Numbers Using a Geometric Approach and Arctangents

We develop a formula for the calculation of Fibonacci numbers using arctangents. We establish a relationship between pairs of Fibonacci numbers and a geometric construction that relates angles to each other in a pattern that follows the Fibonacci sequence.

Maya Gibson, Pacific University
Mathematics of Facial Recognition Methods

Humans can quickly identify faces despite the complexity of the human face. For a computer, the unique geometries of the face, range of facial expressions, and intensity of light in an image make identifying an individual a difficult task. The computer must reduce a large amount of data from an image in a way that retains the most important information while removing unnecessary information. We investigate the mathematics of two common methods used in facial recognition: Principal Component Analysis and Linear Discriminant Analysis. Both methods create a model that best represents a database of images and uses statistical analysis to identify whether a new image belongs to a class of images. Principal Component Analysis reduces the dimensionality of data by finding principal components. These principal components represent the maximum variance of data and give us a standard image to compare new images to. Linear Discriminant Analysis identifies an individual among several classes of faces by finding a model that maximizes the difference between classes and minimizes the variance within a class. This process simplifies the task of determining whether a new image belongs to a specific class. We ask which method is more effective depending on the class size and investigate variations on each.

Parneet Gill, California State University, Fresno
Relationship Between k-Zone and k-Naples Parking Functions

We introduce new variants of parking function rules with a backward movement called k-Zone, preferential, and inverse preferential functions. We study the relationship between k-Zone parking functions and k-Naples parking functions and count the number of parking functions under these new parking rules that allow cars that find their preferred spot occupied to back up a certain parameter. One of our main results establishes that the set of non-increasing preference vectors are k-Naples if and only if they are k-Zone. For one of our findings, we provide a table of values enumerating these new combinatorial objects in which we discover a unique relationship to the order of the alternating group A_{n+1}, numbers of Hamiltonian cycles on the complete graph, K_n, and the number of necklaces with n distinct beads for $n!$ bead permutations.

Jordan Grothe, University of South Dakota
Analyzing Heat Generated from Electro-Osmotic Flow Utilizing Computational Fluid Dynamics

Without extensive vascularization, the transfer of essential fluid and nutrients through human tissue is limited to diffusion and weak interstitial flow. Electroosmosis, or the flow of fluid driven by an electrical field, has become a promising solution. Scientists have began applying an electric field to human tissue to promote stronger interstitial flow; however, optimization of this process has proven to be a challenge due to the ohmic heating that occurs. Cells function in a small range of temperatures, and exposing cells to voltages above the threshold will cause them to degrade and die. This research seeks to better understand and quantify the range of voltage where the heat generated leads to cell degradation and death. When voltage is applied, heat is generated, yielding an increase in the temperature of the nearby cells. Utilizing a computational fluid dynamics software, Sim Center Star-CCM+, a model of tissue mimicking a clinical application of electricity was created and used to test different voltages while monitoring the temperature and time; then, this data was compared to prior-established values depicting when cells undergo irreversible damage. Research has already shown that electrical stimulation can drastically increase the rate at which a wound heals; understanding the thresholds for when damage occurs will allow clinicians and scientists to optimize this process while avoiding cell damage.

Katherine Harr, Xavier University
Sheny Perez, Xavier University
The Game of Cycles on Caterpillar Graphs

The Game of Cycles is a relatively new two-player game. The players take turns placing an orientation on an edge on a graph, until someone wins. This occurs when the player either makes a cycle or makes the last legal move. Our research led us to find winning strategies on two types of graphs: paths and caterpillars. We will outline these strategies and discuss some of the nuances and subtleties of this mathematical game.

Nicole Herre, University of Central Oklahoma
Investigating Monty Hall Variants Through Statistical Analysis and Simulation

The Monty Hall Problem is a well-known and notoriously contentious probability problem, the counterintuitive nature of which illustrates the difficulties presented in reasoning about probability. This poster aims to employ both statistical analysis and computer simulation to explore and shed light on solutions to variants of the Monty Hall Problem. A new variant of the Monty Hall Problem and its respective analysis will additionally be presented.

Annika Hurd, Drake University
APOS Approach to Analyzing Student Understanding of Derivatives Through Online Tasks

APOS, or Action-Process-Object-Schema, theory is utilized to codify student understanding of derivatives. Following the genetic decomposition for derivatives given by Asiala et al. (1997), we categorized and interpreted student perception of the derivative using data collected from an online task. The triad model for schema development of derivatives through the lens of APOS was utilized to analyze student interviews. Results suggest that students, specifically women, are viewing the derivative procedurally rather than conceptually. We identified components of the genetic decomposition and their critical role in student understanding of derivatives. Evidence of the two dimensions of conceptual understanding (property and interval) as outlined in Baker (2000) was also present. Further, after prompting students in a way that aligned with the genetic decomposition, we found that such prompts via online environments could be integral to student understanding. However, there is a need to investigate this further.

Kathryn Ikard, Gonzaga University
Graph Searching Application of Cat and Mouse Game

We explore a Cat and Mouse game on graph families by considering varying numbers of cats. Every turn, each cat picks a vertex to check if the mouse is there. After every turn the mouse invisibly moves to an adjacent vertex. The game ends if and when the mouse is caught. Our goal is to minimize the total number of vertices occupied by the cats over all turns, denoted T. We developed several strategies to minimize T. We demonstrate T on graph families including binary trees and complete graphs. We find that placing multiple cats on the same vertex during some turns can be an optimal strategy.

Eliza Kautz, Dordt University
Jocelyn Zonnefeld, Dordt University
Investigating the Game of Cycles: Strategies and Computations

The Game of Cycles was introduced by Dr. Francis Su in 2020 and has since sparked mathematical interest. In this game, two players take turns adding direction to the edges of a planar graph where the winner either marks the last edge or completes the first cycle. We expand on previously established winning strategies for the Game of Cycles to include certain 3-dimensional boards as well as present new strategies for adjacent symmetric boards, some of which provide a counterexample to a well-known question regarding the parity of board edges. We also develop a tabular representation of a board and introduce a computer program that generates a winning strategy for any legal game board.

Veritatis Kong, United States Air Force Academy
Investigating Gerrymandering with Graph Theory

Gerrymandering is the manipulation of boundaries with the intent of achieving a certain outcome. By using nodes to represent objects, and edges to represent connections between them, we can apply graph theory to effectively gerrymander. Public education in the U.S. is largely dependent on which district you live in. Can we use graph theory to create a consistent standard for public schools across the U.S.?

Uyen Le, Denison University
The Impacts of Unanswerable Questions on the Robustness of Machine Reading Comprehension Models

Machine Reading Comprehension (MRC) is a fundamental and challenging subfield of Natural Language Processing in which the computer simulates a human question-and-answer mechanism by extracting the answers to given questions based on provided contexts. MRC makes it possible for machines to read, infer meaning, and deliver answers immediately while sifting through a large dataset. MRC systems have been widely deployed by industry in search engines and quality assurance systems. With the development of recent deep learning technologies, MRC systems have achieved many state-of-the-art performances, matching or even exceeding human level standards on many datasets and benchmarks. Nevertheless, their relative inability to defend against adversarial attacks has spurred skepticism among the research community about their true robustness. In this presentation, we ask whether additional training on unanswerable questions, which are designed adversarially to be relevant to the context, can help MRC models recognize small syntactic differences between questions and context that are important in the robustness of the models.

Rachel Leslie, Ohio Wesleyan University
Partial Sums in Reverse Lexicographic Ordering

The value of the sign character on the conjugacy class indexed by a partition λ of n is known to be $(-1)^n - \ell(\lambda)$. It is well-known that the sum of these values over all partitions of a fixed integer n is equal to the number of partitions of n with distinct odd parts, hence a nonnegative integer. Sundaram conjectured in her work on the character table of the symmetric group S_n that each partial sum ranging from (1^n) to λ, where the partitions are ordered in reverse lexicographic orders, are nonnegative. This project aims to explore different ways to tackle this conjecture and study the significance of reverse lexicographic ordering of partitions. We also verify the conjecture for all $1 \leq n \leq 51$.

Katherine Levandosky, Northeastern University
see **Maria Pasaylo**

Taylor Luck, Xavier University
Game of Cycles

The Game of Cycles is a two-player deterministic game that is also a relatively new field of study in mathematics. Through the course of our research, we looked at different graphs the game can be played on and corresponding winning strategies for certain players depending on the graph. This presentation highlights these findings and describes the appropriate winning strategies for the graphs we looked at. We hope to continue this research in the future and hope our work throughout the school year presents even more findings in the field.

Maya Mandyam, United States Air Force Academy
Spatial and Temporal Scales of Pulsating Aurora during the Loss Through Auroral Microburst Pulsations (LAMP) Rocket Mission

The Loss Through Auroral Microburst Pulsations (LAMP) Rocket mission launched 5 March 2020 at 11:27:30 UT. As part of the LAMP mission, a high speed Phantom camera with a narrow field of view lens (40 degrees full angle) was deployed at Venetie, Alaska, directly under the apogee point of the rocket. The Phantom camera was equipped with a BG-3 filter to record only the short-lived visible emissions from the aurora. We report on the spatial and temporal scales of the pulsating patches the LAMP rocket flew through. A variety of spatial and temporal scales are observed in the pulsating patches. Faster pulsations appear narrower, while slower pulsations appear wider. The orientation of the pulsations change during a four-minute time span when the rocket flew through the zenith.

Katja Mathesius, Drake University
Data Analysis for Early Prediction of Bank Failure

Brought on by the sudden collapse of many banks, the 2007-2008 financial crisis was the worst economic crash since the Great Depression. Avoiding similar crises in the future requires the ability to quickly identify which banks are likely to fail. As bank failure is rare, even in a financial crisis, identifying the need for preventative action requires a more finely tuned approach. Using decision tree models and data from the 2007-2008 financial crisis, we create interpretable models that give early warning to an individual bank's risk of failure and highlight the significant factors that play into a bank being at risk.

Kayley McBride, University of Central Oklahoma
3D Printed Objects to Enhance Understanding in Calculus

In this project we create 3D printed objects to help students understand calculus concepts. A DFW rate is defined as the percentage of students who earn a D, an F, or withdraw from their course. Nationwide, the DFW rate for Calculus 1 can be up to 60%. At the University of Central Oklahoma, the DFW rate is about 50%. Our goal is to lower the DFW rate, and a first step in this groundwork project is to design and print novel objects based upon the calculus curriculum. Several surfaces and models from the calculus sequence, including a model of the shell method of integration, quadric surfaces, and nonorientable surfaces will be presented.

Dijone Mehmeti, Augsburg University
see **Ridwan Abdi**

Ava Mock, Wellesley College
Repetitions of Pak-Stanley Labels in G-Shi Arrangements

Given a simple graph G, one can define a hyperplane arrangement called the G-Shi arrangement. The Pak-Stanley algorithm labels the regions of this arrangement with G.-parking functions in a way that some G.-parking functions may appear more than once. These repetitions of Pak-Stanley labels are a topic of interest in the study of G-Shi arrangements and G.-parking functions, as well as the many combinatorial objects they are connected to. The key insight of our work is the introduction of a combinatorial model called the "Three Rows Game". Analyzing the histories of this game and the ways in which they can induce the same outcomes allows us to completely characterize the repetitions of the Pak-Stanley labels for path, cycle, and star graphs, and make substantial progress toward understanding the repetitions of the Pak-Stanley labels for trees and general graphs.

Layla Montemayor, University of Nebraska-Lincoln
Optimization in the Emerald Cloud Lab

The Emerald Cloud Lab is a remotely operated research facility that allows scientists to virtually design and execute experiments. Our goal was to optimize the Emerald Cloud Lab laboratory functions by creating a mathematical model of their laboratory operations using the discrete event simulation software called Arena. Using real data given to us by the Emerald Cloud Lab, we specified the number of scientific instruments of each type, including how long they take to perform different tasks, and whether human operators are needed during these tasks. We encoded sequences for various experiment procedures. Given a set of instruments and rate of arrival for experiments, our model can determine the optimal number of laboratory workers.

Rivkah Moshe, Boston University
see **Moriah Aberle**

Katie Munteanu, University of California, Los Angeles
Libby Tiderman, The University of Arizona
An Analysis of Mass Shootings in the US from 2013-2021

Mass shooting incidents have drastically increased in the U.S. in the last 10 years, with a disproportionate number of incidents occurring in some states. Gun laws vary greatly by state, but little research has been conducted to examine the association between the strength of state gun laws and mass shootings. This research aims to explore the aggregate effect of state gun laws on the rate of mass shooting incidents and fatalities from 2013-2021, using mass shooting data from Gun Violence Archive (GVA) and applied Poisson regression models. Results from the Poisson regression model showed that gun law permissiveness was significantly correlated with the fatalities of mass shootings. Time charts were used to determine trends in mass shootings from 2013-2021, and geographic prevalence of mass shootings was determined through the use of a heat map.

Hailey Murray, Embry-Riddle Aeronautical University
Classifying Quantum Adjacency Matrices

A finite directed graph consists of a finite set of vertices and an adjacency matrix that describes when there is an edge from one vertex to another. A quantum graph replaces the finite vertex set with a finite-dimensional matrix algebra and replaces the adjacency matrix with a quantum adjacency matrix, which is a function on the matrix algebra. In this talk, we classify certain classes of quantum adjacency matrices by computing their eigenvalues and determining when they are (quantum) regular or when they are homomorphisms. Additionally, we study relationships that arise between the eigenvalues of a quantum graph's quantum adjacency matrix and its corresponding quantum edge checker, which is analogous to a graph's edge matrix and is used to determine the quantum graph's "edges."

Edmonde Olongo, Dominican University
Mathematically Modeling the Interactions of Community- and Hospital-Acquired C. difficile Infections

Clostridioides difficile (*C. difficile*) is an infection-causing bacterium commonly contracted by patients in medical institutions in the United States. *C. difficile* creates endospores that can survive in harsh conditions for long periods of time. This bacteria can be spread either through contact from person to person or with surfaces hosting the endospores. Patients who are currently on or have recently taken an antibiotic are susceptible to contracting *C. difficile* as certain bacteria in the stomach become weaker, creating an ideal environment for *C. difficile* as its spores spread faster without competition. This mathematical model quantifies the spread of *C. difficile*, differentiating between community- and hospital-acquired infections. Using a system of ordinary differential equations distinguishing between individuals in the local community and hospital as well as varying environmental surfaces, simulated results can be used by local communities to predict and limit potential outbreaks of *C. difficile*.

Kayleigh Page, University of Central Oklahoma
Diversity in Oklahoma City High Schools

The state of Oklahoma contains up to three times as many school districts as other states with similar student populations. This can be seen in Oklahoma City where 25 different school districts either intersect or are completely surrounded by its city limits. This raises questions about integration in schools and how it plays a role in civil rights policies. In this poster, we analyze racial trends over time of school districts in the Oklahoma City area. This is done by using various diversity measurements pulled from sociology and ecology as well as geographical analysis on specific high schools in Oklahoma City.

Maria Pasaylo, University of Florida
Katherine Levandosky, Northeastern University
The Harary Index as a Network Reliability Parameter

In this project, we explored the Harary index as a measure of network reliability. The Harary Index is defined as the sum of the reciprocal distances between all pairs of vertices in a graph. Our focus, however, was on how the Harary index changes when a graph was altered through single edge-removal or vertex-removal. Intuitively, we say that a larger change in this index when an edge is removed implies that the graph is less stable. We investigated complete graphs, bipartite and m-partite graphs, cycles, paths, and binary trees. Additionally, in the graph class $G(n, m)$, which is the class of all graphs with n vertices and m edges, we found graph constructions such that there exists an edge removal that produces the maximum change in the Harary index. We also found graphs which exhibit the minimum change in the Harary index when an edge is removed. Finally, we found graph constructions that have maximal (and similarly, minimal) change in the Harary Index when any edge is removed.

Sheny Perez, Xavier University
see **Katherine Harr**

Alice Ponte, Georgia Institute of Technology
Characterizing when Skew-symmetric Matrix Schubert Varieties are Gorenstein Using Pattern Avoidance

Algebraic varieties are sets of solutions to systems of polynomial equations. In many important cases, these polynomial equations are determined from combinatorial data, for example a graph or a permutation. In these situations, combinatorial properties of the defining objects govern geometric properties of the corresponding algebraic varieties. One class of combinatorially defined algebraic varieties are the Schubert varieties. Each Schubert variety is defined from a permutation. It is well-known that a property of the defining permutation, namely pattern avoidance, determines when the corresponding Schubert variety has singularities. In this poster, we will explore singularities of a related class of algebraic varieties, namely the symmetric and skew-symmetric matrix Schubert varieties, in terms of pattern avoidance.

Kaylee Rosendahl, Illinois Institute of Technology
Distributed Kalman Filter Designs and Experiments for Proliferated Low Earth Orbit (pLEO) Satellite Constellations

Government and private entities are working on developing proliferated low Earth orbit (pLEO) satellite constellations due to their lower latency, lower replacement costs, and higher resilience to satellite outages relative to traditional satellites in geostationary or medium Earth orbit. However, the development of these constellations has raised new position, navigation, and timing challenges as pLEO constellations cannot rely exclusively on information from ground stations. In this project we tackle the timing aspect of these challenges. Specifically, we explore the performance of various distributed Kalman filters for synchronizing the satellite clocks across a constellation. Three distributed Kalman filters are examined: the Naive algorithm, the Primitive Distributed Kalman Filter (PDKF), and the Decentralized Collaborative Localization (DCL) algorithm. Performance of each is measured by "wrapping" them with a centralized Kalman filter that provides us with an estimate of the clock uncertainties accounting for all cross-covariance information between satellites. We show that the clocks converge quickly to low error using the DCL algorithm when we introduce an appropriately chosen update order and tune the filter's parameters.

Dayanna Sanchez, Lewis University
Analyzing the Impact of Alternative Assessment and Growth Mindset

Alternate assessment techniques such as mastery grading, specifications grading, and standards-based grading are assessment techniques professors are implementing in order to support a growth mindset of learning. This proposal will support a multi-institutional collaboration that studies the impact of mastery grading assessment techniques on the growth mindset of students in a variety of mathematics classes. By analyzing pre- and post-surveys with questions adapted from Dweck's Mindset survey, we will explore whether there is a difference in the growth mindset between various cross-sections of student populations between classes (mastery and non-mastery, specific courses, universities, etc.) and whether the growth mindset of students changed by the end of the semester. This research will explore whether there is a difference in students' mindset of learning mathematics between various cross-sections of student populations between classes (mastery and non-mastery, specific courses, universities, etc.) and whether the growth mindset of students changed by the end of the semester.

Janee Schrader, University of Wisconsin-Eau Claire
GCD of sums (and sums of squares) of k consecutive terms of the Pell sequence and related sequences

We explore the GCD of all sums of m^{th} powers (with $m = 1$ and 2) of k consecutive terms of a sequence $(S_n)_{n\geq 0}$ where the terms S_n come from exactly one of the following six well-known sequences: Pell P_n, associated Pell Q_n, balancing B_n, cobalancing b_n, Lucas-balancing C_n, and Lucas-cobalancing c_n numbers. For brevity, we use the symbol $\mathcal{S}^m(k)$ to denote this GCD. We give a complete description of $\mathcal{S}^1(k)$ for all six sequences. These closed forms all involve certain braid sequences of Pell and associated Pell numbers in an intriguing manner. We further give partial results on $\mathcal{S}^2(k)$ for some of the sequences. We collected data through Wolfram programming in Mathematica to gather conjectures and provide further evidence of the results we inevitably proved.

Veer Singh, United States Air Force Academy
The Impact of Human Activity on Wildlife Presence and Behavior During COVID-19

Industrial development and public access to protected lands have been impacting wildlife survival for the last few centuries. Animals are most successful in uninterrupted habitats and the progression of humanity is actively impacting what were once thriving communities. Due to its status as a United States military installation, the United States Air Force Academy (USAFA) has several acres of protected land allowing a unique opportunity for wildlife to thrive in their natural habitat. However, due to increased development and public access to USAFA within the last 50 years, some wildlife (large animals in particular) has become more fearful and less active throughout USAFA. During COVID-19 on March 20, 2020, USAFA closed its gates to the public, which resulted in minimal to no public access to USAFA's protected lands thus creating a unique opportunity to observe wildlife behaviors. This closure significantly decreased the foot traffic on USAFA, which led to a shift in animal behavior. Although this shift has been casually observed, there has not been a directly recorded correlation between base closure and animal behavior. I am using camera trap data from various motion detected cameras on the installation as well as human trail use counters to analyze these trends. Specifically, I'm using statistics in Python along with the package ecoPy to do species diversity and geographic niche analysis. Overall, I seek to use statistics and data science to understand the relationship between fluctuations in human activity and wildlife behavior in a relatively controlled environment (USAFA).

Eha Srivastava, University of Chicago
Arboreal Lagrangian Skeleta and Legendrian Handlebodies

One way to study symplectic manifolds is by building them up from smaller, easily understood pieces. As in the smooth case, we can form symplectic manifolds via handlebody constructions using Weinstein handles. Another way is to study the skeleton of a symplectic manifold, a submanifold that encodes the data of the entire manifold. Arboreal Lagrangian skeleta have simple enough singularities so that the entire manifold can be recovered from just the skeleton itself. This project proves that the symplectic 4-manifold obtained by attaching a Weinstein 2-handle to a 0-handle along a Legendrian (2, 2g+1)-torus knot is equivalent to the cotangent bundle of the genus g surface with 2g Lagrangian disks attached. In particular, the union of the 2g Lagrangian disks constitute an arboreal Lagrangian skeleton for this manifold. In this work, we establish the handlebody diagrams for the two presentations of this manifold and prove they are equivalent using Legendrian Reidemeister moves and Weinstein handle-sliding/cancellation.

Elisabeth Starr, University of San Francisco
Regression Analysis of Student Exercise Engagement with University Health Promotion Department

Every year the University of San Francisco sponsors a challenge called "Go Dons Get Fit" in which students and faculty compete to see who logged the most exercise minutes in the month or October. A linear regression analysis was performed using R. It utilized student data from the 2021 challenge to understand patterns in student exercise behavior over the course of the month, including the midterm period. The analysis found that students' participation in the challenge dropped off as the month progressed. There were several proposed reasons for this, including that students became too overwhelmed around midterms to prioritize exercise. It is recommended that in future the Health Promotion Department emphasizes how beneficial exercise is for managing academic stress and create rewards for consistently logging minutes during midterm week.

Emily Thigpen, Francis Marion University
The Mathematics that Built the Great Pyramid

The Great Pyramid in Egypt is a wondrous work of art, but also a beautiful mathematical construction. Sand, earth, and brick were not the only materials used in the constructions of the Great Pyramid. Likewise, sledges, rollers, and levers were not the only tools used either. When the Great Pyramid was built, the Ancient Egyptians used math as the most useful tool. Trigonometry, algebra, geometry, and the Pythagorean Theorem are math concepts that were used to shape the Great Pyramid. Mathematics meant a lot to the Ancient Egyptians, as it was the answer to many of the problems and questions they encountered in Ancient Egypt. The remains of the Ancient Egyptian pyramids, such as the Great Pyramid, are proof that mathematics was in its developmental stages during the ancient civilization time period. The Ancient Egyptians were the talented mathematicians who put the tool of mathematics to good use to build what are now recognized as mathematical masterpieces. Regardless of whether trigonometry, algebra, geometry, the Pythagorean Theorem, or any other mathematical idea was the key to the Great Pyramid's construction, the Ancient Egyptians unlocked it.

Libby Tiderman, University of Arizona
see **Katie Munteanu**

Ryleigh Tucker, University of Central Oklahoma
Suicide Prevention among Oklahoma's Student Veterans

In 2020, the Governor of Oklahoma issued a statewide challenge to reduce and eliminate suicide among Oklahoma's service members, Veterans, and their families. As a result of this challenge, in 2022, a survey concerning suicidal ideation among Oklahoma's student Veterans was conducted. Multiple agencies were involved in the development of the survey, including the University of Central Oklahoma and the Oklahoma Department of Veterans Affairs. The survey contained items concerning demographics, social support, military affiliation, and academic status. Additionally, to measure depression severity, the 10 items from the PHQ-9 survey (Kroenke, Spitzer, & Williams, 2001) were included. To prepare for distribution, campus Veterans' offices were contacted regarding their current outreach practices. The survey was then distributed through Veterans offices at campuses across Oklahoma, including career-tech centers, community colleges, primarily undergraduate institutions, public research universities, and private institutions. In all, 105 student Veterans responded. Chi-square tests and t-tests were performed to identify factors related to suicidal ideation and major depression. Following this, a multiple regression model for predicting the overall PHQ-9 score was developed. These results will be disseminated to Oklahoma higher education institutions to assist with their outreach efforts and to bring awareness to deficiencies in their current practices.

Sarah Turner, Furman University
Directed Graphs and their Properties: Exploring Entropy and Optimal Travel Times

We set out to accomplish two different but related goals. First, we investigate the entropy of strongly connected directed graphs on grid systems with exactly one directed edge between any two adjacent vertices. We seek to find how reconfiguring the directions of these directed edges impacts the overall entropy on these ladder graphs. Second, we define a directed graph which flows from some number of source points to some number of sink points. By defining a shift as the ability to move any number of items from one vertex to another along an edge with the restriction that we use each edge only once, we seek to find the shortest number of shifts we can use in order to move all objects from the source points in our graph to the sink points.

Rose Una, Western Washington University
Cellular Oscillatory Synchronization and Aggregation with the Cellular Potts Model

Similar to how schools of fish synchronize their movements, certain single-celled species synchronize internal molecular clocks housed in each cell of a colony. Synchronization of clocks is connected to colony aggregation. We develop an abstract Cellular Potts Model (CPM) for this oscillatory synchronization with two-dimensional cells on a square lattice. The model is based on real behavior in slime bacteria (myxobacteria) and slime mold (*Dictyostelium discoideum*) species. Cell-cell adhesion and cell movement are linked to phase differences in the molecular clocks. In the CPM framework, cell-cell adhesion is governed by the so-called Hamiltonian energy function. Additionally, each cell's clock is variably updated in each time step. The spatial attraction parameter and the neighboring clock coordination parameter are explored in this project. Results include phase diagrams, synchronization rates, and cell movement analysis. The results of this project are applicable to pattern formation in cell cultures.

Lily Wartman, Scripps College
Geometric Characteristics of Symmetric Numerical Semigroups in the Kunz Cone

There has been recent interest in the relationships between semigroups and a geometric object called the Kunz cone. Our research explores a specific type of numerical semigroup called a symmetric numerical semigroup. We uncover and identify the characteristics of the faces of the Kunz cone where symmetric numerical semigroups lie, named Ripley faces. We look to characterize Ripley faces and discover the relationships between them.

Lauren Weiland, Augsburg College
The Effects of Rotational Symmetry on the Performance of Laguerre's Method

Laguerre's method is a well-known iterative method used to find the roots of a polynomial. Its weakness as an iterative method has been seen as having issues with symmetry. In this research, the relationship of the rotational symmetry of complex roots of a polynomial and the performance of Laguerre's method are explored. By utilizing many tools developed for GNU Octave, the exploration covered many polynomials of degree five up to 12. As the exploration continued, it appears that there is a strong connection to the symmetry of roots of a polynomial and Laguerre's method.

Ly Xiong, Augsburg University
see **Ridwan Abdi**

Haoru Yang, Colorado College
Improving the upper bound of Ramsey Number $R(J_5, K_5)$

The Ramsey number $R(s,t)$ is defined to be the smallest integer n such that every graph of order n contains either a clique of s vertices or an independent set of t vertices. It deals with finding orderly substructures within apparent chaos. In 2017, Vigleik Angeltveit and Brendan D. McKay improved the upper bound of $R(5,5)$ to 48 using the "gluing" method. In this research, the same method was applied to improve the upper bound $R(J_5, K_5)$, where K_5 is a complete 5-order graph and J_5 is K_5 with one edge removed. The "gluing" method shows that if $G, H \in R(K_4, J_5, 18)$ and $K \in R(K_3, J_5, d)$, $3 \leq d \leq 8)$ can be glued together to form $F \in R(J_5, K_5, 32)$, the upper bound of $R(J_5, K_5)$ can be improved from 33 to 32.

Xingyi Zhang, Carleton College
Graphs with Many Hamiltonian Paths

A graph is Hamiltonian-connected if every pair of vertices can be connected by a Hamiltonian path, and it is Hamiltonian if it contains a Hamiltonian cycle. Every Hamiltonian-connected graph is Hamiltonian; however, we also construct families of non-Hamiltonian graphs with 'many' Hamiltonian paths, where 'many' is interpreted with respect to the number of pairs of vertices connected by Hamiltonian paths. We then consider minimal graphs that are Hamiltonian-connected; we show that any order-n graph that is a Hamiltonian-connected graph must have greater than or equal to $3n/2$ edges, and we construct an infinite family of graphs realizing this minimum.

Jocelyn Zonnefeld, Dordt University
see **Eliza Kautz**