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

January 20 – January 22, 2023

TALK ABSTRACTS

PLENARY TALKS

Dr. Deanna Haunsperger
Professor of Mathematics, Carleton College
Community and Belonging in Mathematics

How can we change the face of mathematics to include more women and members of underrepresented groups? We can consciously build more communities to welcome in people who have been historically underrepresented in mathematics and make them feel like they belong.

Dr. Judy Walker
Associate Vice Chancellor for Faculty and Academic Affairs and Professor of Mathematics, University of Nebraska-Lincoln
The Importance of Mentors

The Nebraska Conference for Undergraduate Women in Mathematics was founded in celebration of the Nebraska math department's receipt of the 1998 Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring. In this talk, I'll share with you some of my own most impactful mentoring experiences, how my mentors have influenced my career, and how these experiences informed the founding of this conference.

Dr. Talithia Williams
Associate Professor of Mathematics, Harvey Mudd College
The Power of Talk: Engaging the Public in Mathematics

When it comes to inspiring the future productivity and innovation of our nation, mathematicians are on the front lines. In this talk, I will discuss the importance of engaging a wide range of audiences in conversations about the nature of our work and of scientific discovery. As we change the way communities think about the natural world and the STEM disciplines, we can begin conversations that improve public perception of science and bring people from all backgrounds into this important work.

Talks by Undergraduate Students

Emma Andrade, California State University, Fresno
User-Item Recommendation Approaches to Detect Genomic Variant Interactions

Organisms' genomes, which are composed of nucleotides A, G, C, and T, are subject to genomic mutations. These mutations are primarily classified as structural variants or single nucleotide polymorphisms (SNPs), each of which can impact the phenotype of the organism. The change in quantitative or qualitative phenotype caused by a group of mutations can be described as epistasis. The epistatic interactions of three or more SNPs are not completely understood. The exponential number of groupings of mutations poses a challenge when analyzing the epistatic relationship between SNPs and the corresponding phenotype. To address this, past methods have required Bonferroni or similar approaches. In this work, we propose user-item recommendation systems for genomic signals to reduce the search space for higher-order interactions. In muscle-mice data, our recommendation system approach detected statistically significant coalitions of SNPs associated with their body weight.

Ezra Aylaian, University of Maryland
Investigations of Hierarchical Temporal Memory

We investigate the effectiveness of Hierarchical Temporal Memory (HTM), a recent machine learning (ML) technology. After introducing the mathematical foundations of HTM, we introduce properties we want a "good" ML system to satisfy, including noise resilience, selective attention, studiousness, and ease of use/technical readiness. We then provide evidence in the form of experiments and our experience to determine to what degree HTM has or lacks these properties. We also test HTM for experimental plausibility for a real-life application—change-of-tactics detection during a multi-raid missile barrage—using simulated data. HTM is new and has many properties that differentiate it from classical ML systems, and we answer some of the basic questions about HTM. In doing so, we determine whether it warrants future study.

Megan Blanchette, Keene State College
Subseries of Divergent Series

The p-series diverges for $0 < p <= 1$ and converges for $1 < p$. We consider a p-series where $log(9) < p <= 1$ and we remove all the fractions having denominator n with at least one 9 as a digit. The surprising result is that the remaining subseries converges. A pandigital number is a positive integer that contains at least one of each of the 10 digits. In this case, we show that the subseries consisting only of denominators that are pandigital is divergent. This research project extends some of these results to other subseries of divergent series.

Louisa Brown, Furman University
Lily Feingold, Furman University
Deciphering Downtime in Disney: Exploring the Impact of Attraction Downtime in Walt Disney World

Walt Disney World is composed of four theme parks that include various rides, character meetings, shops, and restaurants for guests to enjoy. With so many attractions from which to choose, the need for efficiency is crucial. Thus, guests typically prefer to avoid riding attractions when they have long wait times. One aspect that often affects wait times is downtime, a period of time when guests are unable to ride an attraction. Our research studied how downtime in Remy's Ratatouille Adventure, a popular ride in the Epcot park, affected the wait times of surrounding attractions. We received wait time data in partnership with TouringPlans and employed techniques in descriptive analysis and data visualization in order to identify patterns. We were able to specify which attractions were affected by downtime in Remy's Ratatouille Adventure and quantified this impact in terms of the percent increase in ridership attractions experienced following an outage. We found that the impact of downtime varied based on the time the outage occurred and the length of the outage. Our hope is that these findings can better inform guests' decisions when Remy's Ratatouille Adventure, specifically, experiences an outage. This work can be generalized and expanded to investigate guest visit patterns at other attractions and theme parks.

Julia Courtney, Fairfield University
Grace Gallagher, Fairfield University
Elliptic and Hyperbolic Dynamics in Moon Billiards

Mathematical billiards are dynamical models of point particles colliding with fixed boundaries. They generate different types of behavior depending on the geometry of the boundary. In this talk, we study a class of billiards known as moon billiards. These billiards are formed by intersecting two circles of different radii. We attempt to classify the dynamical behavior as a function of certain table parameters such as the radius of the larger circle and the distance between the centers of the circles. With the help of MATLAB simulations, the main features we find are elliptic islands coexisting with chaotic components which ruin ergodicity. This research was carried out in Summer 2022 with funding from the National Science Foundation.

Madison Cox, Northern Arizona University
see **Kaylee Freudenthal**

Cassidy Cubra, United States Air Force Academy
Supervised Machine Learning: Using Statistical Models to Predict College Completion Rates

The Department of Education College Scorecard provides data on all colleges in the United States. The data includes everything from admissions to earnings made by working students. Using this extremely large data set, we created a machine learning model in R to predict four year undergraduate completion rate. After using supervised learning to train the model, statistical and machine learning methods such as K-Fold Cross Validation and Lasso and Ridge regressions were used to test and improve the accuracy of the model. The goal was to create an accurate model, then using the model, find correlations between variables that contribute greatly to a high graduation rate. Identifying the variables that lead to a higher completion rate can aid colleges in changing their institutions to help as many students as possible graduate.

Natalie Dodson, Middlebury College
Constructing User Financial Profiles from SMS Messages

Short Message Service (SMS) messages are a rich form of data for user financial modeling. This study built models for classifying and extracting financial information from SMS messages. We created a synthetic dataset that was suitable for this task by combining template-generated messages and messages from public datasets. Then we implemented multiple models for message classification. Our experiments show that Support Vector Machine achieves the highest accuracy of 98% for detecting financial messages, while fine-tuning the pretrained BERT model gives the best accuracy (79%). Moreover, we experimented with a publicly available tool for information extraction and achieved 91% F1-score. Finally, we gave recommendations on using our results to build a production-level system that can construct user financial profile from SMS.

Mallory Dolorfino, Kalamazoo College
Yuxuan Sun, Haverford College
Characterizing Simple Alternating Groups by Their Codegree Sets

Let G be a finite group. Define the codegree of an irreducible character of G, x, by cod(x) = $|G : ker(x)|/x(1)$, and define the codegree set of G to be the set of codegrees of all irreducible characters of G. Let H be any simple alternating group. We show that if any finite group G and H have equal codegree sets, then G is isomorphic to H.

Armelle Duston, Colorado School of Mines
The Relationship Between Adolescent Obesity and Sleep

Obesity is a widespread condition worldwide and particularly in the US and is associated with many other poor health outcomes. As a result, it is imperative to get a better understanding of the philological aspects of obesity and how we might help people improve their well-being. We also know that short sleep duration and circadian misalignment are associated with reduced insulin sensitivity in adolescents with overweight/obesity. Sleep parameters can be targets for health improvements and require no drugs or other significant medical interventions. This research looks at two studies in which actigraphy and melatonin data was collected from adolescents covering a wide range of BMIs. Preliminary results indicate there may be a link between adolescent obesity and melatonin dynamics. Using two-sample t-tests, it was found that on average dim light melatonin onset (DLMO) happened 43.8 minutes later in the obese group with a p-value of 0.0176 and dim light melatonin offset (DLMOff) happened 48.6 minutes earlier on average with a p-value of 0.0348. Additionally, linear regressions on the data revealed similar trends, with a positive linear association between BMI and DLMO and a negative linear association between BMI and DLMOff. Although these are preliminary results and come with a lot of caveats, the drastic differences between the two groups suggest there may be physiological differences between the two groups.

Lily Feingold, Furman University
Louisa Brown, Furman University
Finding Math in the Madness: Predicting Upsets in the March Madness Basketball Tournament

March Madness is a single-elimination college basketball tournament where 64 teams compete in one of four regions and are seeded from 1 to 16 in each region. Our research focused on predicting upsets in the men's tournament, which we defined as games where there was a seed difference of five or greater and the team with the higher seed (underdog) won. In partnership with ESPN, we studied regular season data from 2007-2021 to determine which characteristics of teams resulted in upsets more or less often than the historical average, which is 23% of the time. We employed techniques such as single and multivariable analysis and clustering to construct 18 models, and we combined them using boosting to create an ensemble model with preferential weighting given to models that were more predictive. We tested our ensemble model on games from 2022, and we hope to use this model as a framework to offer insights into future matchups and help us predict upsets going forward.

Kaylee Freudenthal, Ohio Northern University
Madison Cox, Northern Arizona University
A Topological Invariant of Fullerenes under Goldberg-Coxeter Transformations

A digraph is completely trivial (CT) if the digraph is strongly connected for any choice of edge orientations that does not allow maximal or minimal vertex indegrees; if not, we say the digraph is not completely trivial (NCT). A fullerene is a cubic graph whose faces are only pentagons or hexagons. We will show that all fullerenes are NCT.

Yuhan Fu, Denison University
Bayesian Online Changepoint Detection on COVID-19 Data and National Policy Analysis

Methods for analyzing COVID-19 data and policies have become necessary during recent pandemics. The combination of the changepoint detection method and the policy analysis effectively illustrates the COVID-19 pandemic pattern and the potential time lag effects of policies in a country. A Bayesian online changepoint detection method models the sequential COVID-19 data and infers the most recent changepoints using a recursive online algorithm. The corresponding dates on which the changepoints occur often mark critical time points. Successful detection of changepoints allows us to investigate how scientific methods and government policies infected the COVID-19 situation in various countries. Further studies may provide insights into better decision-making strategies in pandemic situations of different severity levels.

Saja Gherri, University of Michigan
Doubly Non-Local Cahn-Hilliard Equation with Fractional Time Derivative

The Cahn-Hilliard equation was developed to model phase separation in material science. We consider the doubly non-local form, which replaces the traditional Laplacian with two non-local operators. These non-local operators allow more accuracy in the prediction of behavior in the entire system, rather than locally. We then modify the doubly non-local Cahn Hilliard (dnCHE) with the addition of a fractional time derivative. Utilizing time convolution, we add the piecewise $g_(1-\alpha)$ function to incorporate the Caputo fractional time derivative. We establish both the existence and uniqueness of a solution to this modified equation. Rather than a standard fixed-point argument, we define Picard Iterates and show that they converge to our solution. Then we use these iterates to prove that our solution is continuous in time and bounded in space, employing the Weierstrass M-test and uniform limit theorem, fulfilling requirements for existence in a space Y. We prove uniqueness with a standard proof by contradiction. Then, we employ a forward Euler scheme to portray numerical approximations of our solution. We vary time steps and initial conditions. Our results show the convergence of our solution to that of the original dnCHE, as our fractional order approaches 1.

Hannah Graff, Creighton University
Almost All Wreath Product Character Values are Divisible by Given Primes

For a group G with an integer-valued character table and a prime p, we show that almost every entry in the character tables of $G \wr S_N$ is divisible by p as $N \to \infty$. These results generalize the work of Peluse and Soundararajan on the character table of S_N.

Rachael Harbaugh, Ohio Northern University
A Generalization of a Putnam Problem

We generalize a combinatorial number theory problem from the 1973 Putnam Exam. Specifically, we prove the following result. Consider $mn+1$ elements of a characteristic zero field L, subjected to the following property: whichever element is removed, the remaining mn can be split into m groups of n with equal sums. Then, the original $mn+1$ elements must be equal. We also provide counterexamples in finite characteristics by using primitive roots.

Emily Hed, College of Saint Benedict and St. John University
The Independence Coloring Game

This game begins with a graph, and two players (Minimizer and Maximizer) take turns coloring the vertices on the graph following regular coloring rules. Minimizer wants to minimize the total number of colored vertices on the graph, whereas Maximizer intends to maximize the total number of colored vertices on the graph. The game ends when the graph has a maximally independent set of colored vertices, meaning that no more vertices are available to be colored. This talk will present results for vertex-transitive graphs.

Cicely Henderson, Wellesley College
Packing edge-colorings of graphs with maximum degree at most 4

A $(1^j, 2^k)$-packing edge-coloring of a graph G is an assignment of the colors $\{1_1, 1_2, ..., 1_j\}$ and $\{2_1, 2_2, ..., 2_k\}$ to the edges of G such that any two edges that receive the same color are not incident to each other, and furthermore, if two edges are both colored 2_i for the same i where $1 \leq i \leq k$, there cannot be a third edge incident to both. Note that when $k = 0$, this notion is equivalent to a proper j-edge-coloring, and when $j = 0$ this is equivalent to a strong k-edge-coloring. In 1985, Erdős and Nešetřil posed a conjecture regarding strong edge-colorings of graphs based on their maximum degree Δ that has been proven for $\Delta \leq 3$. In the language of packing edge-colorings, this conjecture posits that every graph with $\Delta \leq 4$ has a $(1^0, 2^{20})$-packing edge-coloring. It was recently shown that every graph with $\Delta \leq 4$ has a $(1^0, 2^{21})$-packing edge-coloring. In this talk, we approach this conjecture from a different direction by showing that every graph G with $\Delta \leq 4$ has a $(1^1, 2^{19})$-packing edge-coloring.

Aimee Hernandez, California State University, Stanislaus
Statistical Analysis of Digoxin Medication in a Clinical Trial

Digoxin, an antiarrhythmic and blood pressure support medication, is commonly used to treat heart failure and heart rhythm problems. It is one of the first and oldest medications in cardiovascular medicine and has since been used to reduce hospitalization or death due to worsening heart failure in patients with heart failure. However, uncertainty surrounding the long-term safety and efficacy of Digoxin has arisen and evoked clinical trials to test these claims. In this talk, I will discuss the results of a statistical analysis of one such randomized, double-blind clinical trial with 3,397 patients on the drug and 3,403 patients on a placebo control group. Specifically, we analyze whether there were any baseline variables that acted as effect modifiers between the results of Digoxin and Placebo on time-to-death or hospitalization due to worsening heart failure.

Rachel Hill, University of North Alabama
A Surprising Way to Work With The Group of Integers Modulo n

If $n = n_1, \cdots, n_q \in \mathbb{Z}^+$, then it is known that $\mathbb{Z}_n$ is isomorphic to the usual direct product $\mathbb{Z}_{n_1} \times \cdots \times \mathbb{Z}_{n_q}$ if and only if n_i and n_j are relatively prime for $i \neq j$. We will define a new binary operation on this direct product in which $\mathbb{Z}_n \cong \mathbb{Z}_{n_1} \times \cdots \times \mathbb{Z}_{n_q}$ regardless the factorization of n. If n_1 is odd, then we define $H = \langle n_1 \rangle$ and thus H will have exactly n_1 cosets in $\mathbb{Z}_n$. Using the cosets of H, we construct unique order sets of elements in $\mathbb{Z}_n$ where elements are ordered by the coset of H in which they lie. We define summation sets as the set of sums of consecutive elements from our unique ordered sets. It was previously shown that these summation sets are pairwise disjoint, and the union of all the summation sets is $\mathbb{Z}_n - H$, if n is odd. We will show that if n is even, then each summation set is repeated exactly once. We also show that the union of all summation sets recovers all even elements of $\mathbb{Z}_n$ not in H and not in $(n_1 - 2) + H$, and the summation set recovers only the odd elements from $(n_1 - 2) + H$.

Nicholetta Hitt, Keene State College
Parabolas and the p-norm

A parabola is the set of points, each of which is equidistant from a given point called the focus and a given line called a directrix. The distances are measured using the usual Euclidean distance formula. A p-parabola has the same definition as an ordinary parabola except the distances are now measured using the p-norm where p is a positive integer greater than 2. More specifically, for points (a,b) and (c,d) the p-norm distance between the points is given by $((c-a)^p + (d-b)^p)^(1/p)$. This research project explores the nature of these p-parabolas and develops some of the more unusual properties.

Anika Homan, Dordt University
Fault-Free and Simple Tilings with L-Trominoes on Cylinders, Möbius Strips, and Tori

A tiling of a rectangular board is a filling of the board with tiles in such a way that each space is covered by exactly one tile. In 1981, Ron Graham defined a fault line of a tiling as a straight line (parallel to one of the sides of the board) that cuts through the board but does not cut through any tiles. A fault-free tiling is a tiling that contains no fault lines. In 2019, Montelius extended the notion of fault-free tilings of p×q rectangles with 2×1 dominoes to boards that were cylinders, tori, and Möbius strips. I extend this research to tilings with L-trominoes, which are L-shaped tiles formed from three unit squares. Within this context, I also consider simple tilings, proposed by Graham and others in 1982, which extend beyond fault-free tilings by restricting tiles from forming any rectangles within the board. This research was conducted as part of the 2022 REU program at Grand Valley State University.

Shelby Horth, Wake Forest University
Machine Learning Improves Hemiarray EIT Reconstructions

Electrical Impedance Tomography (EIT) is a low-cost, portable, and noninvasiveimaging system. Though it has seen promising use in many applications including the continuous monitoring of the lungs and detection of cancerous regions in the body, it has potential for industrial uses beyond what is typically recognized in human medicine. However, EIT formulates a very challenging, nonlinear, highly ill-posed problem, even when using a full array of electrodes. Over the past few decades, many approaches have been introduced by incorporating the advancements in traditional methods. However, those approaches lack clinical and experimental versatility as there has been little progress in the execution of using a hemi array of electrodes that would otherwise allow for the expansion of industrial application of EIT. Therefore, we investigate and implement new regularization methods using deep neural network (DNN) approaches for solving the EIT inverse problem, including the Graz consensus Reconstruction for EIT. We compare these approaches to traditional EIT methods and present the results of each technique with respect to improvement (or loss) in spatial resolution as well as influence on computational cost. We then explore the performance of the machine learning techniques using a hemi array of electrodes and evaluate the results by calculating figures of merit.

Nzingha Joseph, Carleton College
Mathematical Approaches to the Archaeological Refit Problem

Archeologists often look for evidence in the remnants of the past, like old bones, to better our understanding of human activity. This evidence is growing increasingly quantitative, incorporating more sophisticated tools from applied mathematics, statistics, and computer science to unearth the stories that broken bones can tell: stories of early human and animal activity and interaction. Working with a consortium of researchers known as AMAAZE (https://amaaze.umn.edu), our research aims to create digital reassemblies of broken bones. This process blends ideas from linear algebra, computational geometry and optimization. In this talk, I describe how 3D scans of these bones are processed to create these reassemblies. I'll discuss how we isolate the break faces, compare their shapes, and use optimization to realign them.

Sayde Jude, University of St. Thomas
Lizzie Paterson, University of St. Thomas
Knots from Puzzle Pieces

Entanglement is replete in nature, for example in DNA and proteins. The mechanisms regulating entanglement in natural systems are not well understood. To provide insights into these mechanisms, one strategy is to analyze entanglement created by tiles, analogous to puzzle pieces. Previous models used what are known as mosaic tiles. We introduce a new set of tiles that more efficiently models the twisting seen in nature, for example in DNA. We present minimal representations of knots and links with these new tiles and find relationships between this model and the mosaic model.

Nicole Lacey, Drake University
Hopping Forcing

Zero forcing is a combinatorial game played on graphs that can model the spread of information between adjacent vertices. Hopping forcing is a variation of zero forcing that enables information to spread from vertex to vertex without using an incident edge. This means that hopping forcing can travel greater distances in a connected graph and even spread between disjoint graphs. In this talk, I will explore a few graph parameters related to hopping forcing including the hopping forcing number, propagation time, and throttling number.

Meghan Lee, Occidental College
Complementation of Subquandles

Quandles were first introduced as a complete classical knot invariant up to orientation reversal by David Joyce in 1982. In this talk, I will introduce our results related to subquandle lattices, subquandle inner automorphism groups, and subquandles whose set-theoretic complements are also subquandles. In particular, we show that for prime p, the p-adic integers $\mathbb{Z}p$ form a profinite Takasaki quandle that has complemented subobject lattices, and conjecture that profinite quandles have complemented subobject lattices. Additionally, we provide a complete classification of subquandles whose set-theoretic complement is also a subquandle, and provide a partial transitivity criterion for the complementation in chains of strongly complemented subquandles.

Katherine Levandosky, Northeastern University
Machine Learning and the Discovery of Differential Equations

In this project, we investigated machine learning algorithms and their ability to produce a partial differential equation representing a given dataset. We focused on the diffusion equation, which describes the process of dye diffusing in water. Given a dataset representing the concentration of dye in water over time, the algorithms use sparse linear regression and differentiation to determine the terms in the differential equation and their coefficients. We generated data using a known solution to the diffusion equation in one dimension and adjusted parameters such as the size of the dataset to assess the accuracy of the algorithms. We also studied the algorithms' performance when given stochastically generated datasets as well as physical data produced by diffusing dye in water.

Maddie Levesque, Furman University
Regan Richardson, Furman University
The Tuffley Poset: Characterizations of Elements with Joins

The edge-product space of phylogenetic trees, $E(X)$, for some finite set X, is a topological space consisting of points corresponding to edge-weighted trees showing the evolutionary relationship between $|X|$ species. Each face of the edge-product space is represented by an evolutionary tree with a specific structure, where the points within each face correspond to different edge-weightings on the tree. Our work focuses on studying the structure of the edge-product space through the structure of a partially ordered set called the Tuffley poset, denoted S(X). The Tuffley poset consists of all evolutionary trees for $|X|$ species, ordered by containment of the corresponding faces in the edge-product space. We will present characteristics that can be used to determine if pairs of elements in S(X) have a join, or least common upper bound, thereby allowing us to determine when pairs of faces in the edge-product space are both contained in a unique, larger face. We will also introduce a process to construct a pair of elements in S(X) that do not have a join.

Hanfei Lin, University of California Los Angeles
Budget Conservation in the Training of Differentially Private Models

The development of practical methods for privatized model building is critical for the advancement of modern data science since many machine learning applications in fields like medicine, social science, and industry depend on the analysis of highly sensitive data. Using the mathematical framework of differential privacy, it is possible to quantify and track the cumulative privacy loss of many model-building iterations. Thus, to create a differentially private model, practitioners can adaptively fit and evaluate models until they either obtain a satisfactory result, or their total privacy loss exceeds a fixed budget. Current methods for differentially private model building only support a prohibitively small number of model building iterations. This project investigates an approach for increasing the number of privatized model-building iterations a data scientist may perform. We attempt to minimize the privacy cost of each model-training iteration by using the subsample and aggregate framework to release a differentially private estimate of test metrics. We show that our algorithm produces high-quality predictions of classification accuracy for a variety of datasets and machine-learning models, indicating that this class of algorithms presents a promising direction for future research.

Huiwen Lu, University of California San Diego
Betti Numbers and Axial Constants of Homogeneous Ideals

Given a homogeneous ideal I of a polynomial ring, two numerical invariants may be defined: the Betti numbers $\beta_i(I)$ and the axial constants $a_i(I)$. The Betti numbers, defined for each as the rank of the i-th differential matrix of a minimal free resolution for I, are studied for characteristic = 2. Using the software Macaulay2, we calculate $\beta_i(i >= 0)$ for all ideals generated by quadratic homogeneous polynomials over F_2. We also obtain a classification for the structure of minimal free resolutions for those ideals with up to 3 generators. The second invariant is the i-th axial constant, $a_i(I)$, of a homogeneous ideal I, which is defined as the smallest power of the variable x_i that belongs to the generic initial ideal of I. We investigate when $a_i(n)$— the i-th axial constant of the ideal I^n, viewed as a function of n— is defined for certain families of ideals.Furthermore, we examine its linearity and show that it is linear for all i for sufficiently large n. We also study different classes of monomial ideals, including those generated by a set of powers of variables, and the behavior of their axial constants. Finally, we establish different relations between the axial constants and other invariants such as regularity.

Victoria Luongo, Clemson University
Numerical Analysis of the 1D Semilinear Heat Equation

The Fujita semilinear heat equation, with Dirichlet boundary conditions and background effects, models various chemical and physical phenomenon from diffusion and reaction to fluid mechanics. While a great deal of literature exists on the well-posedness of this model, blowup criteria, and other mathematical properties, there is much less regarding physical boundaries, numerical methods, and global in time stability. We study an efficient implicit-explicit temporal discretization of this equation with Dirichlet boundary conditions, and analyze its global in time stability. We prove that for certain assumptions on the data (i.e., for certain parameter choices), the method is long time stable. Numerical tests illustrate the theory, and show that parameters chosen in the ranges of the theorem produce long time stable results, while parameters outside the range can lead to catastrophic blowup.

Laila Mahrat, Lewis University
An Agent-Based Model of Environmental Transmission of C. difficile in Healthcare Settings

Clostridioides difficile (*C. difficile*) is one of the most frequently identified healthcare-acquired infections in United States hospitals. Colonized patients, both symptomatic and asymptomatic, shed *C. difficile* endospores that can survive for long periods on surfaces outside the host and are resistant to many commonly used disinfectants. Transmission pathways can include contact with both endospores on fomites, objects likely to carry infection, and endospore-carrying individuals. Our agent-based model simulates the spread of *C. difficile* within a hospital ward, focusing on transmission originating from environmental pathways and healthcare workers. Simulations can help determine effective control strategies to mitigate the spread of *C. difficile* in healthcare settings.

Jordan Martino, Northeastern University
Untangling Knot Theory for Undergraduates: the Jones Polynomial and Khovanov Homology

This talk covers topics learned during my REU at Northeastern University completed in Summer 2022. The presentation begins by laying the foundations for knot theory, exploring knot invariants such as tri-colorability, and building the definition for the Jones Polynomial through the combinatorial definition using the Kauffman bracket and the writhe. Khovanov Homology is then introduced through the connection of the Jones Polynomial being its Euler Characteristic.

Delaney Morgan, Wellesley College
N-potents in Commutative Rings

In a commutative ring, there are certain elements such that e for some natural number $e = e^n$. When $n = 2$, we call these elements idempotents, and when $n = 3$ we call them tripotents. For general n we simply refer to such elements as n-potents. Similarly, there are elements called nilpotents such that $b^n = 0$ for some n. We wish to classify unital, commutative rings where $n = 0n$ every element is the sum of some number of n-potents and one nilpotent. Comprehensive work has been done in classifying rings where every element is the sum of an arbitrary number of idempotents and a nilpotent, or when it is the sum of two n-potents and a nilpotent, but little has been investigated when every ring element can be classified as the sum of two n-potents for two different ns and a nilpotent. My undergraduate thesis research seeks to classify unital, commutative rings where every element is the sum of one idempotent, one tripotent, and one nilpotent.

Grace Morrell, Furman University
Varying Attitudes Toward Discovery-Based Learning Within Higher-Level Mathematics Education: A Case Study

This research presents a case study outlining the variety of student and professor attitudes toward discovery-based learning (DBL) in higher-level undergraduate mathematics education at Budapest Semesters in Mathematics. Discovery-based learning is a method of teaching mathematics that prioritizes active learning. We characterize higher-level undergraduate mathematics courses as those which assume experience in basic analysis and/or abstract algebra, typically taken by students later in their undergraduate careers. Data is collected from the students in both questionnaire and interview format, with questions directed at mathematical identity, previous class experiences, and future plans in regard to mathematics. Data is collected from professors through interviews with questions directed at teaching experience, teaching philosophy, and perceived class profile. The results of the case study identify possible causes for differences in attitude toward DBL, and highlight the importance of considering such causes when implementing DBL in higher-level undergraduate mathematics education.

Lizzie Paterson, University of St. Thomas
see **Sayde Jude**

Zoe Plzak, Boston University
Structural and Practical Identifiability of Adult-Child Compartment Epidemic Models

Compartment modeling has been used extensively in an epidemic for both understanding and prediction of infectious disease. One very important question in epidemic modeling is the balance between complexity of the model and its generalization accuracy. Complex models may be able to explain existing experiment data better due to its abundance in parameters rather than describing the underlying phenomenon. In this talk, we construct an age-based SEIR model that separates the population into Child and Adult compartments and compare it with an simple SEIR model. We determine the structural identifiability of both models using existing algorithm and compute the practical identifiability of both models using Monte Carlo Simulation and Profile likelihood approaches. We demonstrate the practical identifiability of the simple SEIR model and the practical non-identifiability of the SEIR aged-based model. We then present relevant parameter dependencies that construct a full set of practically identifiable parameters for the age-based SEIR model.

Regan Richardson, Furman University
see **Maddie Levesque**

Madison Sousa, University of Denver
Frame Theory and its Applications

Since its introduction in the early 1950s, Hilbert space frame theory has become an active area of research due to its applications in engineering and physics, including in speech recognition, optical imaging, and X-ray crystallography. Frames, like orthonormal bases, give a continuous, linear, and stable reconstruction formula for vectors in a Hilbert space. However, frames allow for redundancy, and this makes frames much more adaptable for theory and applications. Phase retrieval is one of the applications of frame theory in which only the intensity of each linear measurement of a signal is available and the phase information is lost. In 2006, Balan, Casazza, and Edidin introduced a more powerful notion of phase retrieval using the magnitude of frame coefficients. Closely related to the subject of phase retrieval is norm retrieval and weak phase retrieval. In both phase retrieval and norm retrieval, the absolute value of intensity measurements are used to perform signal reconstruction. Norm retrieval gives us the tools to connect phase retrieval to orthogonal complements. Weakening the conditions of phase retrieval, in which we have fewer measurements, still satisfies most of the properties of phase retrieval. In other words, it is not "weak" at all. In this talk, I give an overview of phase retrieval and norm retrieval. In addition, a review of current phase retrieval algorithms will be discussed; however, an algorithm for weak phase retrieval has yet to be established.

Lani Southern, Willamette University
Natalie Dodson, Middlebury College
No Three in a Theta

The no-three-in-a-line problem asks for the maximum number of points that can be placed on an $n \times n$ grid such that no three of them lie in a line. It has remained unsolved for over 100 years, even though it has an easily proven upper bound of 2n. Inspired by this problem, we propose an extension similar to the one studied by Gossell and Johnson: How many points can be chosen on an n $\times$ n grid such that no three of them form an angle of θ? We classify the angles that yield interesting problems and focus on angles that appear in surprising configurations on the grid. We prove upper and lower bounds for specific angles and discuss the geometric properties of the grid.

Grace Stroh, Wisconsin Lutheran College
*Mountain Glacier Segmentation Method Using L*a*b* Color Space*

Change in a glacier's size can be used as a physical indicator of the rate of climate change. However, the remote nature of glaciers renders direct measurement impractical. For this reason, researchers have been working to find an accurate remote measurement technique to calculate the area of glaciers. Since there are almost 200,000 glaciers around the world, such a technique also needs to be efficient and, ideally, automated. This project used Landsat satellite images to identify glaciers and segment them from their surroundings. A color-based image segmentation method was developed to find the area of glaciers from Landsat images, then implemented on images of Gorner Glacier in Switzerland and Franz Josef Glacier in New Zealand. Three satellite color bands were compiled into a false color image and then segmented in the L*a*b* color space. The transformation from the typical RGB color space to the L*a*b color space allowed the red "land" pixels to be easily eliminated, leaving behind the blue pixels of the glacier for area calculation.

Yuxuan Sun, Haverford College
see **Mallory Dolorfino**

Uyen Tran, University of Nebraska-Lincoln
The p-adic Numbers

In this talk, we will introduce the p-adic numbers and discuss an analogy between polynomials and the p-adics. We will also briefly discuss p-derivations, which are a sort of derivative by a prime number.

Heleyna Tucker, Hope College
Using Remote Imagery for Land Classification in Sand Dune Complexes

The Hope College Coastal Research Group and I have researched many areas concerning the mechanisms and effects of sand transport, as well as learning how sand movement and dune vegetation affect one another. We focused on using machine learning algorithms to create ground surface models from drone imagery in an automated way. The images the drone took range from high-resolution low-altitude images to high-altitude (120m) orthomosaic images. Using different height and resolution images in the classification process may prove to be beneficial in increasing the model's accuracy. One way we compared these images is by using key point matching and image alignment. In this presentation, I will report on our work on image alignment and land classification. I will describe the use of random forest models to classify the high resolution images and compare various methods of classifying courage in lower-resolution images that have broader spatial extent.

Laura Vaughan, Vanderbilt University
Testing Hyperinflation Data Against Makochekanwa's Model (2007)

Hyperinflation has become an increasingly common problem in the last century. In 2007, Zimbabwe entered a period of extreme hyperinflation that led to the collapse of the Zimbabwean dollar. In this research, we evaluate Makochekanwa's model, which formed hypotheses surrounding Zimbabwean inflation from 1999-2006. Finding data on semi-recent situations in Zimbabwe to be sparse, we work to find appropriate estimators for missing pieces of data. We apply linear regression and the Toda-Yamamoto variant of Granger causality to check Makochekanwa's findings.

Heather Vogler, Northern Arizona University
Fractional Graph Coloring

A b-fold coloring of a graph G assigns each vertex of G a set of b colors so that adjacent vertices have disjoint sets of colors. The b-fold chromatic number $\chi_b(G)$ of G is the smallest number of colors needed for a b-fold coloring of G. Note that $\chi_1(G)$ is the usual chromatic number of G. The fractional chromatic number $\chi_f(G)$ of G is defined as $\chi_f(G) = \lim_{b\to\infty} \frac{\chi_b(G)}{b}$. We study upper and lower bounds of $\chi_f(G)$ in terms of eigenvalues of the adjacency matrix of G. We also investigate the graphs for which corresponding equalities hold.

Victoria Wiest, California State University, Fresno
The Safety Net Problem: A Variation on Graph Theory's Minimum Spanning Tree (MST) Algorithm

The Safety Net Problem, a variation on the Minimum Spanning Tree (MST) algorithm coined by my colleagues and me, is as follows: Given an arbitrarily weighted grid graph, G, and an arbitrary set, R, of 'required vertices,' what is the most efficient way to draw a low-cost path that connects every vertex and ensures that if an edge is deleted any required vertex would still have a path to get to every other required vertex? We have explored two approaches. For our first approach, the "MST-First" approach, we start with the MST of G and add in edges to form a Hamiltonian circuit that includes all required nodes. For our second approach, the "Path-First" approach, we start by finding a Hamiltonian circuit that includes all required nodes and find the MST of G by treating the set of edges in the circuit as a singular component, C. We found that the most efficient algorithm depends on the graph, and we are continuing to study what properties of a graph might make one algorithm more efficient than another.

Addison Wisniewski, Saint Louis University
Change Point Detection of Internet Traffic Anomalies via Singular Values of the Laplacian Matrix

In a world where there is a rush for automation, computer network management is no exception. Particularly, automatically detecting network attacks and misconfigurations remains a challenging task despite recent advances in data science. Our research aims to locate, observe, and predict Internet traffic level changes in wide-area networks. To do so, we designed and implemented a change point detection technique by applying an existing multi-dimensional change point detection algorithm to the time series of singular values of the Laplacian of the graph. The technique was tested on freely available network data sets as well as on simulated data. Our initial results have demonstrated how, despite its simplicity, this method is effective – perhaps due to the relationship between the eigenvalues of the Laplacian and the connectivity of the graphs. We confirm the utility of the singular values of the Laplacian by detecting well-known Internet traffic patterns, such as seasonality and weekly patterns. We also confirm the correct detection of change points in simulated data.

Qiyu Zhang, University of San Francisco
The Change-Making Problem with Six Types of Coins

Given a set of coin values C and a positive integer c, the change-making problem asks: what is the minimum number of coins needed to represent c with coin values from the set C? For some coin sets, the greedy algorithm gives an optimal solution for all positive integers c. We call such sets orderly. In general, however, it is difficult to know whether a set of coin values is orderly. Over the past 50 years, researchers have gotten a better understanding of the change-making problem, including finding the characterization of all orderly coin sets with three, four, and five types of coins. In our work, we characterize all orderly coin sets with six types of coins, and we discuss which parts of this result can generalize to larger coin sets.