101st Meeting of the Southeastern Section of the Mathematical Association of America, March 10th–12th, 2022

Abstracts of Talks and Posters

Contents

Invited Speakers

DLS1 **Ally Skinner** (ally.skinner@lpcorp.com). *Mathematics in the Manufacturing Industry*

I present my journey to choosing Mathematics and a career in the manufacturing industry. Examples are submitted of how Mathematics and Statistics were used in the various roles. These examples extend from responsibilities of an Accounts Receivable & Trade Credit department, to the Data & Analytics department, and finally to the Financial Planning & Analysis department. Future career paths are proposed to suggest other areas in which students could utilize their degree.

DLS2 **Christian Okitondo** (chris.okitondo@adjuncts.belmont.edu). *How do the skills from studying math play a role in the workplace and lead to different career paths?*

Christian Okitondo is currently an adjunct professor of statistics at Belmont University. He has previously worked as a Biostatistician for Vanderbilt University Medical Center. He was in charge of developing analytical plans that applied appropriate statistical methods for autism spectrum disorder research studies. He obtained his bachelor's degree in Mathematics from La Roche University, master's in Statistics from Ball State University, and currently pursuing a PhD degree in Epidemiology & Biostatistics with an emphasis in Data Analysis & Modeling at the University of Georgia. His research interest includes clinical and structural determinants of cancer risk. His vision is to become a quantitative scientist who excels in epidemiologic methods and applied biostatistics to influence standard of care.

GS.1 **Jennifer Quinn** (jjquinn@uw.edu). *Solving Mathematical Mysteries*

Much as mysteries in fiction consider evidence, find common patterns, and draw logical conclusions to solve crimes, mathematical mysteries are unlocked using the same tools. This talk exposes secrets behind a numerical magic trick, a geometric puzzle, and an unknown quantity to find a fascinating pattern with connections to art, architecture, and nature.

GS.2 **Tim Chartier** (tichartier@davidson.edu). *Dream Classroom*

Think of some of your favorite memories of being in mathematics class. They often capture elements of your dream classroom – as a student and/or teacher. Often, such moments are achieved when the students and professor enter some math groove of togetherness and community. In this talk, we'll discuss our hopes for the classroom and how to enlarge our dreams so we can potentially increase the frequency of dreams being realized and so a sense of community is shared inclusively. We all play a role in a classroom environment and, as in class, we'll learn together in this talk.

GS.3 **Marissa Loving** (mloving6@gatech.edu). *Surfaces: BIG and small*

As a geometric group theorist, my favorite type of manifold is a surface and my favorite way to study surfaces is by considering the mapping class group, which is the collection of symmetries of a surface. In this talk, we will think bigger than your average low-dimensional topologist and consider surfaces of infinite type and their associated "big" mapping class groups.

Special Session: Happy Hundredth: Celebrating the Southeastern Section Centennial

HUN.1 **Brian Beasley** (bbeasley@presby.edu). *The Roaring Twenties: Early Years of the Southeastern Section*
Additional authors (if any):

From the formation of the Section in 1922 through the rest of the decade, mathematicians and institutions in the Southeast began to make a variety of contributions to the MAA. Consequently, the pages of The American Mathematical Monthly slowly yet surely reflected the resulting increase in participation. This presentation will provide a brief history of the creation of the Section and examine regular Monthly columns from the 1920s for references to the Southeast, including the "Undergraduate Mathematics Clubs" feature. The growing interest in mathematics among these students, teachers, and schools set the stage for ongoing development in the Southeastern Section for the next hundred years.

HUN.3 **Jeffrey S. Powell** (JSPOWEL1@samford.edu). *This...Is...Math Jeopardy!*
Additional authors (if any): Michael C. Berry (University of Tennessee--Knoxville)

Math Jeopardy! is one of the highlights of the MAA Southeastern section meeting each year. In this talk, we will take a look back at the history of the contest and give a "behind the scenes" look at how the competition comes together each year and how it has changed over time. We will also highlight some of our all-time favorite categories and questions.

HUN.2 **Julie Barnes** (jbarnes@email.wcu.edu). *Math Treasure Hunt: Past, Present, and Future*
Additional authors (if any): Wei-Kai Lai, University of South Carolina at Salkehatchie; Kerri Jamerson, Mars Hill University

Our section has a long practice of providing a wide variety of experiences for students at our section meetings. One student activity is the annual Treasure Hunt where students collaborate with people from other universities to solve a variety of puzzles. Our first event along this vein was a Math Murder Mystery held at Meredith College in 2005. The next year we changed the format to a Treasure Hunt which had the main structure that we are using today. In this talk we look at an overview of past treasure hunts, how they have changed over time, the logistics behind running these events, and how we modified the event during the pandemic.

HUN.4 **Martha Abell** (martha@georgiasouthern.edu). *Teaching: Doing Our Part to Shape Lives Through Mathematics*
Additional authors (if any):

The Southeastern Section and its membership have a long history of promoting the core values of the Mathematical Association of America in the area of Teaching and Learning. This includes fostering the open exchange of ideas about the teaching and learning of mathematics, as well as developing and promoting research-based instructional resources and practices. The presentation explores highlights and enhancements MAA Southeastern Section programming has experienced over the years.

HUN.5 **Jeff Knisley** (KNISLEYJ@mail.etsu.edu). *Past as Prologue: Our Next Hundred Years*
Additional authors (if any):

At the celebration of the first 70 years of our section, Billy F Bryant, a regional and national leader in mathematics and mathematics education, reflected that the section was not looking back, but instead was looking forward. In fact, much of our past can be attributed to a willingness to look forward, to try new things, and to find new ways to engage students and colleagues in mathematics and its applications. This talk is an attempt to build on that legacy by looking back at how we have looked forward and how doing so today anticipates the history of our next 100 years as a section.

Special Sessions on Recreational Mathematics

REC1.1 **Jeffrey Clark** (clarkj@elon.edu). *Wordle and Entropy*
Additional authors (if any):

The game Wordle is built around guesses and analyzing how close each guess is to being a correct match for a hidden word. This process generalizes to many real-life scenarios such as tests used to diagnose a medical illness. One important strategy is choose tests that give you the most information at each stage. Since we can't know the result of the guess or a test in advance, we seek the most information on average for a given test, which is known as entropy. This talk will very briefly talk about the entropy of a probability distribution and choosing tests that maximize that entropy.

REC1.2 **Vigneswaran Madappan Chinnasami** (madappav@email.sc.edu). *3 by 3 magic square type sliding game*
Additional authors (if any): Dr. Wei-Kai Lai

A sliding game is a puzzle that has pieces of numbers, alphabets, or pictures in a grid with exactly one empty space. For a 3 by 3 magic square, we can construct a magic square type sliding game by subtracting 1 from each number. To solve this game, we try to rearrange all numbers to increasing order from the top row to the bottom row by sliding pieces one at a time. It is known that not all sliding games can be rearranged (solved) this way. Our project will be focusing on how the rotation and reflection impact the solvability of any 3 by 3 magic square type sliding game.

REC1.3 **Brianna Bradley** (brianna.bradley@g.fmarion.edu). *Interconnectedness Of Math and Art: Exploration of the Fibonacci Sequence*
Additional authors (if any):

As a future mathematics educator, it is inevitable that I will eventually receive the question "why do I need to know this," or something to that effect. Future educators are being taught to find the relevance and purpose in each of their lessons; however, I suppose that math educators expose their students to the diversity of math as it can be found everywhere including nature, music, arts, sports, as well as many other categories and fields. I believe this will inspire students to take more of an interest in a field when they can find math in every aspect of their life. I will be dissecting the interconnectedness between mathematics and art forms through the exploration of the Fibonacci sequence. I will discuss the origins of the Fibonacci sequence and golden ratio and the appearance of the sequence in paintings and drawings, music, architecture, and photography.

REC1.4 **Ryan Fox** (ryan.fox@belmont.edu). *"It's not exactly setting your money on fire": Exploring the teaching of expected value contextually*
Additional authors (if any):

In this talk, I will share how I have presented teaching expected value to students taking first-year college mathematics classes through the winning a jackpot in a lottery game. I will also discuss opportunities to extend the exploration to cover additional contexts, applying other applicable contexts to the presentation and a comparison to another game of chance.

REC2.1 **Laurie Zack** (lzack@highpoint.edu). *Some Mathematics of EvenQuad*
Additional authors (if any): Brett Geiger, Jenny Fuselier, Adam Graham-Squire

The Association of Women in Mathematics recently released a deck of cards called EvenQuads and the associated Quad Collector games, which sparked interest in what mathematics could be explored. These accessible, entertaining games can be played and discussed in Math Teachers' Circles, with students in research classes and just for fun. In this talk, I will present some work done by our group on creating an activity based on the Quad Collector games of EvenQuads along with mathematical properties of the game.

REC2.2 **Fabian Salinas** (fabiansalinas125@gmail.com). *A Miraculous Shortcut: Complete Binary Trees and Optimal Pebble Domination*
Additional authors (if any): Thomas Lewis (Furman University)

Though readily approachable, optimizing the mathematical game of Pebbling on graphs quickly becomes an arduous endeavor. Focusing on complete binary trees, we illustrate an unexpected correspondence between optimal pebbling numbers, Mersenne numbers, and sequences of iterated lists (including a Meta-Fibonacci Sequence, OEIS A046699).

REC2.3 **Andrew Simoson** (ajsimoso@king.edu). *Poincare's Geometry via Pythagoras' Theorem*
Additional authors (if any):

In his 1913 book, The Foundations of Science, Henri Poincare described his classic version of hyperbolic geometry G within the unit disk in the plane, observing, "Notice that I have been able to describe G without ceasing to employ the language of ordinary geometry." Poincare leaves many details to the imagination. We fill in some of these details---without using differential equations or projective geometry---and instead use the Pythagorean theorem along with a computer algebra system to help simplify various resulting algebraic expressions.

REC2.4 **Melissa Glass** (mglass@highpoint.edu). *Dimension of Self-Similar Fractals*
Additional authors (if any):

Fractals produce beautiful pictures. But why do we care about them beyond their aesthetic appeal? Fractals are all around us and used in many important applications. This presentation will address some of these applications. We will focus on self-similar fractals using iterated function systems to define them. Famous examples such as the Cantor set and Koch Snowflake will be used to illustrate the dimension of these self-similar fractals.

Special Sessions: You Keep Using That Word

WORD1.1 **Susanna Molitoris-Miller** (Smolitor@kennesaw.edu). *"There Are No Words To Contain All My Wisdom": Concept Image vs. Concept Definition in Mathematics*
Additional authors (if any):

Definitions play a key role in the axiomatic nature of mathematical systems. We use them to characterize, specify, and often teach concepts. However, knowledge of a particular concept often encompasses more than the string of words used to define it. Vinner (1991) breaks this rich understanding into two parts: concept image and concept definition. In this session we explore these two parts of conceptual understanding in both mathematical and non-mathematical contexts as well as their implications for teaching and learning mathematics.

WORD1.2 **Amanda Lake Heath** (alh2ei@mtmail.mtsu.edu). *“Be creative!” A discussion of mathematical creativity and its appearance in an introduction-to-proofs course*
Additional authors (if any):

Creativity. Although most mathematicians would agree that creativity is foundational to the subject of mathematics, there is little agreement on what we mean when we call something “creative” in mathematics. In 2006, Mann recorded that there were over 100 definitions of mathematical creativity in research literature, and this number has only grown with the increased interest in studying this elusive concept.

So, what do we mean when we call something (or someone) creative in mathematics? Participants in this session will learn about some of the most common ways to define mathematical creativity, participate in a brainstorming activity, and analyze examples of student work we might consider “creative” in an introduction to proofs course.

WORD1.3 **Ebenezer Bonyah** (ebbonya@gmail.com). *Beyond the Cloak: The Hidden Meanings of "Rigor"*
Additional authors (if any): Jeneva Clark, University of Tennessee - Knoxville

To be honest, volunteering to lead a talk about "rigor" sounds as scary as Fezzik in a holocaust cloak. The burning black fabric surely hides many unseen intruders, like hidden connotations and paradigmatic differences. In this talk, we will humbly try to uncover some of these nuances, but we need your help. As an international partnership, representing Ghana Africa and the southeast U.S., the speakers regularly encounter differences in student perceptions of "rigor" across cultural boundaries. Join us, and we will attempt to parse out rigorous pedagogy, versus rigorous research, versus rigorous curricula, versus rigorous mathematical proofs. Then, we will consider well-known perspectives that use the word "rigor," such as Van Heile's heirarchy of geometric thinking or the more recent work of the Dana Center, and together, we will chat about whether these may or may not be using the word in similar ways.

WORD1.4 **Doug Daniel** (ddaniel@presby.edu). *Getting Back To Normal*
Additional authors (if any):

We have spent two long years waiting for things to get back to normal, but “what does that even mean?”, we all wonder. In math this can be an especially difficult question. Saying something is normal in math might be like the weather in the Springtime, if you don’t like it, then wait a minute and it will change. Students should be prepared to not get too comfortable with any one definition of “normal”. Next semester it could mean something entirely different. How many ways do we mathematicians use “normal” and its cousin “norm”? In what context? Is there any reason why we use these words so much? Would it be normal to even try to answer these questions?

WORD2.1 **Ashley Johnson** (ajohnson18@una.edu). *Word Choice in Upper Level Proof Courses*
Additional authors (if any):

Teaching upper level math courses for years has led me to reading many student proofs. In particular, even among my brightest students, I often note a struggle with subtle word choice or notation. Let me explain… no, there is too much. Let sum up. When do we use WLOG vs Similarly? Let vs Assume vs Suppose? Let us discuss what we all suppose these words mean. Or is it what we all assume these words mean?
Grandson: “Doesn’t sound too bad. I’ll try to stay awake.”
Grandpa: “Oh, well, thank you very much, very nice of you. Your vote of confidence is overwhelming.”

WORD2.2 **Jordan Kirby** (jek3b@mtmail.mtsu.edu). *Engaging Critical Thinking in Non-Euclidean Geometry*
Additional authors (if any):

How does one define a line? A line in Euclidean geometry perhaps looks different than a line in spherical geometry. In spherical geometry, we can imagine flight paths as straight lines. What do “straight” lines look like in taxicab geometry? This presentation will explore generic terms in a geometry setting and some activities taken from the MODULES(S) project to engage students in critical thinking about the use of words and definitions in an upper division geometry class.

WORD2.3 **Jonathan Clark** (jclar121@vols.utk.edu). *"How Do You Feel?" Phenomenography, Phenomenology, and Student Experiences with Math*
Additional authors (if any):

In the "pit of despair," while torturing Westley, Count Rogan said, "I want you to be totally honest with me about how the machine makes you feel." Not to imply that math is torture, but as instructors, we also care about how the math makes our students feel. In this presentation, we will talk about how students might experience math and how students might make collective meaning about those experiences.

WORD2.4 **Brooke Denney** (bdenney3@vols.utk.edu). *What You Do Not Smell is Called Elegance.*
Additional authors (if any): Jonathan Clark, University of Tennessee - Knoxville

Vizzini took a whiff and said, “I smell nothing,” to which the Dread Pirate Roberts answered, “What you do not smell is called Iocane powder.” Similarly odorless and tasteless, elegance of proofs can be an undetectable characteristic to math students. When speaking of proofs, many mathematicians use terms such as elegant or beautiful. What components make a proof have these attributes? In this talk, we will explore methods to potentially quantify the elegance of a proof. Our goal in this presentation is to better understand different perceptions of elegance in proof strategies. Specifically, perceptions of elegance in proofs may differ for math graduate students from different backgrounds and may also be different from the perceptions of their professors. We hope to highlight the literature on this topic and lead productive discussion during our session.

Special Session: Talks by Graduate Students

GRAD.1 **Brittany Burdette** (beburd@uab.edu). *Finding a Julia Set from a Forward Invariant Lamination*
Additional authors (if any):

The purpose of this research is to simplify the process of finding a Julia set (if it exists) from a given forward invariant set of leaves in a lamination or to specify when a Julia set cannot be found. The process begins by taking the forward invariant set of leaves and finding a compatible critical portrait to find the pullback lamination. The pullback lamination is used to create a Fatou Gap diagram which models where Fatou Gaps in our lamination map under iteration. Given a Fatou Gap diagram and its characteristics, we want to parameterize the corresponding complex polynomial. From this parameterization, we get a system of equations to solve for the set of possible polynomial coefficients. Using Bezout's Theorem on the intersection of hypersurfaces, we expect the number of solutions to be the product of the degrees of each of the equations which can get large quite quickly. The goal is to identify obvious trivial solutions or solutions that generate equivalent Julia sets up to rotation or some symmetry to reduce the work involved to find the appropriate polynomial coefficients.

GRAD.2 **William Cocke** (wcocke@augusta.edu). *Group Theoretic Model Repair*
Additional authors (if any): Paul Attie, Augusta University School of Computer and Cyber Sciences

Model checking is the formal verification that a system (or program) satisfies certain properties. Model repair of a given model and formula is the identification of a submodel that satisfies the formula. In many cases the symmetry of the model can be used to computational reduce the cost of model checking and model repair. We will demonstrate some of the benefits of group theoretic model repair. We will also compare group theoretic model repair with repair by abstraction.

GRAD.3 **Shuler Hopkins** (shopki14@vols.utk.edu). *Hadamard Matrices: What are they Good For?*
Additional authors (if any):

Hadamard matrices are simple to describe, but have proven to be notoriously difficult to understand throughout their 150 year history. Natural questions - when do they exist, where are they, and what do they look like - remain unanswered. Originally studied simply for their combinatorial beauty, Hadamard matrices have recently found applications in areas such as quantum information theory sparking renewed interest in their study. The goal of this talk is to provide an accessible introduction to Hadamard matrices which will be ripe with examples and motivated by famous open problems in the area. Towards the end of the talk, we will mention some new results related to the structure of the space of Hadamard matrices near the nicest examples.

GRAD.4 **William Bitting** (wbitting@vols.utk.edu). *An Algorithm for Constructing the Canonical Lift of Twisted Edwards Curves*
Additional authors (if any): Luis Finotti, University of Tenessee

Let k be a perfect field of charecteristic $p > 2$. Associated to an ordinary elliptic curve E/k is a *Canonical Lift* to the ring of Witt Vectors, denoted $\boldsymbol{E}/\boldsymbol{W}(k)$, that reduces to E modulo p and for which we can also lift the p-th power Frobenius homomorphism, and a lifting of points $\tau: E(k) \to \boldsymbol{E}(\boldsymbol{W}(k))$ that is a section of the reduction modulo p map called the *Elliptic Teichmüller.*

Canonical liftings were originally introduced by Deuring, and further developed by Serre and Tate, and has found applications in error-correcting codes and counting of rational points.

We provide a variation of an algorithm developed by Finotti, originally used to construct the Canonical Lift of a curve given by a Weierstrass equation, to construct the Canonical Lift of an elliptic curve given by a Twisted Edwards equation

$$bx^2 + y^2 = 1 + ax^2y^2.$$

Twisted Edwards Curves have been recently studied for their efficiency in Elliptic Curve cryptography due to their addition being strongly unified; the points $P \oplus Q$ and $2P$ may be computed with the same addition formulae.

In particular, we demonstrate our algorithm satisfies a natural sense of universality, i.e. the solution works or any pair (a_0, b_0) such that E_{a_0,b_0} is an ordinary elliptic curve. In doing so, we prove our algorithm may be used to find Witt Vectors whose entries are rational functions in a, b that are well defined for all pairs (a, b) giving an ordinary elliptic curve.

Contributed Paper Sessions

CP1.1 **Adam Graham-Squire** (agrahams@highpoint.edu). *Conditions for Fairness Anomalies in Instant-Runoff voting*
Additional authors (if any):

There are well-known necessary and sufficient conditions for a 3-candidate, fully-ranked, monotonicity anomaly in an Instant-runoff election. We will describe our work to extend the previous research to find necessary and sufficient conditions in a number of related areas: (1) when the ballots are not necessarily fully-ranked, (2) Participation (No-show) anomalies, and (3) at the 4-candidate level.

CP1.2 **Jessica Sorrells** (jessica.sorrells@converse.edu). *Modeling DNA Self-Assembly with Graph Theory*
Additional authors (if any):

The field of DNA nanotechnology capitalizes on the unique bonding properties of DNA molecules to build various structures via self-assembly. Self-assembling DNA complexes can be modeled as discrete graphs, resulting in new design strategies for increased efficiency in laboratory processes. One recent focus in DNA nanotechnology is the formation of nanotubes from lattices. Optimizing the self-assembly of these lattices and tubes creates open problems in applied graph theory. This talk will give an overview of the graph theoretical approach to self-assembly and explore initial construction methods for lattices and tubes.

CP1.3 **Anilkumar Devarapu** (adevarapu@ung.edu). *Similarity solutions for a class of unsteady convective heat transfer problems.*
Additional authors (if any):

This work deals with different similarity solutions for certain unsteady convective heat transfer problems. The governing unsteady boundary layer equations along with the boundary conditions are transformed to a system of nonlinear differential equations with suitable similarity transformations. We discuss the self-similar, semi-similar and nonsimilar solutions to certain unsteady convective heat transfer problems. Also, we will present the effects of various parameters on the fluid velocity, fluid temperature and as well as heat and mass transfer rates

CP1.4 **Zach Abernathy** (abernathyz@winthrop.edu). *Optimal Control of an HIV Model with Gene Therapy and Latency Reversing Agents*
Additional authors (if any): Kristen Abernathy (Winthrop University), Andrew Grant* (Winthrop University), Paul Hazelton* (Winthrop University) (* denotes undergraduate co-authors)

In this talk, we study the dynamics of HIV under gene therapy and latency reversing agents. While previous works modeled either the use of gene therapy or latency reversing agents, we consider the effects of a combination treatment strategy. For constant treatment controls, we establish global stability of the disease-free equilibrium and endemic equilibrium based on the value of R0. We then consider time-dependent controls and formulate an associated optimal control problem that emphasizes reduction of the latent reservoir. Characterizations for the optimal control profiles are found using Pontryagin's Maximum Principle. We perform numerical simulations of the optimal control model using the fourth-order Runge–Kutta forward-backward sweep method. We find that a combination treatment of gene therapy with latency reversing agents provides better remission times than gene therapy alone.

CP2.1 **Dr. Zephyrinus Okonkwo** (Zephyrinus.Okonkwo@asurams.edu). *On Singular Perturbations Problems for Neutral Equations*
Additional authors (if any):

In this paper, we discuss a class of singular perturbations of stochastic functional equations of Volterra type in abstract spaces. We also obtain the existence and uniqueness of the solution processes.

CP2.2 **C. Bryan Dawson** (bdawson@uu.edu). *The Nearly Universal, Easy-to-use Level Comparison Test for Series*
Additional authors (if any):

The use of infinitesimal methods in calculus can simplify computations for students, including the determination of convergence or divergence of a series. The level comparison test for series with nonnegative terms is an example. Featuring a computation that is similar in difficulty to the test for divergence, this test hinges on whether the reciprocal of the "omegath" term of the series lies in the "convergence zone" or in the "divergence zone." In this talk the test is described and demonstrated. (The level comparison test is introduced in the textbook "Calculus Set Free: Infinitesimals to the Rescue", Oxford University Press, 2022.)

CP2.3 **Kwadwo Antwi-Fordjour** (kantwifo@samford.edu). *A modified Lotka-Volterra predator-prey system*
Additional authors (if any):

In a predator-prey interaction, the dynamics are strongly influenced by the appropriate choice of predator functional response. In this talk, we will consider a modified Lotka-Volterra system. There are some issues with some previous results concerning the global existence of solutions in the existing literature. We will correct some of the previous results and corroborate our study with numerical simulations. Finally, the ecological significance of the obtained results will be discussed.

CP2.4 **James Cook** (jcook@uwa.edu). *New Problems for the Method of Undetermined Coefficients*
Additional authors (if any): William Cook of Appalachian State University

The method of undetermined coefficients is a standard topic of introductory differential equations. We study how to generalize the method to a special class of linear differential equations which are formed by a polynomial in a linear differential operator. The fundamental solution set for such problems is formed by a near-k-chain of generalized eigenfunctions. We demonstrate how these solutions are constructed from a multiplier function. This multiplier is well-known as t for the constant coefficient case and ln(t) for the Cauchy Euler problem. Other choices of the multiplier lead to solution sets and problems which are not widely known in the introductory differential equations literature. This talk should be of interest to teachers and students of differential equations.

CP2.5 **Balaram Ghimire** (baghimire@alasu.edu). *The closed-form particular solutions for the Laplace operator using oscillatory radial basis functions in 2D.*
Additional authors (if any): A. R. Lamichhane

The role of particular solution is very crucial for solving inhomogeneous differential equations. The closed-form particular solutions of the radial basis functions (RBFs) are essential for the implementation of several numerical methods to solve various partial differential equations (PDEs). For instance, RBF collocation methods such as method of particular solutions (MPS) use the closed form particular solutions as the basis functions. Recently, a new class of Oscillatory RBFs has been introduced. In this talk, we discuss how to derive the closed-form particular solutions of the oscillatory RBFs for the Laplace operator in 2D so that it can be applied to particular solutions based numerical methods. We have successfully implemented the newly derived particular solutions in the method of particular solutions (MPS) for solving Poisson’s equation as well as elliptic PDEs with variable coefficients

CP3.1 **Christian Millichap** (christian.millichap@furman.edu). *Flat fully augmented links are determined by their complements.*
Additional authors (if any): Rolland Trapp (California State, San Bernardino)

A natural tool for studying a knot or link K is its complement, which is all of three-dimensional space minus K. The Gordon-Luecke Theorem states that knots are determined by their complements, that is, if two knot complements are homeomorphic, then these knots are equivalent. While this fact does not hold when we expand to links, it is natural to ask: are certain infinite classes of links determined by their complements? In this talk, we will introduce a large and interesting class of links, called flat fully augmented links, and briefly discuss how the hyperbolic geometry of such links can be exploited to show that they are determined by their complements.

CP3.2 **Mingwei Sun** (msun1@samford.edu). *A Principle-Weighted Penalized Regression Model and its Application*
Additional authors (if any):

A new principle-weighted penalized regression model which can be used for reducing the dimensionality of large data without losing important information is introduced. It retains the favorable features of the principal component analysis (PCA) technique and penalized regression models. The new model weighs the variables in a large data set based on their contributions to key principle components obtained by PCA, which improves its ability to discover hidden correlated variables, and does variable selection and regression coefficients estimation simultaneously via regularization methods. An application of the proposed model on high-dimensional economic data is studied. The results of comparative studies show that the new model presents much better fitting and prediction performance than competitors. The resulting model presents high accuracy and is easy to interpret.

CP3.3 **Dan Scofield** (daniel.scofield@fmarion.edu). *Exploring data from the chromatic graph polynomial with BallMapper*
Additional authors (if any): Radmila Sazdanovic, North Carolina State University

We apply methods from topological data analysis to explore data encoding the chromatic polynomials of graphs up to 10 vertices. In particular, we use BallMapper to observe features in which graphs with similar structural characteristics are clustered together. We provide evidence for a relationship between the coefficients of the chromatic polynomial and measures of graph irregularity. In addition, we apply our approach to the Tutte polynomial and observe similar features whose existence sheds light on the structures detected by Tutte coefficients.

CP3.4 **Mark Budden** (markbudden@gmail.com). *Subgraphs of Gallai-Colored Complete Graphs Spanned by Edges Using at Most Two Colors*
Additional authors (if any): Tucker Wimbish

A Gallai t-coloring of a complete graph is an assignment of at most t colors to the edges of the graph such that rainbow triangles are avoided (i.e., no K_3-subgraph has edges that use three distinct colors). The Gallai-Ramsey number seeks to determine how many vertices are necessary in a complete graph so that every Gallai t-coloring contains a given monochromatic subgraph. In this talk, we will consider the analogous problem where the subgraphs sought are spanned by edges that use at most two colors.

An important structure theorem for Gallai colorings will serve as our primary tool when solving this problem for K_5-subgraphs.

CP3.5 **J.C. Price** (jprice12@ggc.edu). *Counting Forests and Star Graphs*
Additional authors (if any):

In this talk, we will introduce our approach to counting forests of labeled graphs and its application to star graphs. In particular, we will present definitions for a rooted system, forest, and forest counting function. We then use these definitions to give a complete characterization of the number of rooted forests of star graphs. (This work was done in collaboration with Daniel Pinzon and Daniel Pragel at GGC.)

CP4.1 **Nicole Panza** (npanza@fmarion.edu). *Student Created Review Videos*
Additional authors (if any):

It has been said that the best way to learn something is to teach it to someone else. That is the premise of student created review videos. These videos emphasize the language and explanation of key ideas throughout the Calculus sequence over the actual answers to the problems. This presentation gives an overview of how these videos are executed, implemented and evaluated in a course.

CP4.2 **Caroline Maher-Boulis** (cmaherboulis@leeuniversity.edu). *Interdisciplinary Interventions to Use in Algebra Courses*
Additional authors (if any):

The National Consortium for Synergistic Undergraduate Mathematics via Multi-Institutional Interdisciplinary Teaching Partnerships, or SUMMIT-P, is a National Science Foundation (NSF) funded project with the goal of improving the curriculum of lower division undergraduate courses by engaging in interdisciplinary conversation. Throughout the past six years, faculty members in 10 institutions have collaborated in local and national faculty learning communities to improve students' attitudes toward undergraduate mathematics courses, and to help them make connections across disciplines. All participating institutions have products resulting from these collaborations. In this talk we present a couple of interventions that were created in collaboration with the biology and health science disciplines at Lee University and are being used in an Algebra for Calculus course. We discuss the interventions, the successes and challenges faced and best practices for implementation.

CP4.3 **Amanda Mangum** (amanda.mangum@converse.edu). *Group Activities for a Mid-Level Biomathematics Course*
Additional authors (if any):

Finding the appropriate level of mathematics for an interdisciplinary class can be tricky. This talk will focus on in-class student activities for a mid-level Biomathematics course taken by students from both mathematics and biology, and the only required prerequisite for this course was Calculus I. The course structure and methods to provide mini lessons on new math skills will be detailed. Several in-class, group activities that were used to explore the material will be discussed.

CP4.4 **Dr. Zephyrinus Okonkwo** (Zephyrinus.Okonkwo@asurams.edu). *Project Outcomes of Affordable Learning Georgia Textbook Grants*
Additional authors (if any): Dr. Anilkumar Devarapu, University of North Georgia

For many years, the cost of college textbooks have been prohibitive. This makes them unaffordable to majority of students, especially at those colleges and universities which are historically attended by poorer pool of students. This also makes it more difficult for students to enroll in certain courses. As you are aware, the overall cost of mathematics and statistics books are exceedingly high, and in some classes, student participation in active learning is very difficult. Affordable Learning Georgia Textbook grant is a Georgia System-Wide project whose core goal is to provide students with free or low-cost textbooks and learning materials. In this paper, we discuss some positive major project outcomes of three Affordable Georgia Learning Textbook grants we garnered and implemented at Albany State University.

CP4.5 **Jing Wang** (jwang@cbu.edu). *An Active Learning Approach in a History of Mathematics Class*
Additional authors (if any):

Once every two years, we offer a geometry/history of mathematics course as an upper-level elective for math majors and minors at Christian Brothers University. The course contains topics such as Euclidean and non-Euclidean geometry, mathematical structures, and the historical development of mathematical concepts. This is a preliminary report on some active learning strategies that we adopt in efforts to engage students in and out of the classroom, promote critical thinking, and improve students' written ad oral presentation skills.

CP5.1 **Jessie A. Hamm** (hammj@winthrop.edu). *Biplanarity of Subgroup Lattices for Finite Groups*
Additional authors (if any):

The subgroup lattice of a group G is the graph whose vertices are the subgroups of G and adjacency is determined by direct set containment. This graph has been studied somewhat recently and it is known for which finite groups the subgroup lattice is planar. A graph is biplanar if it is the union of two planar graphs. It follows that any planar graph is trivially biplanar. In this talk we will take a look at the biplanarity of the subgroup lattice for finite groups.

CP5.2 **Earl Russell Barnes** (earl1942barnes@yahoo.com). *On The Eigenvalues of Hermitian Matrices*
Additional authors (if any):

N. G. de Bruijn has given some inequalities for the eigenvalues Hermitian matrices. We show how these results can be used to determine intervals containing eigenvalues of these matrices. We also give a generalization of de Bruijn's inequality, that includes several classical inequalities as special cases.

CP5.3 **Chad Awtrey** (cawtrey@samford.edu). *When is a field defined by a reciprocal polynomial?*
Additional authors (if any): Gwynnie Hornibrook (Samford University)

A polynomial $f(x)$ of degree $n = 2m$ is called a reciprocal polynomial if $f(x) = x^n \cdot f(1/x)$. Equivalently, f is reciprocal if its roots come in m sets of reciprocal pairs. In this talk, we will answer the question: if F is a field extension of the rational numbers of degree $2m$, does there exist a primitive element of F whose minimal polynomial is reciprocal and how can we compute such a minimal polynomial if it exists? We will give necessary and sufficient conditions on the field extension, as well as an algorithm that constructs a corresponding reciprocal minimal polynomial. There is an interesting connection between this result and field extensions that are defined by minimal polynomials of the form $g(x^2)$, which we will discuss too. We will end with applications to computing Galois groups of reciprocal polynomials of degree 4 and 6.

CP5.4 **Joe Barrera** (joseph.barrera@converse.edu). *On the asymptotics of some strongly damped beam equations with structural damping*
Additional authors (if any):

The Fourier transform, F, on R^N (N⩾1) transforms the Cauchy problem for a strongly damped beam equation with structural damping u_{tt}(t,x)−Δu_t(t,x)+α(Δ^2)u(t,x)−Δu(t,x)=0, α⩾0, to an ordinary differential equation in time. We let u_α(t,x) be the solution of the problem given by the Fourier transform. The goal of the research is to study the asymptotic expansion of the squared L^2-norm of u_α(t,x) as t→∞. With suitable initial data u(0,x) and u_t(0,x), we establish the rate of decay of the squared L^2-norm of u_α(t,x) as t→∞.

In this talk we will discuss the methods used to obtain the desired asymptotic expansion: the small perturbation method, integral estimates, and the parabolic cylinder function. Furthermore, we provide the first few terms of the expansion and give a method to compute as many terms of the expansion as desired. Finally we discuss the relationship to the special case when α=0, namely, the strongly damped wave equation u_{tt}(t,x)−Δu_t(t,x)−Δu(t,x)=0, which has been studied extensively by, among others, Ikehata (2014) and Barrera–Volkmer (2019, 2021).

CP5.5 **Diego Ramirez** (dramirez1@brenau.edu). *Monotone iterative techniques for Caputo fractional integro-differential IVPs*
Additional authors (if any):

In this presentation, a fractional integro-differential equation with Caputo derivative of order q, 0 < q < 1, and initial condition is considered. The forcing function is the sum of an increasing and a decreasing function. By defining lower and upper solutions of the IVP, the author develops monotone iterative techniques, where the iterates are solutions of linear Caputo integro-differential IVPs that converge uniformly and monotonically to minimal and maximal solutions of the main problem.

CP5.6 **Kelly LaRosee** (laroseek@my.erau.edu). *Low-complexity Algorithms to Solve Partial Differential Equations*
Additional authors (if any): Jose R. Gonzalez (Embry-Riddle Aeronautical University), Sirani M. Perera (Embry-Riddle Aeronautical University)

The Discrete Fourier Transform (DFT) has plethora of applications in mathematics, physics, computer science, and engineering. Fast Fourier transform (FFT) is an algorithm used to efficiently compute DFT and its inverse. In this work, we obtain solutions to fundamental partial differential equations (PDEs) using fast, i.e. FFT-like, algorithms. In particular, solutions to the Heat equation, Wave equation, and Schrödinger equation are explored using low-complexity algorithms in connection to the sparse factorization of matrices. We compare the complexity in solving the PDEs using the standard Fourier transform in continuous domains vs the proposed fast algorithms in discrete domains. We also analyze the accuracy of the solutions and present simulation results based on the proposed algorithms. (This work was funded by the Office of Undergraduate Research at Embry-Riddle Aeronautical University, USA.)

Undergraduate Paper Sessions

UT1.1 **Hope Lissitz** (hllissitz@student.king.edu). *Snell's Law via a Barbell Model*
Additional authors (if any):

Looking at Snell's Law, Rene Descartes produced a flawed model based on describing light like a rolling ball crossing from a wooden floor to a rug. Slightly modifying his approach, we show that a barbell model works, giving us Sin(A)/a = Sin(B)/b where A and B are the angles of incidence and exodus across the media boundary and a and b are the speeds of light in the respective media.

UT1.2 **Madelyn Parsons** (mgparsons@csustudent.net). *On the Rate of Polarization of Decreasing Monomial Codes Beyond the Binary Field*
Additional authors (if any): Emmanuel Skora, Furman University; Dr. Felice Manganiello, Clemson University; Dr. Jessalyn Bolkema, California State University, Dominguez Hills

The current generation reaps the benefit of hundreds of years of technological innovation, yet the drive to improve upon the current condition of the world has never been stronger. Technology has become the nucleus of our society, and we seek to join the expedition to transform the future into a brighter, more advanced tomorrow through the study of Coding Theory. Coding Theory is a discipline within mathematics that studies the process of encoding and decoding messages as they are sent through a channel. Within Coding Theory, Polar Codes are a family of codes in which repeated transformations cause channel reliabilities to tend toward 0 and 1, or to polarize. This repeated transformation leads to a higher reliability in specific codewords. These Polar Codes have recently been utilized in the development of 5G cellular networks as used by major communication enterprises. It has already been proven that a decreasing monomial formalism optimizes the rate of polarization of these codes within the binary field, and our exploration expands this formalism beyond the binary field. We investigate how a change in field affects the rate of polarization of a generator matrix for a decreasing monomial code in a general field. Then, we prove general properties of decreasing monomial codes and their error exponents, drastically decreasing computational time when analyzing this family of codes. We ultimately prove that the rate of polarization increases with the field size.

UT1.3 **Maxwell Fox** (maxwelljfox@gmail.com). *Four positive equilibria in a model for sterile and wild mosquito populations*
Additional authors (if any): Ai, Shangbing, Professor of Mathematical Sciences, UAH

A well proposed ODE system that models the interactive dynamics of sterile and wild mosquito populations with a saturated release rate of sterile mosquitoes can have up to four positive equilibria, but only two positive equilibria have been confirmed to exist in the literature. In this note we establish that for a range of parameters this system does have four positive equilibria. We also obtain the stability of these equilibria.

UT1.4 **Noah Wells** (nwells1@citadel.edu). *Comparison of Dimension Reduction Methods on Hyperspectral Images*
Additional authors (if any):

Hyperspectral imaging is a recent imaging technique that allows for the capture of hundreds of bands of light, as opposed to the three bands found in traditional RGB images. Thus, Hyperspectral images contain more useful information than standard images which often makes hyperspectral image analysis a long and resource intensive task. Due to the immense amount of data in hyperspectral images, the application of dimension reduction methods is helpful for reducing the data to a manageable size. However, there are many dimension reduction algorithms and there is debate among image analysts about the most effective algorithm. This project evaluates a variety of image dimension reduction techniques on hyperspectral images in order to increase efficiency and accuracy of classification. Results show that most methods perform at similar efficiencies overall. With no significant differences between the efficiency for each method, minimum noise fraction is the recommended method due to it's speed and relative efficiency. Additionally, linear discriminant analysis is not recommended due to it's lackluster performance relative to the other tested methods.

UT1.5 **Aaron Reynolds** (areynol5@citadel.edu). *Period Analysis of Astronomical Photometric Data*
Additional authors (if any):

For the last 20 years, The Citadel has been a partner in the operation of the Four College Automated Photometric Telescope (FCAPT) located in Washington Camp, AZ. The data collected from this telescope gives important information about hundreds of distant stars. I developed a software package that automatically analyzes each star's data and prepares visualizations of the star's period and Stromgren statistics. This analysis could potentially reveal new information about many stars as well as confirming and refining previously known information. This project required me to determine how to best extend period-finding algorithms to multiband data. Previously, each channel was analyzed separately with some form of average of the periods found in each channel being reported. My program anaylzed data given in a excel sheet, and produced a several page Word document detailing the information requested by the astronomers I worked with.

UT2.1 **Angela Brobson** (albrobson001@converse.edu). *Malicious URLs*
Additional authors (if any): Previous Converse University students Sydney Allen and Kimberly Leone, and current Converse University student Madison Reece-Henderson

For this project, I worked in a team setting with a liaison from a large financial institution to detect whether or not a URL was malicious. Python was used to create programs that rate a URL's reliability, which was then used to venture down three different avenues: logistic regression, random forest, and a lexicon point based system. Through the research of preexisting programs and an analysis of data-sets containing both good and bad URLs, we narrowed our list of permissible websites to exclude social media websites and web-shortening sites. Machine learning was used with the goal of creating a program that betterred itself as it studied different malicious websites. Logistic regression analyzed data based on how well it fit the curve between a binary set of "good" and "bad", while random forests generated a set of decision trees in order to best classify individual data points. The lexicon based point system was designed to rate URLs on a predetermined scale from the probabilities of individual static features' occurrence. One factor that increased a URLs score was based on calculating the probability of a string of letters to be a word. This was after observing the use of long, incoherent strings of randomly ordered letters in the URL's path section as this is an easily duplicated way for hackers to hide under neutral appearing URLs. After reviewing each of the program's success rates, we concluded that random forest provides the most reliable and consistent results.

UT2.2 **Jovana Mitic** (jmitic001@converse.edu). *Data-Driven Retention and Advertising for Camp Kippewa*
Additional authors (if any): Faculty mentor: Dr. Amanda Mangum

This project is focused on participant data from Camp Kippewa, a residential 3.5 week camp for girls ages 7 to 15.

The primary focus is to use historical camper data to predict whether a particular camper will become a repeat customer. Python is used to create a tree trained on select data for this prediction. An evaluation survey was used to collect additional data from 2021 campers to inform advertising based on campers' preferences and on frequently enjoyed aspects of camp. Other data analysis including clustering and marketing tools that Camp Kippewa should use to attract more campers and to keep returning ones will also be presented.

UT2.3 **Robert Roser** (rroser@citadel.edu). *A Deep Learning based Image Optimization Approach to Authenticate Masked Faces*
Additional authors (if any): Dr. Prosenjit Chatterjee

Biometric-based authentication and recognition systems are gaining popularity in the last decade. It is evident that a face-based biometric authentication system has the majority focus, compared to the other biometric traits. Current composition facial feature analyses pose some challenges during and post COVID-19. Given the COVID-19 pandemic environment, people are afraid of removing their masks even in secured premises. A face-based human recognition system is inevitably a highly complex model that needs precise scaling due to the high volume of high-resolution face images. Every human face has several sub features that altogether form a composite unique feature key for every individual during their recognition process. To identify a real authentic user, or to recognize a valid user wearing a mask is nowadays becoming a challenging task for any classifier. Using a masked data set as well as an unmasked dataset for baseline purposes, the developed Deep Neural Networks (DNNs) will be responsible for facial recognition. This article examines the effects of image compression feature extraction as a preprocessing step before the training of a deep-nets model to improve scalability using testing accuracy. Taking into consideration that training time is substantial for image classification using entire images as a training set, an ideal of 80% of data included in the image set will be removed. In our experiment we focus on the periocular image feature extraction of human faces using fractal image feature extraction techniques as data preprocessing steps. Our DNNs will receive the preprocessed data, perform further feature extraction and pattern recognition steps to classify valid user faces in optimized time. Image feature extraction using fractals in combination with the implementation of the Feed Forward DNNs for accurate authentication is still an unexplored research area and conceivably is a novel contribution towards human face based biometric authentication systems.

UT2.4 **Carson Morris** (carmorris@augusta.edu). *Implicit Methods for Solving the Reactive Transport Equation*
Additional authors (if any): Anastasia Wilson, Augusta University

In this presentation, we consider two implicit numerical solutions for the reactive transport equation, which we use to model the protein chromatography process. The desire for more efficient chromatography methods is larger than ever before, and its uses are far-reaching, contributing most prominently to the study of biotherapeutics. The first implicit numerical method utilized is Backward Euler, in which we consider the concentration of a fluid one temporal step ahead and solve for the concentration at each of those temporal steps. We also make use of Implicit Trapezoid, in which we average the Backward Euler and Forward Euler methods to derive a more accurate and quickly converging solution. We then analyze these methods by computing their error convergence rates and comparing simulation results with experimental data.

UT2.5 **Madisson Russell** (mrussell29@my.apsu.edu). *Statistical Analysis of Wildfires*
Additional authors (if any): Dr. Ramanjit Sahi

Wildfires can have far reaching effects on both the climate and the economy. By analyzing the trends of wildfires and the economic impact they have, one may gain an understanding of how those effects have changed, if at all, overtime. In our study, visual comparison was done on various variables that describe wildfires. Then, we conducted a regression analysis to understand the linear/non-linear trends between various combinations of the wildfire variables. This statistical analysis will help in finding the main variables that will contribute to future endeavors to minimize wildfire effects.

UT3.1 **Andrew E. Vick** (avick001@leeu.edu). *Finding the Genus of Cayley Graphs on Billiard Surfaces*
Additional authors (if any):

A billiard surface is constructed by reflecting the copies of a polygon across the sides of the shape; this process is referred to as the unfolding of the path. The goal of this talk is to elucidate the connection between billiard surfaces and the genus of the Cayley graph associated with the construction of the surface. A Cayley graph can show the relationship between the reflections that constructed the surface, which for billiard surfaces is a dihedral group. Our current research focuses on quadrilateral billiard surfaces. Sage generated a large body of workable data and examples. For parallelograms the genus is 0, trapezoids 0 or 1, and currently for any quadrilateral, the highest genus found is 2. It remains to prove the conditions under which a quadrilateral billiard surface's Cayley graph is genus 2 as well as proving an upper bound on its genus.

UT3.2 **Holly Abrams** (habrams1@my.apsu.edu). *An Exploration of Odd Prime Graph Labelings*
Additional authors (if any): Dr. Brad Fox

An odd prime labeling is a variation of a prime labeling in which the vertices of a graph of order n are labeled with the distinct odd integers 1 to 2n-1 so that the labels of adjacent vertices are relatively prime. This paper investigates many different classes of graphs including stacked prisms, binary trees and caterpillars, and uses various methods to construct odd prime labelings.

UT3.3 **Bryant Collins** (bhcollins2@catamount.wcu.edu). *A Variation on Multicolor Rado Numbers*
Additional authors (if any): Mark Budden (Western Carolina University)

Let E_m denote a system of equations/inequalities in m variables. Generalizing the concept of a Schur number, the Rado number $R^t(E_m)$ is defined to be the least natural number such that every t-coloring of the elements of the set $\{1, 2, \dots, R^t(E_m)\}$ contains a monochromatic solution to E_m. In this presentation we will go over the analagous problem where solutions have at most a certain number of colors.

UT3.4 **Zoulaiha Daouda** (zdaouda1@catamount.wcu.edu). *Star-critical Gallai-Ramsey Numbers Involving the Disjoint Union of Triangles*
Additional authors (if any): Mark Budden

Introduced by Hook and Isaak in 2010, the concept of a star-critical Ramsey number serves as a measure of the strength of the Ramsey property in graphs. Specifically, it indicates the number of edges that must be added between a vertex and a critical coloring of a certain complete graph to create the Ramsey property. Ever since its introduction, significant research has been conducted in the field and has resulted in the computation of the star-critical Ramsey numbers of various graphs using combinatorial methods. While these computations provide general results, it has been shown that focusing on a subset of interest can provide more specific information. The subset of Gallai-colored complete graphs (which contain no rainbow triangles) is popular in this sense. Building off of recent research by Su and Liu, the star-critical Gallai Ramsey numbers for certain disjoint unions of K_3-subgraphs are evaluated in this talk.

UT4.1 **Lisa Reed** (lisa.reed@my.uu.edu). *That's Impossible! An Exploration of Three Famous Greek Constructions*
Additional authors (if any):

The three famous ancient Greek construction problems involve using only a straightedge and compass to double the cube, trisect an angle, and square the circle. Attempting these constructions have captivated geometers for centuries. It was not until the nineteenth century that Wantzel proved the impossibility of doubling the cube and trisecting an angle and Lindemann completed the proof of the impossibility of squaring the circle. While the problems seem geometric in nature, proving the impossibility of these constructions requires abstract algebra. This talk will introduce the idea of constructible numbers, i.e., lengths that can be constructed using only a compass and straightedge, and will introduce two important theorems concerning constructible numbers. Using these concepts from abstract algebra along with the fact that pi is a transcendental number, proofs for the three impossibilities will be presented.

UT4.2 **William Jensen** (wjensen@citadel.edu). *The Derivative of a Solution to a Third Order Parameter Dependent Boundary Value Problem on a Time Scale*
Additional authors (if any):

We discuss derivatives of the solution of a third order parameter dependent boundary value problem $y^{\Delta\Delta\Delta} = f(t,y,y^{\Delta},y^{\Delta\Delta},\lambda)$, $y(t1) = y1$, $y(t2) = y2$, $y(t3) = y3$, on a general time scale, and its relationship to a third order homogeneous differential equation which corresponds to the traditional variational equation. Specifically, we show that given a solution y(t) of the boundary value problem, the delta derivative of the solution with respect to the parameter λ is itself a solution to the aforementioned nonhomogeneous equation with interesting boundary conditions.

UT4.3 **Evan Sherman** (evacsher@ut.utm.edu). *Quasi-positive curvature on Bazaikin spaces*
Additional authors (if any): Dr. Jason DeVito

In this presentation, we begin with discussing the construction of Bazaikin spaces by defining an action of Sp(2) x S^1 on SU(5). Using Cheeger deformations, we induce a Riemannian metric where the sectional curvature of a given Bazaikin space can be studied. After doing so, we determine that all Bazaikin spaces admit a metric of quasi-positive curvature.

UT4.4 **Caroline Tvardy** (carolinetvardy@gmail.com). *Incompleteness and the Rise of Modernism*
Additional authors (if any):

This article explores current and proposed methodologies in the history of mathematics as well as how they can be implemented and expanded through the lens of Godel's Incompleteness Theorems and the rise of modernism. While traditional methodological approaches in both the history of mathematics and intellectual history often fail to fully encapsulate the breadth of a mathematician's life and work, this article utilizes an approach that combines elements of both fields to create the most precise picture possible of mathematics presented as well as the mathematician behind it. Gödel's Incompleteness Theorems and the rise of modernism in the 1920s and 1930s is used as this method's vehicle, and through this presentation, Gödel's works in logic, proof, and philosophy are discussed within the context of his time and life. In addition, methods drawn from the history of mathematics and historiography in intellectual history are utilized to explore the crossroads of mathematics and historical research.

UT4.5 **Ja'Nya Breeden** (janya.breeden@g.fmarion.edu). *Simulating Dislocation Densities with Finite Element Analysis*
Additional authors (if any): Jay Gopalakrishnan (Portland State University), Dow Drake (Portland State University), Saurabh Puri (Microstructure Engineering)

A one-dimensional, time-dependent model is developed using the Discontinuous Galerkin Method and is capable of simulating dislocations by implementing a set of partial differential equations. The dispersal of plastic deformation and stress within the system is caused by the transport of dislocations over time are modeled. By implementing the Discontinuous Galerkin method, the evolution equation for the dislocation density is discretized. We are then able to determine how the discretized system is affected by the application of a non-zero applied strain.

Undergraduate Poster Session

UP.1 **Stephen Creamer** (creamersc@email.wofford.edu). *Surviving Ragnarok: Modeling humanity's chance of survival after a major disaster event*
Additional authors (if any): Rachel Grotheer (Wofford College)

Events such as natural disasters, disease epidemics, and wars heighten our collective awareness of the fragility of human life on Earth. Therefore, it comes as no surprise that researchers have sought to create mathematical models to predict the behavior of population growth following these events. Our research models the growth of a population from an initial number of survivors following a catastrophic event by using Markov population chains and differential equations while the population is living within a bunker. We then make use of stochastic models to study the dynamics of the population once it leaves the bunker after a set period of time. With these models, we establish a viable range for the initial population that ensures a steady growth rate.

UP.2 **Mathew Daugomah** (mdaugoma@citadel.edu). *The Best Way to Defend Against the Patriots Passing Offence*
Additional authors (if any):

Operations Research will be used to estimate the most effective way to defend against the New England Patriots football team offense. Game Theory, a subset of Operation Research will be used to analyze data based off past offensive performance. A dataset of games will be used to make a playoff function of the three most used offensive formation used by the Patriots and the three most used Defensive's formation used against the Patriots to analyze the best defense to be used against the Patriots passing offensive.

UP.3 **Sarah Harkins** (sarah.harkins@g.fmarion.edu). *Comparative Study of Gaussian Mixtures and Clustering on Health Data*
Additional authors (if any):

In this project, K-Means clustering and Gaussian Mixture Models (GMM) were compared on their abilities to decipher clusters in 1-dimensional data sets. The K-Means is a popular clustering algorithm, but there are aspects that it fails to capture that possibly leave the GMM to be the superior algorithm.

The abilities of the algorithms were compared with simulated data sets. The algorithms were then further compared on a data set from the National Health and Nutrition Examination Survey. This data set includes 1,030 people ages 8 to 19 years old and their respective BMI. The goal of this application was to see if the algorithms would accurately discern between the group of males versus the group of females based on BMI. GMM is typically used with higher-dimensional datasets, however, only one is used for this project. The GMM delivers a more accurate distribution than K-Means due to the consideration of the standard deviation.

UP.4 **Ernest James** (ejames3@citadel.edu). *The Fibonacci and Lucas Interpolating Polynomials*
Additional authors (if any):

The Lagrange interpolating polynomial can fit a set of N data points to a degree N polynomial. We apply this polynomial to fit the first N Fibonacci and Lucas numbers. We prove an interesting property about the N+1st value of the polynomials. This is a solution to problem B-1294 in Fibonacci Quarterly.

UP.5 **Eric Lilling** (ericlilling@gmail.com). *Statistical Analysis of the Effect of Music on Human Brain Activities*
Additional authors (if any): Dr. Bo Li (research advisor)

Electroencephalography (EEG) data is a measure of the electrical activity in a human brain. It can be recorded using a special headset containing electrodes that are placed around the skull, and interpreted by a computer using a brain computer interface (BCI). Many people have been trying to understand how the human brain responds to certain stimuli, such as music, in order to develop meaningful applications from this data. In this report, we study how music affects human brain activities based on EEG test data. A pilot study based on a convenient sample shows that the mean signal peaks responding to music is moderately significantly higher than that of the control group at significance level 0.1. We collect a "random" sample and study the effect of music by comparing the treatments versus a control group based on the Bonferroni method.

UP.6 **Jada Lytch** (jada.lytch@g.fmarion.edu). *Implementation of Least Squares Method To A Navier-Stokes Solver*
Additional authors (if any): Ja'Nya Breeden, Francis Marion University, Undergraduate Student; Taylor Boatwright, Francis Marion University, Undergraduate Student

The Navier-Stokes equations are used to model fluid flow. Example applications include fluid structure interactions in the heart, climate and weather modeling, and flow simulations in computer gaming and entertainment. The equations date back to the 1800s, but research and development of numerical approximation algorithms continues to be an active area. To numerically solve the Navier-Stokes equations we implement a least squares finite element algorithm based on work by Roland Glowinski and his colleagues. The solver is coded using the C++ language and the deal.II finite element library. We investigate convergence rates, apply the least squares solver to the lid driven cavity problem, and discuss results.

UP.7 **Audrey Meyers** (armeyers1@catamount.wcu.edu). *Differential Equations Relating to the Infectious Disease La Crosse Encephalitis*
Additional authors (if any):

La Crosse Encephalitis is a serious virus that typically infects children and is more prevalent in the eastern Tennessee and western North Carolina regions. It is the most common arboviral cause of pediatric encephalitis in the US. The Eastern Tree Hole Mosquito, Aedes triseriatus, is the primary vector in this area. This work will present a differential equations model of the dynamics of the disease in the mosquito. We focus on the vector as an increase in the mosquito population will cause an increase in the occurrences of La Crosse virus in human populations. Based off the research article by Cook et al (Cameron Cook, 2021). our work hopes to apply their model to the counties of Western North Carolina.

References

Cameron Cook, A. B. (2021). La Crosse virus spread within the mosquito population in Knox County, TN. PLOS ONE.

UP.8 **Briana Monarca** (briana.monarca@g.fmarion.edu). *Can You Belize What We Did?*
Additional authors (if any): Taylor Boatwright - Francis Marion University.

Looking at the physical, microbial, and chemical makeup of water samples gives a good indication of the drinking quality, which is important as it's a vital human need. Testing water from Billy Barquedier National Park and the Valley community in the Stann Creek District, Belize, CA. is important to tell whether contamination is taking place from the water source or in the pipe systems. Testing involved taking samples as well as testing in the field with the Pro DSS water quality meter. Lab testing used a colorimeter and autoclave to test the microbial and chemical makeup. It's important to look to at the connection between the chemical and physical components compared to the microbial components to see connections between harmful bacteria such as Escherichia coli and fecal coliforms.

UP.9 **Amy Moore** (amoore52@elon.edu). *Measuring Gerrymandering: Investigating the distributions of party ratios for districting techniques.*
Additional authors (if any): Dr. Todd Lee & Dr. Crista Arangala, Elon University

The process of creating districts to be used in political elections in North Carolina has been a cause of concern for many years. This process is completed by hand by the legislature and recently has frequently resulted in maps that are later declared unconstitutional. These maps have been gerrymandered or designed specifically to benefit one political party over another, disenfranchising voters across the state. This project aims to investigate and compare multiple mathematical methods for computationally creating districts. These mathematical methods include the use of applied linear algebra, Euclidean geometry, and Voronoi diagrams. Each method is used to create a large number of theoretical districts which will be numerically represented by the ratio of Democrats to Republicans that would be elected from the set of districts based on previous election data. Using the distributions of the party ratio, we can compare the actual congressional districts to the computational methods and find indicators of unfair districting methods.

UP.10 **Madelyn Parsons** (mgparsons@csustudent.net). *An Analysis of Numerical Weather Prediction and Methods for Decreasing Error*
Additional authors (if any): Dr. Ryan Thomas, Charleston Southern University

In 1922, Lewis Fry Richardson, a pioneer of Numerical Weather Prediction (NWP), theorized that to accurately predict changes within the Earth's atmosphere, one would need to assemble a "forecast factory" comprised of 64,000 human "computers" working on numerical evaluations at any given time. Richardson's dream is made possible with increased computing power in the modern age. While NWP has developed with the available computing power, we believe that more can be done to generate longer, more accurate forecasts. NWP is built upon a set of equations derived from atmospheric relations, called the primitive equations. We study these equations and the myriad of variables that contribute to atmospheric conditions. This intricate system of relationships makes forecasting a difficult task, as the primitive equations cannot be solved analytically. The methods involved make forecast models highly dependent on initial conditions, as the solution to numerical approximations are necessary to evaluating the primitive equations. We analyze different methods of reducing error in forecasts, such as forecast ensembles and reducing model resolutions. Ultimately, we highlight ways to increase the accuracy of predictions and we conclude that the accuracy of forecasts will increase strictly with computing power.

UP.11 **Aaron Reynolds** (areynol5@citadel.edu). *Ulam Numbers*
Additional authors (if any):

Last summer, I studied the Ulam sequence and multiple interesting properties that this sequence possesses. The Ulam sequence is a s-additive sequence where s = 1. An s-additive sequence is a sequence where each term is the sum of two previous terms in exactly s ways. I generated sequences up to 900 terms for a variety of unique starting values. When several interesting patterns emerged I narrowed our focus to Ulam sequence of the form (1, s_2) where these terms are the starting values for constructing the sequence. When analyzing sequences of this form, interesting patterns emerge regarding consecutive terms within the sequence. I wrote 7 lemmas that describe the behaviors that emerged, and I am now working on proofs for these lemmas.

UP.12 **Joseph Semler** (jsemler1@my.apsu.edu). *Rational-Logarithmic 4th Order Method and Application to a First-Order Pantograph Equation*
Additional authors (if any): Samuel Jator, Ph.D

Rational techniques are a leading method proposed for solving differential equations with singularities and are often comparable to more conventional methods in error. In this paper, we derive and implement a 4th order Rational-Logarithmic basis numerical technique (RLM4) with a variable controlling parameter for solving singular differential equations. We explore the method's errors and derive its optimal parameter by analyzing the local truncation error. We note that the fourth order RLM is the highest order for which an analytic solution for the parameter is possible. By employing a predictor-corrector mode, our method is both accurate and easy to implement, lending itself to application outside of the field of mathematics. Further, we will adapt the method to solve the first-order Pantograph equation and discuss our approach, a numerical finite-difference technique based on Euler's method, to approximating the delay term. Directions for further study include expansion to higher-order Pantograph equations and other non-analytical singular problems.

UP.13 **Sam Uselton** (sam.uselton@pop.belmont.edu). *Upper Bounds for Semiprime Arithmetic Sequences*
Additional authors (if any):

Semiprimes are positive integers of the form n = p*q where p and q are primes that are not necessarily distinct. Semiprimes can occur in arithmetic sequence, and the upper bound changes depending on the distance, d, between semiprimes in the sequence. The goal of the presentation will be to present proofs for different cases of semiprime arithmetic sequences, including d = 2k+1 where k is greater than or equal to 0 and d=2k where k is positive and not a multiple of 3, as well as a general case for finding upper bounds for varying distances. We will also include the building of semiprime arithmetic sequences off of prime arithmetic sequences and the longest semiprime arithmetic sequences I have found.

UP.14 **Andrew E. Vick** (avick001@leeu.edu). *Open Questions in Rotational Sets and Itineraries*
Additional authors (if any):

The goal of this project is to expand the research done by Dr. John C. Mayer et. al. on rotational subsets of the unit circle under z^d and explicate connections between an orbit's itinerary and the elements of an orbit as a set. By observing the behavior and patterns of rotational sets on the unit circle, one can understand under what conditions an initial value of z will follow a pattern or rotate chaotically. A more robust understanding of such behavior could enable understanding of the angle cubing function, f:C->C defined by z^3+c where c is a complex parameter. Furthermore, itineraries are a method of charting in which partition of the unit circle an orbit lands at various iterations of the function. The connections between itineraries and rotational sets could be an important contribution to the field of dynamical systems. There remain two unanswered questions which interest me: Given a periodic orbit for some d, how do we recognize whether the orbit is rotational? Given two or more rotational periodic orbits for a given d as itineraries, how do we recognize whether or not they can belong to the same rotational set?

UP.15 **Amaya Brinson** (atbrinson@aggies.ncat.edu). *Numerical study of electron plasma crystallization using point vortices*
Additional authors (if any): Ling Xu

This research project aims to study electron plasma crystallization numerically. Plasma crystallization is a process of unstable dot patterns (high concentration of electrons) reorganizing into a new stable pattern via self-interaction. Previous work indicates that energy exchange and interaction with the background affect the crystallization process (Durkin and Fajans, Physical Review Letters, 2000). In our study, we used point vortices to model the crystallized clumps. The evolution of point vortices is governed by ordinary differential equations (ODEs). We have applied both the first-order Euler method and the fourth-order Runge-Kutta four-stage method to solve the ODEs. A systematic comparison between these two methods is documented. Next, we have examined the effects of different parameters on the point vortex evolution. Our parameters include the number of vortices, size of perturbation, and various strengths applied to vortices. This work is supported by CURM 2021-2022.