Kappa Mu Epsilon
National Mathematics Honor Society

KME 46th BIENNIAL NATIONAL CONVENTION
April 13 – 15, 2023

Hosted by New York Rho Chapter at Molloy University in Rockville Centre, NY

KME thanks AMS and ASA for their generous financial support of this convention!

PARTICIPATING CHAPTERS

Alabama Theta (Jacksonville State University)
Kansas Alpha (Pittsburg State University)
Kansas Beta (Emporia State University)
Kansas Delta (Washburn University)
Maryland Delta (Frostburg State University)
Missouri Beta (University of Central Missouri)
Missouri Theta (Evangel University)
New York Rho (Molloy University)
North Carolina Zeta (Catawba College)
Pennsylvania Mu (Saint Francis University)
Rhode Island Beta (Bryant University)
Texas Kappa (University of Mary Hardin-Baylor)
Tennessee Gamma (Union University)
West Virginia Alpha (Bethany College)

AGENDA

Thursday, April 13, 2023

7:00 – 9:00 PM Reception and Mixer in Hagan 339

8:00 – 9:00 PM Meeting with the Officers in Hagan 014

Friday, April 14, 2023

8:00 - 8:30 AM Breakfast in Hagan 339

8:30 – 9:00 AM First General Session

9:00 – 10:00 AM Student Presentation, Session #1

1. Peter Russell, Missouri Theta. Title: Circular Projections of Ellipsoids
2. Catherine McClure, New York Rho. Title: Perfect Numbers in Quadratic Fields
3. Julia DiCianni, New York Rho. Title: COVID. Math Anxiety. Student Performance.

10:00 AM 10-minute break

10:10 – 11:30 AM Student Presentation, Session #2

4. Ian Coleman-Hull, Kansas Beta. Title: Explaining Economic Connectedness in Kansas
5. Abigail Branson, Tennessee Gamma. Title: Lost in the Divergence Zone
6. Celine Lukito, New York Rho. Title: An Introduction to Topological Data Analysis Through the Lens of Persistent Homology
7. John Mancuso, Rhode Island Beta. Title: Song Recommendation using K-nearest neighbors Algorithm

11:30 - 1:00 PM Group Photo and Lunch

1:00 – 2:00 PM **Keynote Address: Pop Culture in the Mathematics Classroom**
Jaimie Stone, Johnson and Wales University

This presentation will examine the profound role popular culture can play in a mathematics classroom. The speaker will share his firsthand experience creating Integrative Learning courses at Johnson & Wales University such as The Statistics of Popular Culture and The Science of Superheroes. Examples such as predicting Oscar winners, Family Feud, and Disney Bracketology will show the value of using popular culture to engage students. Come for the mathematical genius of Tony Stark. Stay for the applied mathematics of Iron Man.

2:00 PM 10-minute break

2:10 – 3:10 PM Student Presentation, Session #3

8. Sanskar Neupane, Kansas Delta. Title: Exploring Ways to Model Stock Prices
9. Perry Wu, New York Rho. Title: A Study on the (Mis)use of Mathematical Definition
10. James Gillin, Kansas Delta. Title: Eulerian Numbers and Relations to Number Triangles and Infinite Series

3:10 PM 10-minute break

3:20 – 4:20 PM Workshop in Casey 015

John Snow, Texas Kappa. Title: Programming in the Liberal Arts Classroom

For the past decade, I have included a number of topics related to programming for art in general education mathematics classes. This inclusion not only exposes students to the

concept of programming, but it also helps to reinforce fundamental mathematical concepts and to exercise problem solving skills in a creative environment. In this workshop, we will survey the material I cover in these classes, and we will work through an exercise similar to the first day of one of class.

Saturday, April 15, 2023

8:30 – 9:00 AM Breakfast in Public Square Larini

9:00 – 10:00 AM Student Presentation, Session #4

11. Jack Lin and Victoria Risner, Missouri Theta. Title: Triangles with Interlacing Rows
12. Austin Crabtree, Kansas Beta. Title: What is a Sandwich? A Fuzzy Approach.
13. Dakota Heathcock, Alabama Theta. Title: To Know or Not to Know: A Bayesian Argument in Favor of Decision Theory

10:00 AM 10-minute break

10:10 – 11:10 AM Workshop in Casey 015

Rajarshi Dey, Kansas Beta. Title: An Introduction to R

This presentation is intended for students in Mathematical sciences who plan to work with applied mathematics or statistics or data science but anyone who is interested in learning a new software is welcome. R is an open-source programming language that is mostly used for exploratory and inferential data analysis and creating user-friendly plots. We will also learn to use RStudio, an integrated development environment for R programming. We will learn basic mathematical functions and how to work with a data.

The participants are strongly encouraged to bring a laptop and get R and RStudio loaded in their laptop from the following websites: https://cran.r-project.org/ https://posit.co/download/rstudio-desktop/

Please note that if you have a Chromebook, then you need to create a free account with RStudio cloud (no downloads necessary)

10:10 – 11:10 AM Committee Meetings Casey 009, 007, 004, 004E

11:10 AM 10-minute break

11:20 – 12:20 PM Awards and Concluding Business in Public Square Larini

PAPER ABSTRACTS

Arranged alphabetically by author

Abigail Branson, Tennessee Gamma, Union University

Title: Lost in the Divergence Zone

In this talk we will consider the level comparison test for series, based on infinitesimal calculus, which outlines the fate of the series if the reciprocal of the Ω term in a series is either always in the convergence zone or always in the divergence zone. Will a series still be able to converge if it has an infinite number of terms in the divergence zone? After finding a few such series on divergence levels consecutively further from the convergence zone, I propose that the answer is yes, as long as there is a sufficiently large proportion of terms in the convergence zone to those in the divergence zone. In order to understand this, we will cover proofs that show the sum of the reciprocals of squares and fourth powers. We will also look at what convergence and divergence zones are. During this we will look at a story to enhance comprehension of the topic.

Ian Coleman-Hull, Kansas Beta, Emporia State University

Title: Explaining Economic Connectedness in Kansas

Economic connectedness is defined as a measure to determine how well-connected a community is based upon the economic status of individuals within the community. Our goal in this study is to explain the factors that determine communities' overall economic connectedness: specifically Kansas communities. We use the help of regression models to look at how different demographic factors possibly affect economic connectedness. We have used the following demographic variables obtained from the last census: population, income, and racial makeup at county levels. We have also used other community-level variables like community cohesiveness and volunteer participation rate at school levels obtained from a study taken by the governmental census organization America Counts. In our research, we present and discuss some of the best regression models, which may assist decision-makers in each Kansas county to become more educated on the connectedness of their respective counties as well as comprehend the abstract relationships wound together in communities, nationwide.

Austin Crabtree, Kansas Beta, Emporia State University

Title: What is a Sandwich? A Fuzzy Approach.

Normally in mathematics, we consider a point to be either in a set or not in a set. What happens when we allow a point to be half in a set or two-thirds in a set? Fuzzy sets are used to describe this phenomenon and introduce vagueness into mathematics. For example, the set of all foods that are considered sandwiches is notoriously vague, as seen by the years of online debates regarding the definition of a sandwich. Using this example of fuzzy sets describing sandwiches, we will explore basic concepts of fuzzy mathematics and fuzzy topological spaces. This

intensive research might even help humanity become closer to answering the question: What exactly is a sandwich?

Julia DiCianni, New York Rho, Molloy University

Title: COVID. Math Anxiety. Student Performance.

Many students struggle from math anxiety throughout their academic years. However, studies have shown that COVID-19 pandemic has greatly affected academic performance, especially when students switched from in person learning to online learning (and then back to in person learning). We will present some of these studies; In particular, we will discuss how many students are lacking the fundamental math skills needed to move forward in their math education. Moreover, we will show that data collected from our local school district support the claims of students' struggles in math in the post-pandemic era.

James Gillin, Kansas Delta, Washburn University

Title: Eulerian Numbers and Relations to Number Triangles and Infinite Series

This presentation highlights the interesting identity of a closed form solution to infinite series of the form $\sum_{i=0}^{\infty} i^n x^i$, and the interesting discoveries I made when trying to find and prove this identity. The main discovery I wanted to highlight were two different arrangements of numbers which we will call number triangles that had similar properties to Pascal's triangle. These number triangles came about when I was trying to find coefficients of a polynomial that would eventually become the numerator in the closed form expression for the infinite series. The first number triangle started with a row with one entry of the number 1 and the 2nd row had two entries of 1s. Each successive row was generated from the previous row. This triangular arrangement of numbers shares various properties with pascal's triangle such as adding two parts from the row above to generate more numbers, however the sum of each nth row is equal to the factorial, n!, while in Pascal's triangle each row is equal to 2^n.

The second number triangle I discovered did indeed prove to have the correct coefficients for the closed form solution, and it is called Euler's triangle and is composed of the Eulerian numbers—which were studied by Leonhard Euler. The Eulerian numbers are related to the number of descents in permutations of the integers 1 to n. In the presentation we define and illustrate the concept of descents. This number triangle also has the property that each row's entries sum to the factorial of the nth row. The Eulerian numbers are also generated from a recurrence relation, and they are the coefficients of the Eulerian polynomial that is used in the closed form expression of the infinite series.

All of these discoveries during my research led to the identity that for any integer $n \geq 0, \sum_{i=0}^{\infty} i^n x^i = \sum_{k=0}^{n-1} \frac{T(n,k)x^{k+1}}{(1-x)^{n+1}}$, where T(n,k) is the Eulerian number for row n with descent k in the triangle, starting with T(0,0) = 1. The proof for this utilizes induction and taking advantage of the recurrence relation to generate Eulerian numbers.

Dakota Heathcock, Alabama Theta, Jacksonville State University

Title: To Know or Not to Know: A Bayesian Argument in Favor of Decision Theory

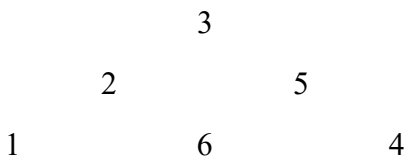
In today's world, particularly in today's world economy, people are faced with a plethora of options in multiple situations, with each option (for each decision) having multiple consequences (positive or negative). With so many decisions to be made, how can one person ever have a decision-making process that accounts for each factor properly? The long and short answer of it is, there is no system that is perfect and will account for all possible scenarios of life. Particularly, it has been proven to be difficult to account for the "human" factor in the decision-making process. Human beings are not always rational thinkers, so approaching this anomaly from a strictly scientific process is a flawed system. However, quantitatively, there are some systems that can improve our understanding of each possibility and allow us to weigh the costs and gains of each option. One of these quantitative analyses, in our opinion, helps to account for the human factor better than the rest. This system of analysis is the statistical model of Decision Theory. In this presentation, we will break down Decision Theory and make a philosophical and mathematical argument that, when paired with Bayesian statistics, Decision Theory is an excellent tool for weighing the costs and gains of a decision, even when accounting for the human factor.

Jack Lin and Victoria Risner, Missouri Theta, Evangel University

Title: Triangles with Interlacing Rows

One can arrange a triangle of n rows where each entry in the triangle is filled with a unique integer from the integers 1, 2, . . . , n(n+1)/2 . We will define the notation (i, j) to represent the jth term in the ith row of the triangle. If every integer in the (i, j) position where $i < n$ has a value between the values of the integers in the (i+1, j) and (i+1, j+1) positions, then we say the triangle has interlacing rows. For example, in the triangle below, the number 3 has position (1, 1). Numerically, 3 is between 2 and 5, which have the positions of (2, 1) and (2, 2), respectively. Similarly, in the second row, the number 2 is between 1 and 6, while 5 is between 6 and 4. For given values of n, we intend to determine the number of triangles with n interlacing rows which can be constructed.

Example Triangle with Interlacing Rows where n = 3:



Celine Lukito, New York Rho, Molloy University

Title: An Introduction to Topological Data Analysis Through the Lens of Persistent Homology

Topological Data Analysis (TDA) is a rapidly growing field in data science that utilizes tools from algebraic topology to extract and analyze geometric structures of complex data sets. There is an urgent need for new methods of data analysis that can process high-dimensional, noisy, and complex data due to the rapid increase in data volume across various fields. TDA provides a powerful set of tools to analyze such data by focusing on its intrinsic geometric and topological properties. In particular, we will discuss how persistent homology is used to measure these features across different spatial resolutions.

John Mancuso, Rhode Island Beta, Bryant University

Title: Song Recommendation using K-nearest neighbors Algorithm

Spotify is the industry leader in terms of a song recommendation system. Through our own personal use and some field interviews we found that while Spotify is the best out there, it is rather lacking when it comes to individual playlists. While Spotify was the forerunner in terms of recommendations, we found that it still did not fully satisfy users. Spotify seems to give recommendations based on what the user likes rather than the content of the playlist. Using Spotify's free API, we have access to a significant portion of their data, so we tried to create our own music recommendation system. We used the API to construct a constantly growing database that contains songs of every major genre on Spotify. The algorithm takes in a playlist and outputs recommendations for songs that fit a user's music taste as shown in the playlist. Using a multidimensional K-Nearest Neighbors model with a creative system for weighting the variables given a user's music taste we can get thoughtful predictions of songs a user might like. We generate songs for the user based on songs that they already have in their playlist, showing the user why that song was recommended. The algorithm then takes in user feedback of whether our prediction was accurate, if inaccurate then the algorithm expands our dataset with songs similar to the one, we made a bad prediction of.

Catherine McClure, New York Rho, Molloy University

Title: Perfect Numbers in Quadratic Fields

We define perfect numbers and explore their fundamental properties in the natural numbers. We demonstrate how the definition of perfect numbers can be extended to the Gaussian integers by examining the properties of $Z[i]$. We then generalize to quadratic fields and identify the limitations that arise when attempting to extend the definition of perfect numbers to Qd, where d is square free, and show what is needed to extend it.

Sanskar Neupane, Kansas Delta, Washburn University

Title: Exploring Ways to Model Stock Prices

The paper aims to explore the effectiveness of different time series models to predict the performance of securities markets, primarily index funds. The study utilizes market data from February 1993 to September 2018 as training data, with the period from September 2018 to February 2020 serving as a test period. The predictive accuracy of the models is evaluated using a Test Sum of Squared Errors (Test SSE). The generated models are compared against the baseline log random walk mode, which is the most prevalent financial predictive model for stock price per the Efficient Market Hypothesis. The study finds that some Autocorrelation (AR) outperforms the baseline model in predicting the S&P 500 index fund. The promising models are then applied to individual stocks and a cryptocurrency for further analysis. The stocks chosen for the study include Apple, Exxon Mobil, and Bank of America, while the cryptocurrency chosen is Bitcoin. The choice of stocks and cryptocurrency reflects a diverse set of sectors, with Apple representing the growth/technology sector, Exxon Mobil representing the legacy business sector, and Bank of America representing the banking sector. Bitcoin is used as a representative of cryptocurrencies. Overall, this study aims to provide insights into how, when, and why the AR models outperform the random walk model, and how can this information be used in the real-world scenario.

Peter Russell, Missouri Theta, Evangel University

Title: Circular Projections of Ellipsoids

Recall that an ellipsoid is a collection of points $(x, y, z) \in R^3$ that satisfy the following equation for some choice of $a, b, c \in R^+$:

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1$$

A year ago, we showed that regardless of the choice of a, b, and c, it is always possible to rotate this shape in such a way that its projection to the xy-plane is a perfect circle. We will now prove some additional facts to expand on this concept.

Perry Wu, New York Rho, Molloy University

Title: A Study on the (Mis)use of Mathematical Definition

Definitions play an important role in undergraduate mathematics since they provide the foundation for concepts and reasoning. In mathematics education, we identify ways of understanding mathematics using the terms concept image and concept definition. We will discuss how concept definition affects students' ability to comprehend and solve mathematical problems. We will show how concept definitions show a significant correlation between students' knowledge of math definitions and their performance. As such, it is critical for educators to prioritize the teaching and mastery of mathematical definitions in their undergraduate math courses.