2023 KYMAA Abstracts for Contributed Talks

A Predictive Model for Wordle

Behnke, Silas (Asbury University)

Our team has constructed a model allowing for the prediction of different aspects of the Wordle game. The developed model is based on a data set provided by COMAP that contains various Wordle data from the past year. Our model comes in three parts. The first part predicts the number of Wordle results posted on Twitter for a given day after February 2, 2022. The second part of our model predicts the score distributions of a given word. The third and final part of our model assigns a Difficulty value to a word based on different attributes of the word, primarily the frequency of the word and the frequency of the characters used in the word.

A Quasi-isometry of P-adic Numbers in a Subset of the Real Plane

Zopff, Kathleen (Bellarmine University)

P-adic numbers are numbers valued by their divisibility by high powers of some prime, p. These numbers are an important concept in number theory that are used in major ideas such as the Reimann Hypothesis and Andrew Wiles' proof of Fermat's last theorem, and also have applications in cryptography. In this presentation, we will explore various visualizations of p-adic numbers. In particular, we will look at a mapping of p-adic numbers into the real plane which constructs a fractal similar to a Sierpinski p-gon. We discuss the properties of this map and give formulas for the sharp bounds of its distance distortion, which shows that the map is a quasi-isometry.

A rational square variant of the Harriss Spiral

D. Jacob Wildstrom (University of Louisville)

Edmund Harriss developed a branching spiral based on a decomposition of a rectangle whose sides are in the plastic ratio into a square and two smaller rectangles. This concept was inspired by the golden spiral, a classical self-similar figure induced by decomposing a rectangle whose sides are in the golden ratio into a square and rectangle. Neither of these decompositions can be realized in a medium where the side lengths of individual components must be rational, but the golden spiral's discrete variant, the Fibonacci spiral, can be so realized. This talk proposes and analyzes an integer-side-length variant of the Harriss spiral.

Adventures with Undergraduate Research

Hoots, Lucas (Centre College)

Over the last few years I have had the opportunity to mentor my first undergraduate students on independent research projects. These were overwhelmingly rewarding experiences that I would highly encourage anyone to seek out, be you a long-time faculty member or just getting started. Join me as I discuss lessons learned, mistakes made, victories, and defeats. Whether you are an old hand at mentoring research or contemplating a first attempt, you can hopefully learn from my experiences.

2023 KYMAA Abstracts for Contributed Talks

Alternative Assessment Strategies in Introductory Statistics

Buckley, Brooke; Miller, Carl (Northern Kentucky University)

Alternative assessment strategies are now a frequent topic of discussion. During this presentation, faculty will share assessment approaches adopted over the last several years, including exam retakes and standards-based grading. These approaches were used in an introductory statistics course that satisfies general education requirements. A discussion of student outcomes and feedback for both strategies will be included, as well as suggestions for implementation and future modifications.

Better Hearing through Adaptive Quadrature

Mathew, Faith and Shibiru, Yoseph (Northern Kentucky University)

Many of us lose hearing as we grow older, making hearing aids a necessity; however, hearing aids are not generally covered by insurance, and are often out of financial reach for many. As a part of a project to develop a cheap combination of hearing tester and hearing aid, we improve on traditional hearing testing by providing a finer “audiogram” than those traditionally provided by an audiologist’s office. Whereas an audiogram is typically a linear spline fit to eight or nine frequencies, we use techniques including adaptive quadrature to explore the patient’s cochlear responsiveness, providing both a finer set of frequencies than those generally found on audiograms and a smooth curve to fit them (the patient’s “Hearing Loss Profile” – HLP). The same device uses the generated HLP to act as a hearing aid, an audio translation conducted on real-time audio input broken down into frequency bands with the help of the Discrete Fourier Transform (DFT). Either signal amplification or frequency shift would be performed on the frequency bands required based on the HLP and a LED feedback system will be used to notify the events of frequency shift.

COMAP Problem E: The Risk of Light Pollution

Hanssen, Willem (Asbury University)

In this paper, we present a metric which allows us to calculate the light pollution risk level for a given location of any diverse type. This model is specialized for various types of large locations on inhabited land.

Our metric was developed to be sensitive to numerous parameters including population size, category of location, and area of the given location. We were able to calculate the amount light pollution for any given location using each of these variables.

Armed with these versatile light pollution calculations and combining them with Ecological concerns, we were able to score any given location for two different light pollution risk values: Present Value and Future Value.

After examining our metric's results for the risk level of each diverse environment, we entertained several intervention strategies, which will assist in mitigating the effects of light pollution on a given location.

After choosing the most effective intervention strategy, we recalculated the numbers for the urban and suburban areas taking into account this mitigating factor. We found that the risk level was cut by around 40%.

2023 KYMAA Abstracts for Contributed Talks

Counterexamples to Frenkel's Conjecture for $HE_{7}^{(1)$ and $HE_{8}^{(1)}$

Baker, Michael (University of Kentucky)

Over 50 years ago, Victor Kac and Robert Moody introduced Kac-Moody Lie algebras as a natural generalization of semisimple Lie algebras that were completely classified already. The Kac-Moody algebras come in three types: finite, affine, and indefinite. Both finite and affine Kac-Moody algebras have had all root multiplicities calculated. The indefinite type has root multiplicities computed in some cases, but they are not completely known.In this thesis, we have studied some root multiplicities for the hyperbolic Kac-Moody Lie algebras g = H E (1)7,H E (1)8. We realize these algebras as minimal graded Lie algebras whose local part is $V \osum \mathfrak{gl}(n;\mathbb{C}) \osum V_{0}$ for suitably chosen $\mathfrak{gl}(n;\mathbb{C})$-modules V and V_{0}. This realization gives rise to a natural $\mathbb{Z}$-gradation $\mathbb{g} = \osum j \in \mathbb{Z}\mathfrak{g}_{j}$, where $\mathfrak{g}_{0} = \mathfrak{gl}(n;\mathbb{C})$, $\mathfrak{g}_{−1} = V$, and $\mathfrak{g}_{1} = V_{0}$. It is known that the multiplicity of root α is the same as $-\alpha$, so without loss of generality we focus on the multiplicity of negative roots. We say the negative root α is of degree $−j$ if the α-root space is contained in $\mathfrak{g}_{-j}$. Kang's multiplicity formula allows one to view the roots of $\mathfrak{g}$ as some combination of weights in $\mathfrak{gl}(n;\mathbb{C})$ modules. Using this formula, we calculate the multiplicities of roots in $\mathbb{g}$. We determine the root multiplicities of all roots up to degree −7 in $H E_{7}^{(1)}$ and root multiplicities of all roots up to degree −8 and one special root of degree −9 for $H E_{8}^{(1)}$. This special root in $H E_{8}^{(1)}$ exceeds the proposed upper bound by Frenkel, which verifies the calculation done by Kac et al. Additionally, three of the roots of $H E_{7}^{(1)}$ have multiplicity that exceeds the proposed upper bound by Frenkel as well, which shows that Frenkel's conjecture does not hold for $H E_{7}^{(1)}$.

Creating functions with prescribed end behavior

McClain, Christopher (WVU Tech)

We explore the converse of a standard Calculus course exercise. Motivated by functions with two different horizontal or slant asymptotes, we discuss the following problem: given two linear or curvilinear asymptotes that are continuous and n times differentiable for some nonnegative integer n, how do we find a continuous and n times differentiable function that has end behavior prescribed by the given asymptotes? Our aim is to provide an explicit construction of such a function rather than merely prove its existence.

Dominion on Grid Graphs

Su, Sam (Midway University)

A minimum dominating set of a graph G is a subset D such that every vertex in G is either in D or adjacent to a vertex in D. The dominion of G is the number of such minimum dominating sets. The dominion numbers of paths and cycles were previously studied by Allagan and Bobga. We here study the dominion numbers of some grid graphs by using a combinatorial optimization problem.

2023 KYMAA Abstracts for Contributed Talks

Ehrhart Functions for Phylogenetics and Conformal Blocks

Mentor: (Manon, Christopher), Presenters: 1) (Jones, Nathan) 2) (Rieke, Nikolas) 3) (Yalla, Sai) 4) (Lozano, Ale) 5) (Castro, Ian) (University of Kentucky)

A family of convex integral polytopes arises from the study of trivalent tree graphs with applications in phylogenetics. The discrete volume of these polytopes under a bounding integral hyperplane is best described using techniques from linear algebra. The L^th coefficient from the Ehrhart Series of a polytope arising from a tree with v-many vertices can be described by summing the entries of a certain L-dimensional square matrix taken to the v^th power. This problem reduces to understanding the spectra of this family of matrices. These matrices exhibit symmetry and anti-symmetry, and interesting recursive properties on the dimension emerge upon investigation.

How to Minimize Dense Sets?

Lan (Nguyen)

A dense set in a metric space X is a subset of X that is large enough to preserve most properties of X. One important question we can ask is how we can minimize such a set in a way that can be easily constructed. In this talk, we present some interesting examples of how we can formulate dense sets, including the Weierstrass Theorem. Then, we introduce a process to minimize a dense set such that it maintains its characteristics.

Incorporating Post-Graduation Preparation into the Major

Buckley, Brooke (Northern Kentucky University)

For students majoring in either mathematics or statistics, it is incredibly rare to find job titles of mathematician or statistician. Because of this, students who might have a passion or aptitude for the disciplines find themselves unsure of what career paths exist after earning their Bachelor's degree, despite the fact that the majors are often included on lists of "high demand" majors. This presentation will discuss a junior-level seminar, Career Explorations in Mathematical Sciences, designed to support majors in their exploration of post-graduation opportunities.

Is it time to teach the mathematics of post-quantum algorithms?

Christensen, Chris (Northern Kentucky University)

1976 marked the introduction of public-key cryptographic algorithms. Public-key algorithms are built on interesting mathematical problems that are thought to be "hard." Now cryptologists see quantum computers on the horizon – computers that would render insecure most currently used public-key algorithms. Since 2017 a standardization process has been operating to design new, quantum-safe algorithms. In this presentation we will briefly explore the standardization process, the algorithms, and the mathematical problems on which they are based.

2023 KYMAA Abstracts for Contributed Talks

Kolams in Graph Theory: Mathematics in Southern Indian Ritual Art

Nathan Hartmann (Murray State University)

Kolams are a ritual art form found in India, most commonly in the southern state of Tamil Nadu. Comprised of different interlocking knots, these women-drawn designs are placed on the entrances to people's home to showcase the household's emotional state and ask the earth goddess Bhudevi for forgiveness. More aesthetically pleasing kolams are considered latshanam, where the design permeates beauty; monolinearity is one such aspect that implements latshanam. Using graph theory, we examine one style of these drawings, the labyrinthine variety, and generalize ways to draw these kolams of any size without picking up the drawing instrument.

Model for Light Pollution Diagnosis

Stanley, Katherine (Asbury University)

This model presents a method of accessing the light pollution in an area, and mitigating the damage associated with it. The metric used for light pollution in this context is the Sky Quality Meter (SQM) measured in units of mag./arc sec2. Various metrics suspected to be correlated to the SQM were plotted against the SQM, and the regressions appropriately complied by their strength of correlation. Considering the risk of each city, various intervention strategies were proposed. This model found that an increase in light pollution was ideal for optimizing the effects of light pollution in an area.

Modernizing Calculus at the U.S. Air Force Academy: Preliminary Effects on STEM Retention

*González-Espada, Wilson** (Morehead State University); *Maj Matthew T. Johnson, C1C Brandon Kim, Maj Daniel S. O'Keefe* (United States Air Force Academy)

Many introductory college mathematics classes consist of fast-paced lectures that lack engaging pedagogies and encourage passive learning. Differential and integral calculus, in particular, tends to serve as a gatekeeper course and one of several "leaks" in the STEM major undergraduate pipeline. Fortunately, science and technology changes have created opportunities to reimagine how colleges teach calculus. This study reports the effect of a revamped differential and integral calculus sequence on student persistence in STEM. Student retention of those who completed the revamped calculus sequence improved, but modestly. Focus group data (n = 24) revealed that student perceptions were more positive for the revamped calculus course, while perceptions of the traditional course by students who ended up declaring a non-STEM major were more negative.

Potential Indications in K-12 Education: Correlations between High School Start Times, Chronic Absenteeism, and Academic Performance

Worth, Sophia (University of Louisville)

Kentucky's K-12 public schools are facing an epidemic of chronic absenteeism, with 99 out of 120 counties having absenteeism rates over 20%. Additionally, only one county in Kentucky has the majority of 11th-graders meeting the ACT Math score benchmark. With the largest school system in Kentucky, Jefferson County Public Schools (JCPS), beginning to stagger school-day start times this upcoming year, it is timely to analyze how start times truly affect the students of our state. This study is a statistical

comparison with variables of interest including high school start times, state assessment and ACT scores, and chronic absenteeism rates for at least 115 public school systems in Kentucky, with initial results indicating interesting correlations.

Reflections on a First Year Explorations Course

Buckley, Brooke; Agard, David; Newman, Stephen (Northern Kentucky University)

The Mathematics and Statistics Department at Northern Kentucky University began a new freshman initiative designed for students expressing an interest in one of the majors in the department. Globally, the objective of the two-semester sequence was to build community, spur retention, and engage these students in content to be seen later in their course work. The courses were to be centered on some application of mathematics and statistics accessible to an audience with a wide range of mathematical preparedness. In this presentation we discuss the development of the initiative, the primary topic chosen for this inaugural offering, and recommendations for our colleagues in future semesters.

STEM Persistence in Kentucky: What Disparities Affect Students?

Hicks, Riley (College)

Even though children in the U.S. have the right to receive a quality education, concerns about disparities in school funding, facilities, and resources between different counties within a state have emerged. This "zip code effect" causes some students to be "predestined" to receive a poor foundational education based on their home address. Because high school STEM classes require lab space, materials, equipment, and specialized teachers, disparities in school funding can impact students who want these careers, particularly in quantitative disciplines like mathematics. To make matters worse, national research suggests that female college students experience further disparities and are less likely to declare a STEM major and persist until graduation. The purpose of this exploratory study is to identify disparities associated with STEM persistence in Kentucky.

Taming the 3n+1 Monster

Zarnowski, Roger (Northern Kentucky University)

“A really dangerous problem.” “A great time waster.” These are just two of many similar descriptions that mathematicians have attached to the famous Collatz 3n+1 conjecture, a problem that has for decades attracted the attention of amateurs and professionals alike. Yet, in the words of Jeffrey Lagarias, a leading expert on the problem, “No problem is so intractable that something interesting cannot be said about it.”

It is in this spirit that we will briefly discuss some history and recent results pertaining to this unresolved conjecture about iteration of a function on integers. We will then present a modified, but equivalent, conjecture that filters out some extraneous behavior, reveals certain mapping properties, and lends itself to a three-dimensional representation of the related dynamics. We will also point out similar problems that have sprung from the study of this most famous one. These problems all hold mathematical mysteries yet to be revealed, and people with interests in computing and graphics may find additional avenues for exploration.

2023 KYMAA Abstracts for Contributed Talks

The Newtonian Limit of Hermitian Gravity in 8-Dimensional Complex Space

Knupp, Richard (Morehead State University)

A unified theory of gravity has been a long-standing problem in modern-day physics. Many attempts have been made to intricately weave general relativity and quantum mechanics into a smooth fabric. The works of Mantz, Prokopec, and Burgers suggest that by considering the theory of Hermitian gravity, one can approach this unification problem in a different way. In this paper, we extend the work of Mantz, Prokopec, and Burgers. In their paper, the authors show the Newtonian limit for three complex dimensions. In this presentation we show the Newtonian limit for eight complex dimensions to better understand the theory of Hermitian gravity and further generalize Einstein's theory of general relativity.

The weight of a ten-pound bag of potatoes

May, Rus (Morehead State University)

The weight of a ten-pound bag of potatoes is not exactly ten pounds. Rather, it is the result of a stochastic process with a fixed stopping time. We show that generating functions are great tools for quantifying the statistics of such processes and deftly calculate means and variances, using only basic results from calculus, like geometric series and l'Hospital's rule.

Using games for exploration in a math teachers' circle

Fuselier, Jenny (High Point University)

Since 2019, the Triad Area Math Teachers' Circle has sought to bring together mathematics educators across North Carolina's Piedmont Triad region into an engaging, collaborative, and non-competitive community. We centered our first few events around games, which provided a built-in element of play and fun for our events. We began by creating a series of activities about the mathematical properties found in the game Spot it! Encouraged by the success of these, we then created a similar series centered on the Quad Collector games played with the AWM's recently released EvenQuads cards. In this talk, we will give an overview of these types of activities and discuss ways similar explorations can be implemented in a mathematics classroom.

Varignon's Theorem in the Hyperbolic Plane

WILLIAM (Bill) FENTON (Bellarmine University)

In 1731, Pierre Varignon published (posthumously) a surprisingly easy theorem about quadrilaterals, namely that connecting the midpoints of the sides of any quadrilateral forms a parallelogram. Of course, parallelism works differently in the hyperbolic plane. In this talk, I examine what is true and what is not true about Varignon's result when interpreted in the hyperbolic context.

Visitors from the 4th Dimension: The Length-4 Wavelets

Roach, David (Murray State University)

The parametrized length-four wavelets are the solution to a nonlinear system of equations where each equation represents an object in 4-space, and the wavelet solution is the intersection. In this talk, we will examine some projection models that describe the shape of these objects and animate their cross-sections as they pass through our dimension. This topic is accessible to both students and faculty.

2023 KYMAA Abstracts for Contributed Talks

When are all rankings Kemeny rankings?

Powers, Bob (University of Louisville)

Kemeny's rule fK takes as input any n-tuple π of linear orders on a finite set A and, using a mini-sum criterion with respect to the Kemeny distance, outputs a nonempty subset fK(π) of linear orders of A. The linear orders belonging to fK(π) are called Kemeny rankings. The question given in the title can be formalized as follows: for which n-tuples π is it the case that fK(π) is the set of all linear orders on A? This question was posed by Tom Richmond during his KYMAA talk in 2019. An answer to Tom's question will be given and an extension of this work to graph theory will be explored.

Wordle- A Game of Random Inquiry?

(Haughton,Seth) (Bill, Caleb) (Asbury University (College))

In this paper, we present models and use them for data predictions. These predictions are made in fields of reported results (# of players for a day), estimate of a word's difficulty, and the distribution of percentages of how quickly the reported results solved a given word. We make these predictions based linguistic studies, our graphs, and our program. The linguistic studies helped in determining the values we assigned to ascertain a given word's difficulty. The graphs we created are used to easily determine the given data. Our graphs range from the reported results to tables for values we found. Our program was used to analyze our graph and create the models, as well as make "best fit" graphs for predictions. These factors allow us to take new information to predict with accuracy what the data should be for any given day and for any given 5 letter word.