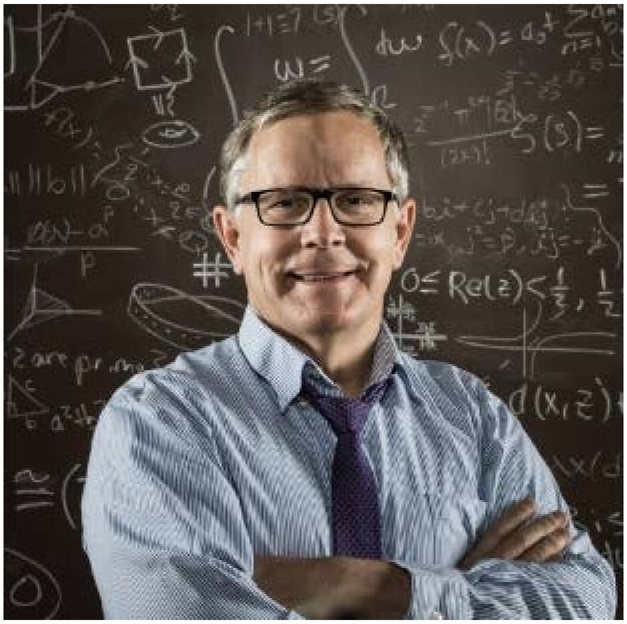
Invited Talks: Abstracts and Biographical Information

David Coulliette, Asbury University

"What Do (Computational) Mathematicians Do?"

After serving for over 20 years as a US military officer in both the Navy and the Air Force and earning his PhD in math from Florida State University, David Coulliette retired in 2000 as an Air Force Lieutenant Colonel and joined the faculty at Asbury University. At Asbury, he has served as professor of mathematics and was department chair for over ten years. David was named the 2004 recipient of the Francis White Ewbank Excellence in Teaching Award at Asbury and in 2018 he was designated an Asbury Faculty-Scholar. In 2018, he was honored to receive the 2018 Distinguished Teaching Award from the Kentucky Section of the Mathematical Association of America. David's research interests are varied, but all center on computational mathematics. He has presented and published in geophysical fluid dynamics, computational environmental science, computational biology and computational finance. His current research projects are in computational chemistry (synthetic fuels) and computational biology (algae processing of carbon dioxide). David and his wife, Carol, have two adult children and four grandchildren. They enjoy weightlifting, ultimate frisbee and cycling together, and Dave is a confirmed gearhead.

Abstract: Those of us working in Arts and Sciences Schools or Liberal Arts Colleges are often viewed suspiciously by our nonmathematical colleagues because of the 'mysterious' nature of our work. The explosion of mathematical volume and variety, however, has created the potential for some uneasiness even among our own mathematical community as we are forced to retreat to our research silos. Computational mathematics is a relatively young branch of mathematics that is growing quickly in breadth and importance (at least if one subscribes to the *Mathematics 2025* conclusions), yet many mathematicians only have vague notions of the area. This talk will present a very brief survey of some of the interesting applications of computational math and then focus on an application in environmental science that involved undergraduate research.



Michael Dorff, Brigham Young University

"How Mathematics Is Making Hollywood Movies Better"

Michael Dorff is the department chair and professor of mathematics at Brigham Young University. He earned his Ph.D. in 1997 from the University of Kentucky in complex analysis, has published about 35 refereed papers, and has given about 500 talks on mathematics. He is interested in undergraduate research, in non-academic careers in mathematics, and in promoting mathematics to the general public. He is the President of the MAA. Also, he is a Fellow of the American Mathematical Society, a Fulbright Scholar in Poland, received a national Haimo Teaching Award from the MAA, and co-directs the PIC Math (Preparation for Industrial Careers in the Mathematical Sciences). He is married with 5 daughters. In any free time he has, he enjoys reading, running, and traveling.

Abstract: What's your favorite movie? *Star Wars? Avatar? The Avengers? Frozen*? What do these and all the highest earning Hollywood movies since 2000 have in common? Mathematics! You probably didn't think about it while watching these movies, but math was used to help make them. In this presentation, we will discuss how math is being used to create better and more realistic movies. Along the way we will discuss some specific movies and the mathematics behind them. We will include examples from Disney's 2013 movie *Frozen* (how to use math to create realistic looking snow) to Pixar's 2004 movie *The Incredibles* (how to use math to make an animated character move faster). Come and join us and get a better appreciation of mathematics and movies.

Dominic Klyve, Central Washington University

"Mathematical Fights! The Seedy Underbelly of Mathematical History"

Dominic Klyve (KLEE-vee) is a Professor of Mathematics at Central Washington University. He is the author of more than 40 papers in number theory, the history of mathematics and science, and applied statistics. His interdisciplinary works have appeared in journals ranging from *Gastrointestinal Endoscopy* to *Shakespeare Quarterly*. Klyve has been nationally recognized for promoting the use of primary sources in the teaching of mathematics, and currently serves as a PI on $1.5 Million grant from the National Science Foundation to develop classroom materials for this purpose. He was a 2014 winner of the MAA's Alder Award, a national teaching award for young faculty who have a demonstrated impact within and beyond the classroom. He currently serves as editor of the *College Mathematics Journal*.

Abstract: Although students are often led to believe that mathematics is a purely rational, unemotional, and orderly field of study, history shows that this is often not the case. This talk will discuss some of the greatest fights in the history of mathematics. We will hear stories of friendships destroyed and national rivalries heightened because of disagreements about underlying mathematics. We will consider what these fights teach us about the nature of mathematics, and we will learn some interesting math on the way.

Abstracts of Contributed Talks

(f) = faculty, (g) = graduate, (k) = K-12 educator, (o) = other, (u) = undergraduate

Timothy Ablondi (u) and Ashley Hayes (u), Centre College
Results on Neighborhood Prime Graphs
A neighborhood-prime labeling of a graph is a variation of a prime labeling in which the neighborhood of each vertex is examined. A neighborhood is the set of all vertices adjacent to any given vertex, not including the vertex itself. A neighborhood prime graph is one whose vertices can be labeled from 1 to $|V (G)|$ in such a way that the neighborhood of any given vertex consists of only one vertex or has the greatest common divisor 1. In this talk, we will examine neighborhood prime labelings for simple classes of trees: spiders (trees with only one vertex of degree three or more) and bivalent-free trees (trees with no vertices of degree two). Additionally, we will discuss new results on trees as well as graphs with degree limits.

Abdullah Ateyeh (u), Western Kentucky University
Finding the Most Influential Factors Which Control the Healing of Chronic Wounds
Up to $18.7 billion is spent on the treatment of chronic wounds per year, which afflict over 6.5 million per year. To combat this issue, we set out to analyze and refine a mathematical model that describes the interactions within the healing of a specific chronic wound, diabetic foot ulcers, and then find the most influential factors, or parameters, in the model. Thus, once these factors are found, treatment can be optimized. Using this differential equation model and patient data from a study previously conducted, this work focuses on an approach using a global sensitivity analysis, aiming to find the most influential factors which control the dynamics of the wound. The approach is a variance-based algorithm, which was coded in MATLAB ®. Using model output vectors, relative “Sobol” or “sensitivity” indices are computed. These were then ranked and using a cutoff, a subset of factors was found to be the most influential. The subset was then tested using model parameter Markov Chains and posterior densities. This serves to demonstrate the validity of our results; however, some of the patients’ chains would not converge. Subsequently, an identifiability analysis was performed, and an explanation was found. This research shows the two most influential parameters and with the insights gathered, our results can be generalized to chronic wounds of all cases.

Ferhan Atici (f), and Ngoc Nguyen (f), Western Kentucky University
Discrete Fractional Pharmacokinetics-Pharmacodynamics Model of Tumor Growth in Mice
In this paper, the pharmacokinetics-pharmacodynamics (PK-PD) models, each consisting of a system of fractional difference equations in discrete time, are introduced to study drug effects in mono- and combination therapies on tumor growth. The nabla fractional difference operator is considered in the sense of the Riemann-Liouville definition of the fractional derivative. For the data fitting purpose, we use a newly developed method which is known as an improved version of the partial sum method for parameter estimations. Sensitivity analysis is conducted to incorporate uncertainty/noise into the model. We employ both frequentist approach and Bayesian method to construct 90 percent confidence intervals for the parameters. We also compare the fitting between continuous, discrete, and discrete fractional models.

Mustafa Atici (o), Western Kentucky University
Application of Huffman Coding in Cryptographic Hash Function SHA-1
There are many cryptographic hash functions which have been broken previously and some of them are used today in real-world applications. Early 1990's the National Institute of Standards and Technology (NIST) introduced SHA-1. This algorithm produces a 160-bit message digest when an arbitrary length of message less than 264 is given as input. According to NIST, all these hash functions including SHA-1 share common phenomena, Security Attacks. In 2017, a group of researchers broke the collision resistance of SHA-1 hash function. In this study, we have developed a new method SHA-1 PAD(x). This new method produces a message digest, say y, so that two distinct messages that generated to break SHA-1 can no longer collide. With this new method, the possible message space that may contain two distinct messages that collide using SHA-1 is bigger than the original message space of SHA-1.

Michael Belcher (u), Western Kentucky University
Mathematical Modeling of Diabetic Foot Ulcers Using Optimal Design
A mathematical model for the healing response of diabetic foot ulcers was developed using averaged data (Krishna et al., 2015). The model contains four major factors in the healing of wounds using four separate differential equations with 12 parameters. The four differential equations describe the interactions between matrix metalloproteinases (MMP-1), tissue inhibitors of matrix metalloproteinases (TIMP-1), the extracellular matrix (ECM) of the skin, and the fibroblasts, which produce these proteins. Recently, our research group obtained the individual patient data that comprised the average data. The research group has since taken several approaches to analyze the model with the individual patient data. One approach was to introduce mixed modeling techniques on certain parameters in that model, which used MATLAB's nlmefitsa routine to analyze the equations in the model. Another approach has been to use an optimal design technique to identify which times are ideal for data gathering for the model. For this project an SE-optimal design method was chosen with the goal of minimizing the sum of squared normalized standard errors. This was done by maximizing the difference of sensitivity functions found between time stamps. Our project seeks to combine these previous works to see how the interaction between mixed-modeling of specific parameters affects, adversely or beneficially, the results of the optimal design work.

Axel Brandt (f), Northern Kentucky University
Maths for Funsies (and Learning)
Fifth grade. Seventh grade. High school precalc. College algebra. Instructors at all levels can "ruin" students' relationship with maths. However, instructors can also inspire interest and encourage enthusiasm while strengthening and/or rekindling that relationship. In this interactive exposition, we will discuss various maths-based activities that have engaged and excited K-16 learners.

Axel Brandt (f), Northern Kentucky University
Polynomials for Peace: Avoiding Scheduling Conflicts
We discuss two questions related to scheduling committee meetings for the U.S. House of Representatives so that no representative is conflicted by trying to be in two meetings at the same time. These questions will be approached by constructing a polynomial for which every for which every committee schedule resulting in a conflict corresponds to a zero of the polynomial. After providing some intuition, we will discuss the Combinatorial Nullstellensatz and how it can be used to guarantee the existence of a committee schedule without conflicts.

Hannah Brewer (u), Morehead State University
Farewell: Switching from Math to Non-STEM Majors
Although STEM graduates are essential for a large number of professions and for strong national and local economies, researchers warn that more than half of college freshmen who declare STEM majors switch out of them, especially in quantitative disciplines, such as mathematics, physics, chemistry, and engineering (Q-STEM). The process of selecting and changing any college major is a deeply personal process that is influenced by family, friends, mentors, and discipline related experiences. The following exploratory study used a case study approach and semi-structured interviews to identify “push” and “pull” factors that influenced the participants’ decision to select a Q-STEM major and, later on, switch out of STEM altogether. Preliminary results and implications will be discussed.

Will Britt (u) and Jeffrey Heath (f), Centre College
Effective Teamwork: The Analytics of Basketball Lineups
Basketball coaches are tasked with making the lineup substitutions that give their team the best likelihood of winning games. We discuss the analytics of 5-player lineups in basketball and present findings from recent NCAA data.

Brooke Buckley (f), Northern Kentucky University
Incentivizing Behaviors That Promote Student Success
Improving student success rates in mathematics & statistics courses has increasingly become a point of discussion at institutions. In fall 2018, I implemented a pilot in hopes of improving performance that minimally incentivized behaviors often associated with student success. The course used was a mass lecture section of introductory statistics. While the results are limited to a single semester, they are quite promising. The course GPA increased, and the percentage of students earning a D, F, or W decreased. In this session, I will outline the pilot program, discuss course outcomes, and solicit ideas for improvement.

Chase Cavanaugh (u) and Jeffrey Heath (f), Centre College
Basketball Shooting Efficiency and the Shot Clock
Basketball teams take a different distribution of shots depending on their personnel, opponent, style of play, and even the score and time remaining of the game. In general teams should be attempting the shots that have a high expected points per possession. However, the time remaining on the shot clock plays a key role in this shot selection. We investigate how shooting efficiency in basketball relates to the shot clock, specifically in NCAA basketball.

Doug Chatham (f), Morehead State University
Applying the Hastings-Metropolis Algorithm to Chessboard Placement Problems
In an article entitled 'It's Puzzling' in the September 2018 issue of The College Mathematics Journal, C.D. Howard describes using the 'Hastings-Metropolis algorithm' to quickly generate 4-by-4 crossword puzzles. Inspired by that article, we produced a program to place pawns and queens on an n-by-n board so that no two queens attack each other. In this talk we describe and demonstrate our program and compare our results to those found by other methods.

Craig Collins (f) and Elizabeth Donovan (f), Murray State University
Math Teachers' Circle: Rediscovering the Fun of the Problem
A Math Teachers' Circle (MTC) brings middle school teachers and university faculty together to work on low-floor, high-ceiling problems. The goal is to reinvigorate teachers by involving them with content-rich problem solving activities and also to build a comprehensive K-20 community of mathematicians. We will discuss the creation and launch of the West Kentucky MTC (based at Murray State University), then give a brief interactive example of a typical MTC problem.

Julian DeVille (g), Eastern Kentucky University
2D Image Comparison with Krawtchouk Descriptors
It is known that image comparison can prove cumbersome in both computational complexity and runtime, due to factors such as the rotation, scaling, and translation of the object in question. Due to the locality of Krawtchouk polynomials, relatively few descriptors are necessary to describe a given image, and this can be achieved with minimal memory usage. Using efficient computation of Krawtchouk moments to produce local descriptors, we are developing software which can query an image and compare similar patterns locally across a potentially large database. These local descriptors are rotation, scale, and translation invariant to ensure accuracy of results, and following a query, significant results are ranked by likelihood of match.

Rob Donnelly (f), Murray State University
Which Unit Shapes Have Area Less Than Pi?
At the KYMAA Berea College meeting in 2017, Alex Thome, a Murray State undergraduate, and I introduced the concept of a unit shape to analogize, for any family of similar shapes, the role that the unit circle plays within the family of all circles. The simplest criterion for a shape to be unital is that its area must equal its semiperimeter. Within this context we posed and answered many natural calculus questions, such as: Which unit triangle has the smallest area amongst all unit triangles? (It's the unit equilateral triangle.) We posed, but could not answer at the time, the titular question for this talk. In this talk, we answer this question.

Elizabeth Donovan (f), Murray State University, and Lesley Wiglesworth (f), Centre College
Engaging Undergraduates in Cross-Institutional Research Collaboration
The positive effects of undergraduate research on students are well documented. Students who participate in undergraduate research experiences report increased communication skills, growth of self-confidence, improved focus on a career path, as well as positive improvements in student learning and attitude. In this talk, we will discuss a year-long research collaboration between undergraduate students at Centre College and Murray State University. Successes and challenges throughout the process, as well as our own reflections, will be presented.

Jacob Englert (u), Alli Zembrodt (u), and Parker Kain (u), Northern Kentucky University
Mapping the Opioid Epidemic Using Linear Regression
A national crisis involving the abuse of synthetic and non-synthetic opioids has plagued the United States in recent history. The CDC, FBI, and DEA are a few federal organizations that have been combating this crisis. In fighting the opioid crisis, it is useful to be able to describe how the epidemic is spreading geographically and socioeconomically. This research describes the complexities of modeling opioid spread and proposes a statistical model to help understand and visualize the spread of opioids since 2010 in the following states: Ohio, Kentucky, Pennsylvania, Virginia, and West Virginia.

Kelsey Etherton (u), Thomas More University
Lie Algebras in Quantum Mechanics
Quantum Mechanics is a high-level physics course that involves very in depth math. Physicists utilize lie algebra to grasp a deeper understanding of the particle world, in particular, protons and neutrons. With basic concepts learned in linear algebra, the tau matrices are developed from annihilation and creation operators. The linear combinations of these bilinear products are used to construct lie algebras which can change the state of a particular particle. Physicists operate with this type of math when trying to understand strong interactions and electromagnetic interactions between particles.

Emily Frame (u), Kendra Herweck (u), and Tyler Labree (u), Northern Kentucky University
Modeling the Interactions Between Dragons and Their Environment Using Numerical Methods
We recently took part in the Mathematical Contest in Modeling and chose to model and analyze the characteristics of three dragons from the hit television and book series Game of Thrones. We used multiple types of models from a variety of disciplines, including a logistic growth model, sigmoid functions, mean free path, and Kleiber's Law, to determine the physical needs of the dragons. In our approach, we used facts and assumptions drawn from Game of Thrones and applied real life data to predict how the dragons will fare over their lifetime.

Justin Garagnani (u) and Michael Kelly (f), Transylvania University
Optimal Advertising Strategies for Use in Popular Media
In today's world, information is disseminated quicker and to a wider audience than ever before. We investigate the role information hubs, such as social media and internet news sites, play on the spread of such media. We formulate a mathematical model, structured after a Susceptible-Infected-Recovered (SIR) epidemic disease model. After parameterizing our model, we use optimal control methods to determine best advertising strategies that maximize exposure while minimizing the associated costs. We parameterize our model using data from popular media and our solutions are approximated using numerical simulations.

Nicholas Gaubatz (u), Murray State University
A Parametrized Solution of Length-four Wavelets
We will explore the refinement equation for the length-four scaling functions with finite support and their respective wavelets, and include graphical illustrations. Next, by assuming orthogonality, we will generate a necessary nonlinear system of equations and give a parametrized solution. Finally, we will animate a continuum of solutions and their respective wavelets.

Rebekah Habeger (u), Asbury University
Where to Raise Your Dragon
Imagine a world in which dragons really do exist. Now imagine that earth is that world. Would the dragon survive? What kind of food would it eat and how much would it need? Where would it live? How much space would it need to hunt and roam? If you have ever asked yourself these kinds of questions, look no further! Described below is a model for dragon growth, required area, caloric necessity, and ecological impact. While the model is simplistic, the effectiveness lies in the simplicity. Much of the simplicity comes from these dragons being treated as though they were animals, not magical creatures. Essentially, magic was excluded so that the model had as much realism as can be expected with dragons. To create such a model, data from the saltwater crocodile (largest reptile), the Steller's sea eagle (largest eagle), and the Spinosaurus (largest carnivore) were combined and adapted. Using this information as a guideline, all the above factors were modeled and analyzed. Based on this model, the dragons would be larger and more powerful than any other creature in history, but not implausible. Although the dragons would consume large amounts of food, it would not be considered unsustainable for hundreds of years even assuming the prey do not reproduce. Each dragon would only require roughly one percent of the entire continent of Africa, a minuscule domain in comparison to the world at large. On the whole, should dragons exist today, they would not only be possible but easily sustainable.

Virginia Hallman (u), Eleni Buss (u), and Jahred Hull (u), Asbury University
Time to Leave the Louvre
As public safety has become a greater priority in light of recent events, the French Government is considering updated evacuation plans for several major locations. The Louvre, as the largest museum in the world, is a high-risk location due to both its high attendance and historical significance. In any event, a primary concern of safety precautions is developing the most effective method for the evacuation of the museum. To this end, we divided the Louvre into sections of equal size ("nodes") which create a network of the building. By subdividing the Louvre as such, we tested exit routes while taking potential bottlenecks into account. Implementation of Dijkstra's algorithm determines the shortest path from occupant nodes to exit nodes. Distances between nodes were established based on bottle-necking equations using data such as walking speeds, distances between rooms, and the capacities of various areas. Our model can not only calculate objective evacuation times given a static occupancy condition; it can also adapt to a dynamically changing scenario with the potential to optimize evacuation. Examples of calculations under certain events have been placed in the paper as a demonstration of what the model, accompanied by the algorithm, can do to minimize evacuation times. In catastrophic situations, seconds can determine one outcome from another. Our model is focused on evacuating the occupants to safety as quickly as possible and in having emergency personnel enter to take care of the situation. Time is the biggest factor in saving as many lives as possible.

Nadine Innes (u), Murray State University
Time Series Analysis: Forecasting Treasury Bill Interest Rates
A Treasury Bill is a short-term investment typically with a maturity date of 12 months or less that is backed by the Treasury Department of the United States government. Rates of return for Treasury Bills are constantly changing over time due to the constant change of demand from borrowers and supply from lenders. This study seeks to forecast treasury bill rates that mature in 3 months. Since actuaries employ their knowledge of mathematics and statistical methods to analyze the likelihood of future events and their possible financial repercussions, having a projection of future treasury bill rates can provide guidance to investors in managing their own potential risk. Taking a closer look at the weekly rates of return from August 2013 to August 2018, this study will use standard time series methods such as Autoregressive Integrated Moving Average (ARIMA). The data will be fitted with an appropriate ARIMA model and the fitted model will be used to forecast future observations.

Cheryll Crowe Johnson (f), Asbury University, and Bethany Noblitt (f), Northern Kentucky University
Sharing the Conversation: Kentucky Association of Mathematics Teacher Educators
The Kentucky Association of Mathematics Teacher Educators (KAMTE) is a relatively new professional organization in the state of Kentucky that seeks to promote excellence in the preparation and continuing development of teachers of mathematics. This session will provide participants with an overview of this organization as well as an introduction to the Standards for Preparing Teachers of Mathematics, a recently released the document by the Association of Mathematics Teacher Educators (AMTE).

Joel Kilty (f) and Alex McAllister (f), Centre College
Enabling Student Persistence and Success in the Calculus Sequence
While traditional methods of teaching and learning mathematics ostensibly served well for decades, the mathematics community is re-examining and re-envisioning these approaches in response to multiple changing realities, which include: evidence that the standard approach “filters” traditionally under-represented students, extremely different levels of student preparedness, the diverse career and continuing education paths of students, more sophisticated technologies, and access to large data sets that enable more realistic and more relevant applications. This talk shares the outcomes of a 2018 project at Centre College and Southwestern University that sought to understand and address filters that inhibit student persistence and success in mathematics and other STEM disciplines, particularly among under-represented minority, first-generation, low-income, and female students. We provide details about two particular efforts that sought to make a positive difference in improving persistence and success:
1) designing, implementing, and assessing a pilot cohort model for Calculus I students in Fall 2018, and
2) re-envisioning the entire calculus sequence during 2018 with planned implementation beginning in Fall 2019.

Dominic Klyve (f), Central Washington University
Derivatives and p Values from Primary Sources
In this talk, we will present two Primary Source Projects developed to teach undergraduate mathematics through the NSF-funded "TRansforming Instruction in Undergraduate Mathematics via Primary Historical Sources" grant. The speaker will discuss projects he has written to teach p-values in an Introductory Statistics class, and derivatives of trig functions in Calculus 1.

Matt Ko (u), Centre College, Jason Pinto (u), Centre College, and Aaron Davis (u), Murray State University
Subtractive Vertex and Edge Magic Labelings
Magic labelings, originating from magic squares in 13th century China, are a labeling of the vertices and edges of a graph such that each vertex is tied to the same magic constant. These labelings can be extended to include directed graphs as well. In this talk we will discuss subtractive magic total labelings on various families of directed graphs, including dipaths, dicycles, trees, and a newly defined lemniscate graph, considering both edge and vertex magic labelings.

Michael Lamar (f), Centre College
A Statistical Learning Model for Rating-Scale Data
A challenging problem in statistics is predicting how customers will rate items they may potentially consume in the future based on the rating history of a large collection of customers. We explore a new statistical model to learn an embedding for all customers and all the items to be rated and show how this embedding can be used to predict future ratings. We show that working on a high dimensional torus can lead to much faster convergence than working on a similarly high-dimensional sphere even though the sphere is a common choice in other, similar embedding approaches. We discuss the application of this model to the famous Netflix Prize data set from the last decade and show that it can be used to good effect even when each customer rates only a tiny fraction of all the possible items.

Robert Lamphere (f), Elizabethtown Community and Technical College
Revisiting Gauss' Problem
Gauss' problem is to compute an orbit of a planet given two of its positions at two different times. A proposition in Newton's Principia shows this problem is made up of two problems: an astrodynamics one and a geometric one. Lambert solved the astrodynamics problem and Newton solved the geometric one. We shall use their solutions to give a simple solution to Gauss' problem. We shall also explain why mathematical symbolic software makes this problem suitable for first- and second-year math majors.

Trevor Leach (g), University of Louisville
Aggregating Preference on Permutation Closed j-rich Domains
Fishburn (1979) proved that majority rule on any permutation closed j-rich domain is the only social choice function satisfying faithfulness, consistency, cancellation, and neutrality. In this talk we will characterize the set of all permutation closed j-rich domains for which the result still holds if the condition of neutrality is dropped.

Carl Lee (f), University of Kentucky, and Ian McCauley (o), Dunbar High School
A Virtual Math Museum
For his final project in the MSTC program at Dunbar High School, Ian McCauley collaborated with Carl Lee to create a virtual mathematics museum. Using the HTC Vive virtual reality system, and powered by the Unity program, one can enter a virtual room with an assortment of mathematical displays to interact with: a collection of Platonic and Archimedean solids, a Soma Cube puzzle, quadric surfaces, a slicer to exam cross sections, and projections of the six 4-dimensional regular polyhedra.
Note: This is an exhibit that will be open for participants to drop by during Friday afternoon to try out the equipment.

Duk Lee (f), Asbury University
Fly! Fly! My Paper Airplane!
Most of us have a childhood memory of folding paper airplanes and throwing them for fun. Interestingly, paper airplane challenges are on-going events for many people of all ages all over the world. Joe Ayoob (a former quarterback of an Arena football team) has thrown a paper airplane designed by John Collins and broke the Guinness World Record for distance in 2012. His distance was 226 feet, 10 inches, shattering the previous record of 207 feet, 4 inches. Obviously, throwing a paper plane far is a combined matter of good design and a thrower's balance, arm angle, and power at the moment of releasing it. While every aspect is interesting to discuss, in this brief talk session, we will examine crease pattern and other mathematical features of the Collins' airplane design and of other paper plane designs.

Enyu Li (u) and Christopher Turner (u), Asbury University
Evacuate the Louvre
Because of the rise in emergent situations in France, the officials of the Louvre need to make different plans to adjust to different emergencies. In order to do that, they need a model that can describe the flow of people once a problem arises.
We created a system of nodes that represent key places that population may concentrate in and a system of arcs that represent path ways between nodes. Our model does not explain the entire system but aims to illustrate the change in number of people of a single node.
In our result, we assume that people are evenly spread out initially, and people walk toward the direction that has the shortest distance to the exits. However, to account for these assumptions, the leaders of Louvre just need to make changes in initial conditions depending on the situation.
With our assumptions, the evacuation times for top floor to bottom floor are about 6 minutes, 11 minutes, 15 minutes, 5 and a half minutes, and 5 minutes, which makes the total evacuation time around 15 minutes. Based on our simulation, there are several severe bottlenecks at floor 0 and floor 1, which is fairly reasonable. The most chaotic one is undoubtedly the entrance represented by node 1 which connects to 4 other nodes.
We believe, in order to resolve this situation or at least make it not as bad, officials should send agents to floor 1 and redirect more people to node 11 which connects to exit node 11 in floor 1. That way, it relieves the pressure at node 1 in floor 1. By doing so, it could significantly decrease the evacuation time, we believe, by units of minutes.

Andrew Long (f) and Jacob Englert (u), Northern Kentucky University
Climate Change in Togo, West Africa: 3 Degrees C Hotter (or so) by the End of the Century
Models of temperatures for West Africa have the country heating up by the end of the century. A math modeling class at Northern Kentucky University (Spring, 2018) examined meteorological data for Togo for sixty years, and created a model for temperatures in Togo which suggests an increase on the order of 3 degrees C. We were also interested in identifying periodic trends in the temperature record, and so we subsequently used Singular Spectrum Analysis to identify important periodic features in the temperature records. Both the technique of SSA and the results will be discussed.

Jessica Lugo (g), Murray State University
Optimal Control of a Tumor Model with Delay
Mathematical models simulating the interactions between tumor cells, immune system cells, and chemotherapy drugs provide valuable information to medical researchers. The application of optimal control theory to these models offers insight into the development of effective treatment regimens by indicating the best dosage levels and delivery schedules. In this talk, I will discuss the application of optimal control to a cell-specific cancer model, first presented by Liu, et al, that incorporates a delay differential equation. The analytic representation of the optimal control is derived from Collins, et al, and used in numerical simulations to provide valuable information for determining treatment schedules.

Yangsai Lyu (u) and Jordan Turley (u), Centre College
Results on Coprime Labelings of Various Graphs
A coprime labeling of a graph with n vertices is a labeling of the vertices with distinct integers from the set {1, 2, …, k} where k >= n, and the labels of any two adjacent vertices are relatively prime. Any graph has a coprime labeling where the labels are all primes, but the goal is to minimize the labels of the vertices. In this talk, we discuss coprime labelings where the vertex labels follow some consecutive nature. We discuss coprime labelings of bipartite graphs, unions of cycles, and other graphs.

Andy Martin (f), Kentucky State University
Brun's, Last Talk
The series of reciprocal twin primes converges, let us say to B. This was proven in 1919 by Norwegian Viggo Brun. The truly amazing points are that Brun gave no estimate for B, nor is it known to this day if there are infinitely many twin primes! It is known, of course, that if B were proved irrational it would follow that there are infinitely many twin primes. But if B were proved rational it would have no bearing on whether there were infinitely many twin primes. I first learned of Brun's constant B by accident, casually thumbing through a new book at Joseph-Beth's Booksellers in 1994. My first conference talk on B was in February 1999. This talk explains how my fascination with B lead over the past 20 years to interactions with Thomas Nicely, Pascal Sebah, Carl Pomerantz, Yitang Zhang, and our featured speaker, Dominic Klyve. As for the title of the talk, this will be my last talk on the topic.

Andy Martin (f), Kentucky State University
Counting the Members of NxN
In showing that the ordered pairs of natural numbers form a countable set, the most common argument, even in set theory texts, is a diagram with arrows snaking back and forth along the diagonal lines of number pairs between the positive x- and y-axes. This is strange, as the same texts routinely explicitly construct bijections between sets in demonstrating they are equinumerous. Why not do the same with NxN? In this talk the speaker will define such a bijection, and also recount his own history with this problem.

Katelyn May (u), Murray State University
Colorings and Sudoku Puzzles
Motivated by our study of ring theory in a standard undergraduate modern algebra course, we expand upon the division algorithm to study Gröbner bases in multivariate polynomial rings. We utilize Gröbner bases of an ideal of a multivariate polynomial ring over a finite field to solve coloring problems. In particular, we use these techniques to investigate Sudoku type puzzles.

Rus May (f), Morehead State University
Risk Analysis
Risk is a board game (note to millennials: a board game is like a video game, but played on a physical board) in which players try to achieve world domination by conquering all opponents' territories. A player conquers a country by rolling dice to simulate losses of armies until the opponent's forces are depleted. We apply asymptotic analysis of multivariate generating functions to approximate chances of victory in a battle between two players with different sized armies.

Trivan Menezes (u), Western Kentucky University (Gatton Academy)
Detecting Flypes Using Planar Diagram Codes
The planar diagram code (PD code) of a knot diagram is an encoding of the diagram easily manipulated by a computer. A flype is a 180-degree rotation of a part of a knot diagram called a tangle. Given a minimal diagram of an alternating knot, all other minimal diagrams of the knot can be reached through a finite sequence of flypes. This talk will discuss a method to detect which tangles are flype-able in a given knot diagram by relating its PD code to a tree structure. Performing all possible flypes will yield a list of all minimal diagrams of the given alternating knot. This can be used to calculate knot invariants' functions which can distinguish different knots.

Jacob Menix (g), Western Kentucky University
The Lattice of Functionally Alexandroff Topologies
If $f:X \rightarrow X$ is a function, the associated functionally Alexandroff topology on X is $P_f = \{A \subseteq X : f(A) \subseteq A\}$. We present a characterization of functionally Alexandroff topologies on a finite set X and show that the collection $FA(X)$ of all functionally Alexandroff topologies on a finite set X, ordered by inclusion, is a complemented lattice.

Emma Moore (u), Western Kentucky University
Preliminary Numerical Results for the Vibration Control of a Piezoelectric Beam
A piezoelectric beam is a smart material (most notably Lead Zirconate Titanate) to develop electric displacement that is directly proportional to an applied mechanical stress, and vice versa. Piezoelectric materials have the ability to dampen vibrations particularly in the lower frequency range, either actively or passively. This project aims to develop a reliable computational tool to simulate the control of vibrations on a single piezoelectric beam, described by a novel "partial differential equation" model. Our primary goal is to develop reproducible computational tools by an emerging stable approximation technique, the so-called filtered semi-discrete or fully-discrete Finite Difference Method, which are proved to provide faster and reliable computation. Filtering in the approximation is necessary since the spurious vibrations, due to the blind application of these methods, provide false stability results. The computational tool developed in this project is essential to provide new insights into the active controlling of piezoelectric devices involving piezoelectric components such as cardiac pacemakers or NASA/commercially-operated inflatable space antennas.

Bethany Noblitt (f), Northern Kentucky University
The Nine-Point Circle in Taxicab Geoemtry
A nine-point circle is a circle that contains nine unique points constructed from a given triangle: the three midpoints of the sides of the triangle, the feet of the altitude of a triangle, and the Euler points of the triangle. Taxicab geometry is a non-Euclidean geometry in which the metric of Euclidean geometry is replaced by a new metric in which the distance between two points is the sum of the absolute differences of their respective Cartesian coordinates. How does this new metric affect the nine-point circle? Does the nine-point circle even exist in taxicab geometry? In this session, we will explore these questions.

Ahmet Ozkan Ozer (f), Western Kentucky University
Preliminary Uniform Boundary Observability Results of Semi-discrete Finite Difference Approximations for a Rayleigh Beam Equation with Only One Boundary Observation
First, we study a space-discretized Finite Difference approximation for the well-known Rayleigh beam equation w_{tt} âˆ’ Î±w_{xxtt} + Kw_{xxxx} = 0 with simply-supported boundary conditions. This equation describes transverse vibrations for moderately thick beams. Even though this equation is known exactly observable with a single observation in the higher-order energy space, its Finite Difference approximation is not able to retain exact observability with respect to the mesh parameter. This is mainly due to the loss of the uniform gap among the eigenvalues of the approximated finite dimensional model. To obtain a uniform gap, and therefore, an exact observability result, we consider filtering the spurious high frequency eigenvalues of the approximated model. In fact, as the mesh parameter goes to zero, the approximated solution space covers the whole infinite-dimensional solution space. Both the discrete multipliers and the non-harmonic Fourier series are used for the proofs.

James Pack (u), Centre College, and Abby Bigham (u), Murray State University
Prime Labelings of Snake Graphs
A prime labeling of a graph G is a labeling of the vertices with distinct integers from the set {1,2,...,|V(G)|} such that the labels of any two adjacent vertices are relatively prime. In this section, we will introduce Snake graphs, the fused union of identical cycles, and their possible prime labelings. Limitations and directions for future research will also be explored.

Bob Powers (f), University of Louisville
Strategy-Proof Voting Rules
The manipulation of a voting rule occurs when one voter can achieve a preferred election outcome by casting a ballot that misrepresents his or her actual preferences. A voting rule that cannot be manipulated is said to be strategy-proof. One of the most famous results in mathematical social choice is the Gibbard-Satterthwaite Theorem. It says, based on some standard assumptions, that a strategy-proof voting rule is dictatorial. In my talk, I will carefully define manipulation, give a precise statement of the Gibbard-Satterthwaite Theorem, and give some details on how to prove this amazing theorem.

DJ Price (u), Western Kentucky University
A Complete List of Minimal Diagrams of an Alternating Knot
A knot is an embedding of a circle in 3-space. A knot can be represented by tangling some string and then fusing the ends of the string together. Given some knot in 3-space, a diagram D of that knot is obtained by shining a light on the knot and observing the shadow of that knot on the plane. Places where this shadow intersects itself are called crossings. The lines that form these crossings are called strands; we do not allow for three or more strands to compose a crossing, only two. We call two knot diagrams equivalent if we can stretch and compress the strands in the first diagram in such a way that we are able to recreate the second diagram. However, we do not tear or cut any strands in this process. When viewing a diagram, the strand that is on top in a crossing is called the overstrand. The other strand is the understrand. A knot diagram is called alternating if when traversed, the strands constantly alternate between over and under. A tangle T in a knot diagram D is a region R bounded by a simple closed curve that intersects D at exactly four points that are not crossings themselves. A flype is a move whereby T is flipped 180 degrees such that if there were a crossing on one side of T, it is moved to the other side of T. A reduced diagram of a knot is a diagram that has the least number of crossings possible. All alternating diagrams are inherently reduced. By the Tait-Flyping Conjecture, two reduced diagrams of an alternating knot can be transformed to each other through a finite series of flypes. Consequently, given a reduced diagram of a knot, it is possible to generate all other reduced diagrams of that through performing all possible flypes on it and continuing this process recursively until all diagrams have been found. The programming languages used include PHP, C, and Mathematica. The software used includes Ubuntu 18, Ubuntu 14, and Docker.

Tom Richmond (f), Western Kentucky University
Kemeny Rankings
A city wants to create a prioritized list of four spending options. They decide to ask the voters to rank the spending options from 1 to 4. Once the ballots are collected, how should they be counted to find the single ranking (among the 4! options) which best represents societal preference? One method is the Kemeny ranking. This method may produce tied rankings, or may produce a preferred societal ranking which no one voted for. In investigating how this may happen, we encounter some interesting graphs, including a truncated octahedron.

Robert Riehemann (f), Thomas More University
Neighborhood Paths
Finding a path of minimal length on the sphere that comes within ϵ of its points, the “planet road problem”, was originally posed by Croft, Falconer and Guy in 1991 in Unsolved Problems in Geometry. It was based on convexity problems investigated by Melzak in 1965. We reduce the problem to a kind of density question for a finite set of points and then use standard minimization techniques with rather complicated constraints to move these points to optimal positions. The conjecture in Croft, et al., that the apple peeling spiral is the minimal path, is mistaken.

David Roach (f), Murray State University
Visitors from the 4th-dimension: Visualizing the Length-four Parametrized Wavelets as Points in 4-space
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 solution is the intersection. In this talk, we will examine some models that describe the shape of these objects and animate their cross-sections as they pass through our dimension.

Mark Robinson (f), Western Kentucky University
Explorations with Systems of Differential Equations
Systems of differential equations may be linear or nonlinear and their solutions can exhibit many interesting properties. In this presentation, several autonomous systems are examined. Visualization of solutions using direction fields and phase portraits, the nature of the solutions, and identification and classification of critical (or equilibrium) points are considered.

Timothy Schroeder (f), Murray State University
Mock Reflection Surfaces
A right-angled mock reflection group (RAMRG) is a generalization of a Coxeter group in the way it acts on topological spaces. We look at examples of such groups, their Cayley graphs, and how maps to finite groups can produce closed orientable and non-orientable manifolds of certain genus.

Richard Schugart (f), Western Kentucky University, Michael Dorff (f), Brigham Young University, Beth Donovan (f), Murray State University, Lesley Wiglesworth (f), Centre College, Emily Hoard (u), Murray State University, and James Pack (u), Centre College
Highlighting Undergraduate Research in Mathematics and the Center for Undergraduate Research in Mathematics: A Panel Discussion
We offer a unique panel discussion highlighting undergraduate research in mathematics and the Center for Undergraduate Research in Mathematics (CURM). Panelists are Michael Dorff (CURM Director Emeritus), Beth Donovan and Lesley Wiglesworth (current CURM Faculty), and Emily Hoard and James Pack (current CURM undergraduate students). Faculty and student panelists will talk about their current experiences in undergraduate research, while faculty panelists can answer questions about ways to engage undergraduate students in research. Panelists can answer a variety of questions from finding opportunities to fund undergraduate research to whether engagement in undergraduate research has an impact on future endeavors, like choosing to go to graduate school.

Matthew Shaw (u), Thomas More University
Epsilon Roads
The original problem found in Unsolved Problems in Geometry (Croft, Et Al.) was to find the shortest continuous curve on the unit sphere that traveled within distance Îµ of every point on the sphere's surface. The book also suggests that the so-called "apple-peeling" spiral is the solution to this problem in general. I have computed relationships between the length of the curve and the value of Îµ for this curve and have found an example of a curve that is shorter than the spiral for at least certain values of Îµ. I also offer a more intuitive geometric way to view the problem.

Karolyn Stewart (k), Cincinnati Children's Hospital Medical Center
Chronic Health Conditions: Implications for Math Education
Students with chronic health conditions are statistically more likely to struggle with academic coursework than their healthy peers. How can we, as math educators, help students with chronic health conditions reach their full potential in our classrooms?

Wesley Stratton (u), Murray State University
Predicting Interest Rates Using Integrated Autoregressive Moving Average Time Series Model
Every day, investors attempt to generate the highest return in their investment portfolios. One way that can be used to help generate this return is being able to predict interest rates. In this study, we attempt to build a model that is fit for predicting changes in biweekly rates of 52-week United States treasury bills. Treasury bills are a type of non-coupon paying bonds that are considered a rather safe, or low risk, investment as they are backed by the United States government. Because interest rate data is not stationary by nature, we use time series analysis to construct an Autoregressive Integrated Moving Average, ARIMA, model. The fitted model is then used to predict short term changes in the interest rate of the treasury bills. The predicted values from the model are fairly close with the actual observed interest rate.

Ryan Stuffelbeam (f), Transylvania University
Farey Sequences and Diophantine Approximation
The concept of a Farey sequence will be introduced and this definition will allow us to discuss an intriguing result concerning this sequences. Then, these sequences will be used to motivate introductory results in the field of Diophantine approximation.

Jianning Su (f), Georgetown College
On Set Representable Orthocomplemented Difference Lattices
We focus on the class of all orthocomplemented difference lattices (ODLs) that are set-representable and prove that this class is not locally finite by constructing an infinite three-generated set-representable ODL. This result answers a question posed by Matousek and Ptak. We also prove, by example, that not every concrete OML can be OML-embedded into an ODL.

Kelsey Sutton (u), Centre College, and Emily Hoard (u), Murray State University
Results on Cyclic Prime Labelings
A prime labeling of a graph with n vertices is a graph labeling in which the labels come from the set $\{1, 2,\ldots, n\}$ and the labels on each pair of adjacent vertices are relatively prime. Many classes of graphs are known to have prime labelings, including cycle graphs. We will discuss prime labelings on the unions of cycles by introducing a consecutive cyclic labeling of these graphs. In particular, we identify the maximum number of n-cycles we may include in a disjoint union and obtain a prime graph using our consecutive cyclic labeling. We primarily consider graphs of the form mC_n and $mC_n \cup C_\ell$ where C_n and C_ℓ are cycles of different sizes and m represents the multiplicity of the n-cycle in our graph.

Justin Taylor (f), Murray State University
Eigenvalues of Differential Operators
We study the idea of an eigenvalue of an elliptic 2nd order differential operator on different classes of domains. We will examine Dirichlet and Mixed-type eigenvalues.

David Thompson (u), Thomas More University
Classification of Finite-Dimensional Group Actions on the Real Numbers
A group action is a representation of a group as a set of symmetries of a geometric object, such as the representation of D_4 as the symmetries of a square. As demonstrated by Sophus Lie, an algebraic set may serve as the geometric object a group action's elements work on. Lie also showed that elements of group actions on a set G can be represented as functions of functions taking the form $f(x) \frac{d}{dx}$, where $f(x) \frac{d}{dx} g(x) = f(x) \cdot g'(x)$ for all $g(x)$ over G and some $f(x)$ over G. In this paper, we investigate the classification of group actions over $\mathbb{R}$ by dimension, while also demonstrating that one such group action has a direct relationship with the set of all linear fractional transformations on $\mathbb{R}$.

Sarah Townsend (u), Dakota Owens (u), and Caleb Engler (u), Asbury University
Modeling the Spread of Opiates Through KY and 4 Other States
In this report, we analyze data that was provided to model the spread and growth of the opioid epidemic throughout Ohio, Kentucky, West Virginia, Virginia, and Pennsylvania. By analyzing which counties had high opiate reports in 2017 and 2010 we pinpoint what we believe to be the origin county for the epidemic in each state. Our predictions were further supported by the amount of drug reports found in surrounding counties. We identified Hamilton County OH, Fayette County KY, Philadelphia County PA, Kanawha County VA, and Prince William County WV as the starting points and main contributors to the growth of opioid use. In addition to pinpointing the origin in each state, we developed a way to model the spread between counties and between states. We found that major interstates played a critical role in this growth between states. By using a regression model we were also able to identify which factors had the largest effect on opiate reports. These were number of households in the county, percentage of single father household, percentage of people with disabilities, percentage of population that were veterans, and the percentage of households that were family households rather than individuals. With all of this information, we put together a plan that we believe will help those who already suffer from some form of opioid addiction and stop the growth of the opioid epidemic at its source.

Bekkah Trachtenburg (u), Bellarmine University
Toxin Effects on a Competitive Species
A competitive species model can show how two species that use the same resources interact with each other given the carrying capacity of their environment. When put into the same area one species will eventually go away while the other thrives, meaning there is not a stable coexistence solution for the two species. Using a system of differential equations, we build on this competitive species model to see if we could find a coexistence solution if we add an environmental toxin that affects only one of the species. We want the direct effect of the toxin to be focused in their rate of death. Once we set up our model for competitive species affected by a toxin, we then find the equilibria and their stability. We show that a stable coexistence solution is possible and we find an example of this.

Jerod Weber (u) and Amelia Floehr (u), Northern Kentucky University
Examining the Impact of Dragons in the Real World
As part of the annual Mathematical Contest in Modeling, we explored the possible effects of dragons, from Game of Thrones, living in the real world. We considered how many calories they would need to intake, and thus how much food would be necessary to sustain these creatures over time, while growing at a fast rate. We examined five biological growth models to determine which model best represented the growth of the dragons. To determine caloric intake, we compared dragons to the flying dinosaur called the Pterosaur, and also had to take into account the exhausting action of flight. Come find out if dragons could exist in our world.

Holden Wight (u), Northern Kentucky University
Understanding XAX-1
We will consider a matrix description of rotor-based cipher machines and a process from linear algebra that might aid in their solution. The possible solution method is based is based on primary sources from the mid-twentieth century when rotor machines were still widely in use.

Steven Wilkinson (f) and Lisa Holden (f), Northern Kentucky University
Computing Certification Exams for Students
As computing becomes more important for those in the mathematical sciences, it has taken a larger role in our curriculum. Some of the languages we educators teach our students have certification exams. If students take such an exam, they can use the results to not only assess how well they know the language compared to others across the world, but if they pass the exam they can provide that certification as formal proof of their competency to future employers. Three languages that have such exams are Mathematica, MATLAB, and SAS. To determine if Wolfram's Mathematica Student Certification Exam is a worthwhile gauge of competency in Mathematica, we had two students with previous experience in the language take the certification exam during summer 2018. Before they took the exam we had them review the basics of the language and then had them explore some of the more recent technologies included in Mathematica. These two students then took the exam and reported back to us their experiences with it.

Tilekbek Zhoroev (g), Western Kentucky University
Controllability and Observability of Linear Time-invariant Nabla Fractional Discrete Systems
In the paper, we study linear time-invariant nabla fractional discrete control systems. The nabla fractional difference operator is considered in the sense of Riemann-Liouville definition of the fractional derivative. We first give necessary and sufficient rank conditions for controllability of the discrete fractional system via the Gramian matrix and controllability matrix. Then we obtain rank conditions for observability of the discrete fractional system. We illustrate main results with some numerical examples. We close the paper by stating that the rank conditions for the dynamic systems on time scales, continuous fractional systems, and discrete fractional systems coincide.