ISMAA 2022 Abstracts
Millikin University
March 25 & 26, 2022

Pre-conference Workshop

James Sellers, University of Minnesota Duluth, *Advising Mathematics Students Academically and Professionally*
For many mathematics faculty members, advising is a fundamental task. Yet, there is usually no training in this area for graduate students while they are earning their degrees. This was my personal experience as I left graduate school and became a college professor. With this in mind, my goal is to discuss a variety of issues surrounding advising of undergraduate students. This includes "pre-advising" (such as working with high school students and parents), advising of undergraduates considering a change to the mathematics major, advising of mathematics majors, and professional advising of mathematics students (as they look to their future after graduation). I will also share a variety of resources that will hopefully prove useful to you.

Plenary Addresses

Sumanth Swaminathan, Co-founder of Vironix, *Machine-learning methods and patient data generation schemes for remote detection and monitoring of Health Deterioration due to Lung & Heart Illness*
The 2020 Covid-19 pandemic heavily accelerated the adoption of telemedicine and remote care services to reduce infection spread and protect essential workers. This has created a new climate of remote-care opportunities to tackle long-standing public health problems endemic to respiratory illness. Acute health deterioration events (exacerbations) due to chronic lung disease account for approximately 200,000 annual deaths and $70 billion of an astounding $130 billion in annual US direct costs. Hospitalizations from heart failure exacerbations account for 6.5 million hospital days, the leading cause of hospitalization in the USA and Europe. The lack of accurate, automated, and personalized approaches for self-identification and early care of these illnesses has led to unnecessary healthcare utilization, increased morbidity, and missed opportunities for timely therapeutic intervention. Moreover, at present, there are no scalable technologies for identifying early-onset illness at home.
Here, we describe a machine-learning approach to classifying and triaging health deterioration events due to chronic and infectious illness. Algorithms

are trained to consume patient health data inclusive of symptoms, consumer-available biometric data, and patient profile/demographic info. Novel simulation schemes are used to generate clinically diverse, statistically comprehensive patient scenarios that form the train and test datasets for machine-learning classifiers. Classifiers take an input of patient health data and return an assessment of both the existence and severity of health downturns. Performance studies on the machine-learning classifiers indicate superior accuracy, sensitivity, and specificity in making predictions when compared to standard-of-care.

Talithia Williams, Harvey Mudd College, *Power in Numbers: The Rebel Women of Mathematics*
The movie "Hidden Figures" brought visibility to the lives of African American women who served as NASA "human computers" in the 1960s, women who dreamed the impossible in a field where their presence was lacking. When it comes to inspiring the future productivity and innovation of our nation, women mathematicians are on the front lines. In this talk, I'll discuss my personal journey as a woman of color in mathematics and share ways we can excite public interest in mathematics, building upon the rich legacy of the Hidden Figures that have come before us. As we shift the fixed mindset around mathematics ability, we can begin conversations that improve public perception of STEM and bring people from all backgrounds into this important work.

James Sellers, University of Minnesota Duluth, *On Euler's Partition Theorem Relating Odd-Part Partitions and Distinct-Part Partitions*
In the mid-18th century, Leonhard Euler single-handedly began the serious study of integer partitions and made fundamental contributions to the area for the next few decades. In particular, he proved a remarkable result which says that the number of partitions of the integer n into distinct parts equals the number of partitions of n into odd parts. My goal in this talk is to discuss Euler's impressive work on partitions, including snapshots of historical (original) publications of Euler, and then to describe numerous 20th and 21st century results which spring from Euler's original result. The talk will be self-contained and geared for both students and faculty alike.

Brittany Stephenson, Lewis University, *Mathematical Modeling: Finding A Balance Between Reality and Utility*
In the study of disease transmission, mathematical modeling has become an important practical tool. The Centers for Disease Control (CDC) have used

models to predict the course of the Ebola epidemic and now that of COVID-19. What are mathematical disease models and how are they created? In this talk, I will begin with an overview of the modeling process and then describe the creation of different types of models, including both differential equations models and agent-based models. We will discuss the pros and cons of modeling and learn what George Box means by "All models are wrong, but some are useful."

Contributed Talks—Friday

Angela Antonou and Christina Jamroz, University of St. Francis, *Undergraduate Research Training Seminars*
In this talk, we share the development and outcomes of a new initiative at University of St. Francis to train undergraduate students in skills needed for conducting undergraduate math research. In particular, we describe a model for how to engage students in research through the use of mini research training seminars spread over the course of an academic year.

Paula R. Stickles, Millikin University, *Reading Assignments Meets Flipping in Calculus I*
Calculus I is a gatekeeping course that needs its doors pushed open. One of the obstacles in Calculus is the learning curve for vocabulary and notation amid new topics. Without a complete flipping of the course, we wanted to engage students in the material prior to class. In this session we will look at the implementation of a pre-class reading and notes assignment used in Calculus I. We will share students' work, lessons learned, and next steps.

Todd Oberg, Illinois College, *Teacher Shortage, Legislation, and Other Topics for Teacher Preparation*
This first part of this talk will be focused on providing updates and basic information regarding the new IL Culturally Responsive Teaching and Learning Standards, current legislation under consideration at the state level that could impact teacher education, and the current version of the Secondary Math Content Area Test. The second part of the talk will focus on teacher shortage and retention with the goal of looking for ways to encourage individuals to consider teaching math in K-12 schools and to support new math teachers once they are in the field so that they are retained.

Marie Meyer, Lewis University, *Laplacian Simplices Associated to Threshold Graphs*

Polytopes are generalizations of the familiar 2-dimensional polygons and 3-dimensional polyhedra. Recently there is a heightened interest in studying polytopes associated to graphs. One such technique is to use the Laplacian matrix of a graph to form a polytope by considering the rows of the matrix as vertices of the polytope. For a connected simple graph with n vertices, the resulting polytope is an $n-1$ dimensional simplex. In this talk, we narrow our focus to Laplacian simplices arising from threshold graphs. We relate properties of the simplex with its underlying graph and establish interesting connections with other families of simplices to describe reflexivity, the h-polynomial, and the integer decomposition property of the simplex in these cases.

Catherine Crawford and Jon Johnson, Elmhurst University, *Gibbs Phenomenon and Modified Fourier Series*
We modify the classical Fourier series by introducing a weight function in the inner product used to define orthogonality. Using the Gram-Schmidt method, we obtain a new orthogonal basis, which is then used to find a modified Fourier series representation of a function. For a function with a finite jump discontinuity, we show that the choice of the weight function can greatly reduce the size of the observed Gibbs phenomenon.

Elizabeth DeWitt, Trinity Christian College, *Counting Leading Shifted Tableaux*
A partition of integer n satisfies the property that if a cell is in the diagram then so are all cells that are above and/or to the left of the cell. For partitions of distinct parts this property holds even if we shift the i-th row of the diagram $(i-1)$ places to the right. From two partitions of distinct parts with one contained in the other, we can create a skew shifted tableau by filling the cells of the difference of the diagrams with marked and unmarked positive integers. The number of assignments that give the leading content according to lexicographic order has long been known to be a power of two and is easy to find for a given pair of partitions by filling the diagram by hand. After an introduction to shifted tableaux, we will discuss a closed formula for this exponent based only on the partitions.

Joe A. Stickles, Jr., Millikin University, *A Rudimentary Analysis of Wordle and Its Variants*
Wordle is an online game in which the user attempts to guess a five-letter word within six guesses using information about the occurrences and positions of the letters. Strategies used to write computer simulations, as well as

thoughts on how to spark student inquiry, will be shared.

Ellen Ziliak, Benedictine University, *Conjugacy Classes of Unipotent Elements in Symmetric Spaces of the Special Linear Group over a Finite Field*
In this presentation I will discuss the generalized symmetric spaces for the special linear group, in particular I will focus on a characterization and classification of the orbits for the inner involutions of the unipotent elements of this group.

Alexis Langellier*, Trinity Christian College, *Poetry and Mathematics for Education*
During the summer of 2021, I experimented with a new way of getting children excited about mathematics. Math is often a trigger word for children and many adults. I wanted to find a way to make learning math fun—without the students knowing they're doing math. These low level poems include arithmetic, counting, shape filling, prime number, Fibonacci sequence and letter symmetry. I used these poems for grades two through five, but this concept can be utilized for any level including college. I presented on how higher level mathematics is used in poetry during my junior year of college. Poetry can make mathematics fun for any student at any level of education.

Lucas Hancock* and Angela Antonou, University of St. Francis, *"Physical" Model of the Extended Euclidean Algorithm*
This talk presents an activity of embedding cubes into rectangular prisms and connects it to concepts in number theory. It is based on a Math Teachers' Circle activity implemented by Dr. Angela Antonou and Dr. Brittany Stephenson, which used physical models to explore continued fractions. This activity (fitting squares into rectangles) models the Euclidean Algorithm for two numbers. Our extension (fitting cubes into right rectangular prisms) offers a physical way to model the Euclidean Algorithm for three numbers.

Alia Alramahi*, Benedictine University, **Harvey Campos-Chavez***, Lewis University, **Miles Mena***, Lewis University, **Jacob Prince***, Lewis University, **Robbie Dudzinski***, Benedictine University, **Will DeBolt***, Lewis University and **Soren Thrawl***, Lewis University, *Predictive Hockey Analytics*
Predicting the outcome of a hockey game can be challenging due to the fast paced and physical nature of the sport. In this talk, we share several approaches for determining the outcomes of NHL hockey games. One method involves a continuous time Markov process-based model that takes the cer-

tain state the home team is in at any point in the game and gives a winning probability statistic for that time. This state is based on the home team's shot and goal differential relative to the opposing team and approximates the probability that the home team would win depending on the state they are currently in at a given time in the game. Our second analysis technique uses hypothesis testing to determine whether variables (or combinations of these variables) like shot differential, manpower differential, face-off win percentages, the amount of time in power plays, and the number of low, medium, or high-danger shots are predictive in determining the outcome of NHL hockey games. Finally, we created Colley models, which used the results gained from hypothesis testing, to predict which teams would likely come out on top in the end-of-season standings.
This work is funded by a grant received from the Center for Undergraduate Research in Mathematics (CURM).

Miles Mena*, Lewis University, *Spanning Forest Probabilities on Path Graphs and Binary Trees*
From a simple graph, a forest-building process can be applied to create a new graph from the spanning forest on the original graph. The process is summarized as follows: remove all the edges from the graph and enumerate them in any fashion, then, in order, add the edges if and only if the edge can be drawn from a vertex that has not already been visited by an edge.
This talk enumerates, among other things, k-component graphs arising after the forest building process on a collection of graphs including path graphs. A generalization of these enumerations is given and we establish a connection to the peaks and valleys problem in a set of integers.

Jordan Thompson*, Jared Reiling*, Kidus Olana* and Trung Pham*, Augustana College, *NFTrig: A Digital Card Game of Trig Functions*
Non-Fungible Tokens are used as a way of verifying and transferring ownership of digital property. Our project seeks to utilize NFT technology in fostering mathematics education via a collectible digital card game of trigonometric functions. Users can collect functions and create new functions by combining two cards together. Cards will display the name of the function, an animated graph of the function, as well as facts such as identities, derivatives, integrals, and Taylor series.

Contributed Talks—Saturday

Cassidy Krause, Millikin University, *Reflections on Christopher Emdin's "For White Folks Who Teach in the Hood... and the Rest of Y'all Too*
For Millikin University's Fall 2021 Social Justice Book Club, faculty, staff, and students gathered to read and discuss Christopher Emdin's book: For White Folks Who Teach in the Hood... and the Rest of Y'all Too. In this book, Emdin addresses ways in which (white) teachers fail their urban students, and provides a new lens with which to view the education of urban youth. This talk will reflect various viewpoints and discussions shared through Millikin's Social Justice Book Club, and will present a few takeaways that I, as a white educator, have implemented in my classroom.

Haley Yaple, Carthage College, *PIC Math: Students become mathematical consultants in a real-world research class*
As part of a national program called PIC Math ("Preparing for Industrial Careers in Math"), faculty facilitate student research with a local company as part of a semester-long research course. Students gain experience in messy, open-ended problem solving and gain professional skills that will position them well for future careers in mathematics. After running such a course in 2019, I am eager to continue working with local partners as a regular part of my research and teaching. In this talk, I will share my experiences and provide information on how to get started, whether as part of the official PIC Math program or independently.

Muhammad Inam, Alabama A&M University, *The word problem for one relator inverse monoid*
If $w \in (X \cup X-1)*$ is sparse, then the word problem for $M = \mathrm{Inv}(X|w = 1)$ is solvable.

Michael Sostarecz, Monmouth College, *Applying Mathematics to Archaeology*
Reflectance Transformation Imaging (RTI) is an imaging technique used to non-invasively bring out surface details on artifacts. This lecture will share improvements on how the data are collected, an original model to combine the experimental images, and new options for post-processing. The artifacts presented will include Greco-Egyptian pottery from the Ashmolean and British Museums, spear points from Monmouth College's Native American Lithic Collection, and Greek coins from the College's Shields Collection. Mathematical application areas will be highlighted from linear algebra, trigonometry,

and multivariate calculus. Planned extensions of the project involve forensic science, dinosaurs, and scuba diving, albeit probably not at the same time.

Katie Ansaldi, Wabash College, *Rainbow Numbers over $\mathbb{Z}_n$*
The rainbow number for an equation over $\mathbb{Z}_n$ is the smallest number of colors k so that every exact k-coloring of $\mathbb{Z}_n$ forces a rainbow solution, that is a solution where each element is a different color. In this equation we discuss rainbow numbers over $\mathbb{Z}_n$ for linear equations, as well as the equation $x-y=z^2$.

H. M. Wiranthe Bandara Herath+ and S. Yaser Samadi, Southern Illinois University Carbondale, *Partial envelope models for multivariate time series*
We introduce partial envelope models for multivariate time series, which leads to a parsimonious technique when some lag variables are of particular relevance. In the estimate of the coefficients of some lag variables, our proposed model has a potential to generate huge efficiency gains compared to the standard vector autoregressive (VAR) model. The partial envelope model for multivariate time series focuses on subset of the important lag variables, and as a result efficiency in estimation can be improved. In this talk, we present simulation study and a real data analysis to demonstrate efficiency gains from the partial envelope model in the time series context.

Cara Sulyok, Lewis University, *A Mathematical Framework to Augment the Q-MARSH Score in the Diagnosis of Celiac Disease*
Celiac disease is a hereditary autoimmune disease that affects approximately one in 133 Americans. It is caused by a reaction to the protein gluten found in wheat, rye, and barley. After ingesting gluten, a patient with celiac disease may experience a range of unpleasant symptoms while small intestinal villi, essential to nutrient absorption, are destroyed in an immune-mediated process. The only known treatment for this disease is a lifelong gluten-free diet and there is currently no drug treatment.
This work provides a mathematical model to better understand the effects of immune activation on gut health using a system of ordinary differential equations. The system tracks changes in small intestinal cell densities and relates them to the Q-MARSH score, a criterion used in the diagnosis of celiac disease. The model can be used to investigate and analyze the immune response and various theories behind the progression of this disease by focusing on understanding the dynamics of the small intestine in situations mirroring healthy function and celiac disease. By doing so, we can assist

in further quantifying and augmenting diagnostic measures and investigate potential therapies to mitigate the negative effects of celiac disease.

Greta Jacobson*, Millikin University, *Exponential-Ansatz Density Functional Theory*
Size-consistency indicates the ability of a computational model to properly describe the potential energy surface of a system, especially when a chemical bond is being broken. Although many correlated wavefunction computational methods feature size-consistency, commonly used density functional techniques are not able to achieve this, with some exceptions. As a result, the potential energy of certain molecular systems cannot be accurately represented by density functional theory. It has been shown that, unlike traditional DFT methods, exponential-ansatz density functional theory (DFT-eXp) is size-consistent and will produce accurate potential energy surfaces for the dissociation of these molecules. In this research, we examine the Python code for DFT-eXp. Specifically, we investigate how the perturbative approximation to the t-amplitudes is carried out in the code, and how these amplitudes are iteratively updated using a quasi-Newton method.

David Kovalev*, Lewis University, *Effects of Optimally Performed Healthcare Measures On C. Difficile Infection Rate*
Clostridioides difficile (C. diff.) is an infection causing bacteria, common in healthcare settings, that causes severe diarrhea and colitis. Infections can be spread by spores when a colonized patient, symptomatic or asymptomatic, touches a surface. A C. diff. infection (CDI) can also become recurring if a patient is not treated properly. CDIs are potentially fatal to those with a weakened immune system, killing around 30,000 patients each year, but with precautionary measures, the number of CDIs can be significantly reduced. This work applies optimal control theory onto a mathematical model of the epidemiology of C. diff. introduced in Sulyok et al. (2021). Optimal control theory is a branch of mathematics used to control time dependent, constrained systems of differential equations toward a state determined to be optimal by the minimization or maximization of a variable. The focus of this work is understanding the individual contributions of precautionary measures, when optimally controlled, in minimizing the infection rate and spread of C. diff. Results can be applied by healthcare professionals to reduce healthcare-associated costs by focusing their attention towards the precautionary measures that most reduce the impact and risks associated with C. diff.

Shengan Wu*, Igor Araujo+, Kareem Yusef Benaissa*,Richard Bi*, Sean English and Pai Zheng*, University of Illinois at Urbana-Champaign, *Tight bounds for rainbow k-connectivity in complete multipartite graphs*

n graph theory, a path in an edge-colored graph is said to be rainbow if no color repeats on it. A graph G is rainbow connected if every pair of vertices in G is connected by a rainbow path. The rainbow connection number $\mathrm{rc}(G)$ is the minimum number of colors m such that there exists a coloring with m colors that makes G rainbow connected. In this talk, we will consider a generalization, rainbow k-connectivity, for complete multipartite graphs. We solve a question posed by Liu and Magnant, and provide tight bounds for when $\mathrm{rc}_k(K) \leq 3$ for complete multipartite graphs K.

This is joint work with Igor Araujo, Kareem Yusef Benaissa, Richard Bi, Sean English and Pai Zheng.

Laszlo Toth*, David James* and Anirudh Eswara*, University of Illinois at Urbana-Champaign, *Edge-colorings without small substructures*

We consider the minimum number of colors needed to color the edges of the complete graph on n vertices while avoiding certain small forbidden substructures. For example, avoiding two incident edges of the same color is equivalent to a proper edge-coloring. Several problems in extremal combinatorics fit this framework. In this talk we focus on two forbidden substructures in proper edge-colorings, alternating paths of length 4 and 2 disjoint 'color-isomorphic' triangles, which display some interesting opposing behavior.

Career Panel for Undergraduate Students

Preparation for Industrial Careers in Mathematical Sciences

Levi Laws, Company: Stifel Nicolaus, Title: Financial Advisor

Bio: Levi Laws is a 2019 Millikin graduate from Mt Carmel, IL. He has worked at a brokerage firm since June of 2019 and has been a financial advisor since May of 2021.

Sydney Rudny, Company: Caterpillar, Title: Associate Data Specialist

Bio: Sydney Rudny is a 2021 Millikin graduate from Orland Park, IL. She currently works for Cat Digital on the platform data engineering team.

* Undergraduate student

+ Graduate student