ABSTRACTS OF TALKS PRESENTED TO THE INDIANA SECTION OF THE MAA

1. Introduction

The Fall 2022 meeting of the Indiana Section of the Mathematical Association of America is being held at Rose-Hulman Institute of Technology, October 22. The abstracts appearing here are based on text electronically submitted by the presenters.

Contributed presentations are listed in alphabetical order by presenter.

2. Invited Talks

Presenter: Deirdre Longacher Smeltzer, MAA Senior Director for Programs

Spherical Inversions and Applications to Geometry

Standing on the deck of a cruise ship in the ocean and looking off into the horizon, it's easy to understand how our ancestors thought the earth was flat. While an infinite plane and a bounded sphere look completely different to an observer from afar, the spherical earth appears flat when standing upon it. In inversive geometry, the informal notion of visualizing a plane as a sphere with an infinite radius is made precise mathematically, and the distinction between spheres and planes disappears. Furthermore, spherical inversions can be used to provide elegant solutions to geometry problems involving spheres.

Presenter: Darrin Weber, Data Scientist, Lirio

Bridging the Gap Between Academia and Industry

What we do in a classroom and what we do in industry are distinctly different. They have to be, mainly because they have different goals. But that can also make transitioning from academia to industry difficult and result in a steep learning curve when beginning a job. In this presentation, I'm going to talk about how to bridge that naturally occurring gap between academia and industry from two different perspectives, appealing to both students interested in what data science and math look like outside the classroom as well as professors interested in giving their students a unique, unparalleled, resume-building experience that helps smooth the transition to industry.

First, I'll walk through my winding path from undergraduate math education major to professor of mathematics to data scientist as well as talk about my current day-to-day and the problems I work on as a data scientist for a start-up company.

Next, I'll talk about a national award-winning collaboration I was a part of while I was a professor of mathematics at the University of Evansville. I'll talk about the genesis of the project, how the collaboration worked (and how it benefited both parties) as well as a little bit about the math and statistics we used. Along the way, I'll offer up some tips and lessons learned that can be used to replicate the successful collaboration.

3. Indiana Project NExT Panel Discussion

Panelists:

- Deirdre L. Smeltzer, MAA Senior Director for Programs
- Darrin Weber, Lirio
- Courtney Taylor, Anderson University

Moderator:

- Justin Lambright, Anderson University

Being a Mathematician: Beyond Teaching and Research
Dr. Deirdre Longacher Smeltzer will lead us in a discussion about various career paths (administrative, etc), as well as other ways to engage in the community both internally and externally. Dr. Courtney Taylor is Provost at Anderson University.

4. Contributed Talks

Presenters: Adam Coffman, Purdue Fort Wayne, and Rick Gillman, Valparaiso University
Joint work with: Justin Gash, Franklin College, and John Rickert, Rose-Hulman
MSC 2020: 00A07, 01A99
The history and future of the Indiana College Math Competition
The ICMC has been a (nearly) annual event for over 50 years, giving students the opportunity to work together on problems from the undergraduate mathematics curriculum. Rick Gillman's MAA problem book, *A Friendly Mathematics Competition — 35 years of Teamwork in Indiana*, presented problems and solutions from 1965 to 2000. In this talk, we will outline our work so far on a 21^{st}-century update and ask for feedback from the audience about what coaches and students would find useful in a problem book. This is also an opportunity for attendees to contribute their own new solutions, anecdotes, or historical artifacts to this project.

Presenter: Robert Foote, Wabash College
Joint work with: Gregory Galperin, Eastern Illinois University
MSC 2020: 51M09
What do circles look like in the Beltrami-Klein model of the hyperbolic plane?
In the Poincaré (conformal) models of the hyperbolic plane, H^2, hyperbolic circles are represented by Euclidean circles. This is commonly taught in an introductory course on non-Euclidean geometry. Less well-known is how hyperbolic circles are represented in the Beltrami-Klein (projective) model of H^2. It is easy to guess that they are ellipses, but which ones (as there are more ellipses than circles)? This talk answers this and other closely related questions.

Presenter: David Housman, Goshen College
Joint work with: Ebtihal Abdelaziz, Goshen College undergraduate student
MSC 2020: 91A12
Game and group theories together
One way to model people, nations, or other agents who can freely cooperate with each other is a *coalition game*: the worth of each subset of cooperating players is determined and then an allocation method can be used to either predict the outcome of negotiations or recommend a fair outcome. A *group* is a set G with a binary operation $\circ$ that is closed, associative, and has an identity and inverses. One example of a group is the set $\mathbb{Z}_6 = \{0, 1, 2, 3, 4, 5\}$ with the binary operation addition mod 6. Ebtihal Abdelaziz, an undergraduate student at the time, and I defined a coalition game on a group by having the group elements serve as the players and the worth of a subset S of players be the number elements in the subgroup generated by S, and we found the nucleolus for such coalition games on a variety of groups. This talk will summarize some of our results, hint at the proofs, tell the story of our journey into this topic, and suggest a wide variety of open questions.

Presenters: Haseeb A. Kazi, Trine University, and Lance W. Jutze, Trine University undergraduate student
Best practices for online instruction of mathematics for students who face learning barriers
Online instruction of mathematics has become a more prevalent medium of education with the increased surge of technological advances. The bond between a teacher and their students serves as a key motivator for teachers to instill an effective mode of communication for the advancement of education, particularly in mathematics. However, disabilities that hinder the academic performance of a student can affect their overall chances to succeed, especially in an online setting. Two groups of disabilities act as major barriers for students, and those are physical and mental ailments. An effective strategy for teachers to accommodate their students with certain disabilities in the online setting can lead to a better future for teachers to instill mathematical knowledge in students who show promise but cannot facilitate their education on their own. For both physical and mental conditions that affect mathematical education in the online setting, certain practices can be implemented by teachers to help students who are impaired to obtain the same level of mathematical knowledge as any other student who learns under their direction.

Presenter: Rodney Lynch, Indiana University - Purdue University Columbus
A method to produce all integral triangles of a given type
It is known how to produce all Pythagorean triples from the single triple $(3, 4, 5)$ by making use of three 3×3 matrices. It is also known how to produce all integral triangles (other than $(1, 1, 1)$) that have a $60°$ angle from the triples $(7, 8, 5)$ and $(13, 15, 7)$ by making use of five 3×3 matrices. I will show that it is possible to obtain all the triangles in each case by squaring certain complex numbers instead of multiplying matrices.

5. Contributed Posters

Presenter: Dennis G. Collins, University of Puerto Rico, Mayagüez (retired)
Drama triangle cycling of WWII Big Three
On Sept. 14, 2019, Dennis Collins presented a a paper "Drama Triangle Cycling of Julius Caesar Triumvirate" at the AMS (American Math Society) Sectional Meeting $\#1150-81-546$ in Madison, WI, and also a similar talk at an MAA Meeting at Wabash College on Oct. 26, 2019, and at the Wolfram Tech Conference on Oct. 29, 2019. An astounding fact is that the same chart works to describe the Drama Triangle Cycling of the World War II Big Three with only a re-labeling of columns and change of period from 12 to 30 years. Change of lifespan from about Roman 33 years to 1945 65 years, as background book *Scales* by Geoffrey West may help explain. Thus, Crassus (victim died 53 bce), Pompey (rescuer died 48 bce), and Caesar (aggressor died 44 bce), versus FDR (victim died 1945), Stalin (aggressor died 1953), and Churchill (rescuer died 1965).

Presenter: Aaron Marshall, Butler University undergraduate student
Faculty Advisor: Mohammad Patwary, Butler University
Estimating multiple missing values in linear models
When estimating for missing values, the most important thing to do is minimize the squared error loss function associated with respective the outlined model. The squared error loss function for the linear models is given by the sum of squares due to errors (SS_E). The equation for the SS_E can be obtained by the following algebraic manipulation of different components' sum of squares and notationally given by

$$SS_E = SS_T - SS_{Treatments} - SSBlocks \tag{1}$$

where SS_T is the total sum of squares, $SS_{Treatments}$ is the treatments sum of squares, and SS_{Blocks} is the blocks sum of squares. This means that we also need the algebraic expression for each of these separate sum of squares. For the full or complete dataset, those three expressions are as follows:

$$SS_T = \sum_i^a \sum_j^b y_{ij}^2 - \frac{y_{..}^2}{N} \tag{2}$$

$$SS_{Treatments} = \frac{1}{b}\sum_{i=1}^a y_{i.}^2 - \frac{y_{..}^2}{N} \tag{3}$$

$$SS_{Blocks} = \frac{1}{a}\sum_{j=1}^b y_{.j}^2 - \frac{y_{..}^2}{N} \tag{4}$$

where a is the number of treatments, b is the number of blocks, and $N = ab$ is the total observations in the data.

With two missing variables, these expressions (Equation 2, 3, 4) become completely different different due to incorporation of missing values to be estimated. However, once those expressions are derived, then the expression for SS_E (Equation

1) can be obtained using algebraic manipulation. Then one can take the partial derivatives of the SS_E with respect to the missing values, set that equal to zero to get a system of equations built on the number of missing values. The analytic solution to this system of linear equations would provide the estimates of the missing values.

Presenter: Reuben Moser, Purdue University Fort Wayne undergraduate student
Faculty Advisor: Drake Olejniczak, Purdue University Fort Wayne
Modeling asynchronous juggling patterns using digraphs
Juggling is an interesting activity which also has an equally interesting mathematical structure behind it. Standard juggling consists of throwing objects (often balls) into the air at consistent intervals in a repeating pattern. In asynchronous juggling, each hand takes turn throwing the balls, one ball at a time. Throws can be done at various heights allowing for a myriad of patterns to be possible. For this project, we use a digraph to model the structure behind asynchronous patterns, and use the model with the help of a Python program to find all possible asynchronous patterns up to a given maximum throw height.

Presenter: Drake Olejniczak, Purdue University Fort Wayne
MSC 2020: 05, 06
The down-arrow Ramsey set of a graph
This project lies in the intersection of graph theory and Ramsey theory. A graph is a set of vertices together with a set of pairs of vertices called edges. A graph can be visualized by drawing a point for each vertex and a line segment between points if those vertices are in the same edge. Ramsey theory, and its connection to graph theory can be introduced through the following recreational problem:

Assuming any two people at a party are either friends or strangers, what is the smallest number of people that need to be invited to a party to guarantee that there will be either three mutual friends or three mutual strangers?

This problem can be modeled with an edge-colored complete graph: connect each pair of points with an edge and color the edge red if the two people are friends or color it blue if they are strangers. The problem can then be restated in terms of this graph model:

What is the smallest complete graph for which every red-blue coloring of its edges results in a monochromatic triangle (three vertices such that the edges between them are the same color)?

In this project, we turn this classical Ramsey problem on its head to try and solve the following problem:

Given a graph G, determine the set of all graphs H for which every red-blue coloring of G results in a monochromatic H.

We call this set of graphs the down-arrow Ramsey set of G, and we denote this $\downarrow G$. In this poster, we provide examples of $\downarrow G$, introduce the concept of a graph ideal, and depict our two main methods for determining $\downarrow G$.

Presenter: Eleanor Waiss, Butler University undergraduate student
Faculty Advisor: Mary Krohn, Butler University

Dabbling in Dobble!: An exploration in monomatching games

This project is a deep dive into the mathematics behind card games like *Dobble!* (US: *Spot it!*), where cards are composed of a subset of symbols and any two cards are guaranteed to share exactly one and only one symbol. It is known that these games can map neatly to finite projective planes. By transforming the plane into a matrix and multiplying by the transpose, a special matrix form was observed. For our project, we used this matrix form to build a system of non-linear equations. We considered different sizes of systems and wrote C++ and Mathematica code to solve them. The ultimate desire is to generate a program to form a finite projective plane of a new size, which then can create new cards for a revised game of *Dobble!*.