ABSTRACTS OF TALKS PRESENTED TO THE INDIANA SECTION OF THE MAA

1. Introduction

The Spring 2019 meeting of the Indiana Section of the Mathematical Association of America is at the University of Indianapolis, April 5–6. The abstracts appearing here are based on text electronically submitted by the presenters. Contributed talks are listed in alphabetical order by presenter.

2. Invited Talks

Presenter: Alissa Crans, Loyola Marymount University

Cracking the Cubic: Cardano, Controversy, and Creasing

We're all familiar with the solution to a general quadratic equation — some of us even learn songs or mnemonics in school to help us remember the famous formula. But have you heard about analogous formulas for the cubic, quartic, or quintic equations? It turns out that the solution of the cubic didn't reveal itself to mathematicians quite so easily. There's a real story here, filled with challenges, drama, and controversy! Surprisingly, we can trade in our formulas for folding. Our exploration will take a turn toward the concrete as we follow the footsteps of Margherita Beloch and solve the cubic using only origami.

Presenter: Deanna Haunsperger, Carleton College and Past President of the MAA

A Glimpse at the Horizon

What do a square-wheeled bicycle, a 17^{th}-century French painting, and the Indiana legislature all have in common? They appear among the many bright stars on the mathematical horizon; that is, in *Math Horizons*. *Math Horizons*, the undergraduate magazine started by the MAA in 1994, publishes articles to introduce students to the world of mathematics outside the classroom. Some of mathematics' best expositors have written for *MH* over the years; here is an idiosyncratic tour of the first ten years of *Horizons*.

Presenter: Manda Riehl, Rose-Hulman Institute of Technology

Discrete Mathematics Applied to Biology

Discrete mathematics is a useful field for computer scientists and electrical engineers, covering essential topics including logic, Boolean algebra, theory of computation, recursion, and many others. But recently the tools of discrete mathematics have brought about advances in the biological sciences, particularly in modeling biological systems and processes. We'll explore some applications of discrete mathematics to topics such as gene regulatory networks, food webs, and RNA secondary structures.

3. Indiana Project NExT Panel Discussion

Panelists:

- Alissa Crans, Loyola Marymount University
- Deanna Haunsperger, Carleton College
- Manda Riehl, Rose-Hulman Institute of Technology

Moderator: Amber Russell, Butler University

Teaching Students to Think about Learning

Our jobs as educators are to help prepare our students for a lifetime of learning, and mathematics courses are tasked with teaching students much more than just the mathematics content. We strive to give our students analytical reasoning skills, problem solving skills, and critical thinking skills to name a few. The panelists here will share some of the techniques they have used in their own classrooms to encourage students to think about their own learning and lead a discussion about related topics.

4. Panel Discussion

Panelists:

- Roza Aceska, Ball State University
- Crystal Lorch, Ball State University

Open Discussion of Innovative Ideas for Linear Algebra Instruction

Linear algebra is a crucial building block in the understanding of mathematics and is required for students in a variety of majors. Indeed, it is increasingly important in applications as data and algorithms play larger roles in our society. However, teaching linear algebra is difficult. Students are often overwhelmed by the number of new definitions, the expectations regarding proofs, and the lack of connection with previous knowledge. Our discussion will center around various questions such as: What has been most successful for us in this course? What innovative approaches would we like to try? What ideas do we have for incorporating technology, writing, and collaboration in meaningful ways? How could we adapt this course for online teaching?

5. Student Activities Workshop

Presenter: Mindy Capaldi, Valparaiso University

Recognizing Gerrymandering: Are You Smarter than a Supreme Court Justice?

6. Contributed Talks

Presenter: Joshua Arroyo, Rose-Hulman Institute of Technology undergraduate student

Proof of a construction of odd order magic cubes

A magic cube of order n is an $n \times n \times n$ array filled with n^3 distinct positive integers $1, 2, \ldots, n^3$ such that the n integers in each row, column, pillar, and space diagonal all sum up to the magic sum. A magic cube of any odd order can be constructed through an algorithm that places elements in order along the 2-dimensional backward diagonals of the cube. We prove that our construction gives a magic cube by first deconstructing the magic cube into 4 cubes each containing the entries $0, 1, \ldots, (n-1)$. Then we show that the sum of the entries of the rows, columns, pillars, and space diagonals are all the same. Time permitting, we show that the algorithm extends to create magic hypercubes of odd dimensions.

Presenter: Tyler Billingsley, Purdue University West Lafayette graduate student
MSC 2010: 11

The specialization homomorphism for elliptic surfaces

For an elliptic curve defined over a number field k, a fundamental question is to determine its group of k-rational points. More generally, one can ask how large the group of k-rational points can be. The most recent developments regarding this question have been made by specializing elliptic surfaces. In this talk, I will build up the concepts needed to understand this approach through concrete examples. If time permits, I will mention a new way of thinking about specialization given by Gusić and Tadić in 2014.

Presenter: José Contreras, Ball State University

Investigating the picnic problem with The Geometer's Sketchpad

In this presentation, I will use The Geometer's Sketchpad to model, represent, and solve the picnic problem, which can be stated as follows:

Three towns are the vertices of an equilateral triangle. The sides of the triangle are parts of the roads that connect the towns. A picnic area will be constructed such that the sum of its distances to the roads is as small as possible. a) What are all possible locations for the picnic area b) For practical reasons, what is the best location for the picnic area?

Presenter: Dan Coroian, Purdue University Fort Wayne
Joint work with: David Benko, University of Southern Alabama
MSC 2010: 40A05

A fresh look at Cauchy's convergence criterion: Some variations and generalizations

Several interesting variations, generalizations, and extensions of Cauchy's convergence criterion for real sequences are presented, including some unusual 2-dimensional versions and some new results.

Presenter: Christopher Creighton, Purdue University West Lafayette graduate student
Faculty Advisor: Donu Arapura, Purdue University

Pushing Hurwitz's bound: History and recent results in finding the bound of the automorphism group of a variety of general type

In 1893, A. Hurwitz showed that for any nonsingular projective curve of genus $g \geq 1$, its automorphism group is bounded by $84(g-1)$. 101 years later in 1994, G. Xiao proved that the automorphism group of a minimal smooth projective surface S of general type is bounded by $288K_S^2$ (unless S/G is rational). In this talk, I will discuss these results and more recent advances for higher dimensional varieties of general type. This includes the seminal result of C. Hacon, J. McKernan, and C. Xu in 2013 showing that there exists a universal constant c such that the automorphism group of a smooth projective variety X of general type is bounded of order cK_X^n where $n = \dim(X)$ and the need to compute examples (e.g. via Kodaira fibrations) to find a possible value of c.

Presenter: Jackson Hansen, Lewis University undergraduate student

Design strategies for modeling Mongolian tent graphs using DNA self-assembly

Motivated by the recent advancements in nanotechnology and the discovery of new laboratory techniques using the Watson-Crick complementary properties of DNA strands, formal graph theory has recently become useful in the study of self-assembling DNA complexes. In this talk, we present our results applying graph theoretical and linear algebra techniques for Mongolian tent graphs. We explore designs strategies in which graphs smaller than or equal to the target graphs are acceptable.

Presenter: Amanda Harsy, Lewis University, IL

Joint work with: Leyda Almodovar, Stonehill College; Joanna Ellis-Monaghan, Saint Michael's College; Cory Johnson, California State University San Bernardino; and Jessica Williams, Converse College

Designing optimal strategies for DNA self-assembly

Motivated by the recent advancements in nanotechnology and the discovery of new laboratory techniques using the Watson-Crick complementary properties of DNA strands, formal graph theory has become useful in the study of self-assembling DNA complexes. Construction methods developed with concepts from undergraduate level graph theory have resulted in significantly increased efficiency. One recent focus in DNA nanotechnology is the formation of nanotubes which can be modeled using a lattice graph. These nanotubes are thought to have wide-ranging potential, such as containers for the transport and release of nano-cargos, templates for the controlled growth of nano-objects, and in drug-delivery methods. The rules governing the structure of these nanotubes are not yet well understood, and this naturally offers open problems in the realm of applied graph theory. In this research, we focus on mathematical construction methods for self-assembling DNA structures which involve junction branched molecules whose flexible k-arms are double strands of DNA.

Presenter: David Housman, Goshen College

MSC 2010: 97M

A mathematical modeling course

Goshen College offers a project-centered course in mathematical modeling. Students are asked to complete three relatively open-ended projects involving a functional relationship, optimization, and randomness. This talk will describe at least one of the project assignments, student preparation to engage in the project, and examples of student work.

Presenter: Bir Kafle, Purdue University Northwest

Joint work with: Florian Luca, University of the Witwatersrand; and Alain Togbé, Purdue University Northwest

On triangular numbers

Positive integers of the form

$$\frac{n(n+1)}{2}, \quad n \geq 1$$

are called the triangular numbers. In this presentation, we will talk about the triangular numbers in some interesting sequences of positive integers such as Fibonacci numbers, repdigits, Lucas numbers, and repblocks of two digits (positive integers with repeated blocks of two digits).

Presenter: Michael A. Karls, Ball State University

Incorporating a modeling first approach into a traditional ODE course

In summer 2017, after teaching an introductory ODE course in a traditional format for many years, I decided to try incorporating a "modeling first" approach into my fall 2017 course, using projects from SIMIODE. In this talk I will outline the projects chosen and look at how they fit into the overall course structure, how they were introduced to the students, student reactions and responses to the projects, and the impact of the changes to the course on the students. I will also discuss what worked and what did not work and how the course could be modified for subsequent offerings.

Presenter: Tiffany Kolba, Valparaiso University

Estimation of the population mean with the sample maximum

In many applications, the mean value of a variable of interest in unknown for the entire population. The most common approach for estimating the population mean is to use the mean value of a sample drawn from the larger population. However, in some applications it is not possible to measure a sample mean. This talk will discuss a novel approach for estimating the population mean when the only known information is a sample of sample maxima. The method is applied to estimate the mean length of pollen tubes in the flowering plant *Arabidopsis thaliana*, where the current biological procedures can only measure the longest pollen tube in each plant sample.

Presenter: John LaMaster, Purdue University Fort Wayne

Increasing participation in an online college algebra class

To succeed in online College Algebra, students must be motivated to learn. Incorporating research-based motivation tactics into the instructional design of the course has significantly increased student participation. In particular, examples of hands-on interactive videos and web-based, self-scoring, algorithmic homework using Möbius will be showcased, as well as Texas Instruments graphing calculator activities which enable students to view a problem from multiple perspectives. The motivation model of instructional design that was used (`https://elearningindustry.com/arcs-model-of-motivation`) can be applied to face-to-face or online delivery as well as any content area.

Presenter: Rodney Lynch, Indiana University - Purdue University Columbus

MSC 2010: 12

An elementary approach to Galois theory of cubics and quartics

For an irreducible cubic an automorphism polynomial is a polynomial that maps one zero to another. In this talk I will make use of a quadratic function with a 3-cycle to obtain an automorphism polynomial for a cubic of the form x^3+px+q with cyclic Galois group. Knowledge of Galois Theory will not be necessary – my approach will be computational and I'll give explicit examples. I will also state some results for irreducible quartic polynomials.

Presenter: Rachel Lynn, Purdue University West Lafayette graduate student
Joint work with: Lindsey Hill, Purdue University West Lafayette graduate student
Faculty Advisor: Bernd Ulrich, Purdue University West Lafayette
MSC 2010: 13B22

Rees algebras and normal ideals

In this talk, we will discuss how the integral closure of the Rees algebra $R[It]$ can help us check whether an ideal is normal (that is, whether I^n is integrally closed for all n) without checking that I^n is integrally closed for infinitely many n. Unfortunately, computing the integral closure of the Rees algebra is also difficult, so we will discuss some past and recent results about the complexity of the integral closure as well as future directions of research.

Presenter: Carley Maupin, Lewis University undergraduate student

Impact of time-restricted feeding on digestive health

Digestive and gastrointestinal diseases affect a large proportion of people in the United States. This may be due to a disrupted circadian rhythm, in which one does not allow enough time for fasting and proper digestion by the body, thus disease risk is increased. We will explore how implementing time-restricted feeding (TRF), and thus regulating the circadian rhythm, may improve and restore the gut microbiome.

Presenter: Emily Morris, Olivet Nazarene University undergraduate student
Joint Work With: James Kitchens, Warren Wilson College
Faculty Advisors: Barbara Bennie, Doug Baumann, and Roger Haro, University of Wisconsin - La Crosse; and Richie Erickson, Molly Van Appledorn, and KathiJo Jankowski, USGS

Using environmental DNA to predict sea lamprey population size in Great Lakes tributaries

Integrated Pest Management (IPM) strategies often require detailed population size information for target species that can be time-consuming and costly to obtain using traditional techniques. Environmental DNA (eDNA) has promise as a cost-efficient alternative for determining population sizes, but its ability to generate reliable estimates can be impacted by environmental factors like stream discharge and retention. Our goal was to evaluate the effectiveness of eDNA in estimating population size of invasive sea lamprey (*Petromyzon marinus*) in three Great Lakes tributaries with known lamprey populations densities. First, we evaluated several ways of quantitatively handling missing and inhibited eDNA samples, a common feature of eDNA datasets, and found they had no effect on the estimates. Second, we found that eDNA corresponded well with measured abundances of adult lamprey, but was not an effective indicator for larval lamprey populations due to low eDNA concentrations. Using a multiple linear regression model, we found that increased streamflow corresponded to decreased eDNA concentrations, yet its effect as a predictor for eDNA concentrations varied by stream. Our results suggest that eDNA-based population models require a better understanding of stream-specific factors that dilute and degrade DNA. We recommend that sampling for stream factors, such as streamflow, channel substrate, and river sinuosity, be done with eDNA sampling. We also recommend investigating alternative eDNA sampling methodology for larval stages.

Presenter: Phil Mummert, Purdue University West Lafayette

Differentiating by Parts?

The derivative of a one-variable function with multiple occurrences of x is simply the sum of the derivative "parts", where we consider each occurrence of x one at a time (while treating all other occurrences of x as constants). x^x and its relatives make for good illustrations of this (perhaps not so well-known) technique. Should it be standard in first-semester Calculus?

Presenter: Son Nguyen, DePauw University undergraduate student

Spectral dynamics for second order differential equations with singular weight

In this talk, we investigate the eigenvalues and corresponding eigenfunctions of second order ordinary differential equations (ODE) with singular weight. We employ general techniques in ODE and Mathematica programming to visualize the behavior of the dynamics of eigenvalues and eigenfunctions.

Presenter: Yifei Pan, Purdue University Fort Wayne

A general blow-up phenomenon for $\mathcal{C}^1$ functions in $\mathbb{R}^n$

We will present a general blow-up phenomenon for any $\mathcal{C}^1$ (continuously differentiable) function in $\mathbb{R}^n$. Theorem: Let Ω be any bounded connected open set in $\mathbb{R}^n$ $(n \geq 1)$, f any $\mathcal{C}^1$ function on Ω, and $Z = \{x \in \Omega : f(x) = 0\}$ the zero set with $Z \neq \emptyset$ and $Z \neq \Omega$. Then we have $\sup_{\Omega \setminus Z} \dfrac{|\nabla f|}{|f|} = \infty$, or more precisely $\displaystyle\int_{\Omega \setminus Z} \left(\frac{|\nabla f|}{|f|} \right)^n dx = \infty$.

Presenter: Sarah Percival, Purdue University West Lafayette graduate student

Joint work with: Nathanael Cox, Purdue University West Lafayette graduate student

Faculty Advisor: Saugata Basu, Purdue University West Lafayette

Reeb graphs and their applications

The Reeb graph provides a visualization of the connected components of the level sets of a continuous real-valued function on a topological space. First introduced by Georges Reeb in 1946 as a tool in Morse Theory, the Reeb graph has gained recent attention due to its applications in topological data analysis. In this talk I will discuss some recent theoretical results on Reeb graphs in addition to their implications for future applications in data analysis.

Presenter: Victoria Pflueger, Grace College undergraduate student

Faculty Advisor: Kristin Farwell, Grace College

MSC 2010: 90

Any Given Sunday

Have you ever wondered how your favorite NFL team compares to teams they have never played? We used the Traveling Salesman Problem as an inspiration to create an integer programming model that does just that. It finds the maximal parity between all 32 teams in the NFL. Can your favorite team win on Any Given Sunday?

Presenter: Christina Pospisil, University of Massachusetts Boston undergraduate student

Generalization Theory of Linear Algebra I: An embedding algorithm

An algorithm for multiplying and adding matrices regardless of dimensions via an embedding is presented. An equivalent embedding for a general determinant theory is also investigated. In future work there will be applications to physics and other natural sciences explored.

Presenter: Edward F. Price III, Purdue University West Lafayette graduate student
Joint work with: Monte Cooper, Purdue University West Lafayette graduate student
Faculty advisor: Bernd Ulrich, Purdue University West Lafayette
MSC 2010: 13A30

Defining equations of Rees algebras

The Rees algebra of an ideal represents the blowup of a variety along a subvariety in algebraic geometry. In this talk, we will describe the Rees algebra of an ideal and see how it can be described in terms of polynomials (called defining equations). We will then look into how presentation matrices of an ideal can give us some insight into the defining equations of the Rees algebra.

Presenter: Andy Rich, Manchester University

Cotangent averaging and Euler's product formula

The cotangent has the unusual property that if you chop it into pieces, stretch each piece over the interval and average the pieces, the result is the original function. Do any other functions have this property? This property can be used to derive Euler's product formula for the sine.

Presenter: John Rickert, Rose-Hulman Institute of Technology

The behavior of a function derived from a test for divisibility by three

We look at some properties of a function $f : \mathbb{Z} \to \mathbb{Z}$ in which the coefficient of 2^k in $f(n)$ is either 1 or 0 depending on whether the last k bits of n are divisible by 3 or not. The number of k-bit members of the kernel is given by the Fibonacci numbers. The function f satisfies the equation $f(n + 3f(n)) = \begin{cases} 2^k & \text{if 3 divides } n \\ 0 & \text{otherwise} \end{cases}$, where $k = \lfloor 2 + \log_2(n) \rfloor$.

Presenter: Gavin Roswarski, Grace College undergraduate student
MSC 2010: 90

Is fantasy football profitable?

Have you ever considered trying to make money playing fantasy football? Millions of Americans participate in some variation of fantasy football every year. Many play in leagues where they spend money with the chance of winning a payout at the end of the year. In this presentation, we explain how we solved this problem using an Integer Programming formulation that minimizes the amount of trades needed to score a certain number of points each week.

Presenter: Brittany Stephenson, Lewis University

Joint work with: Cristina Lanzas, North Carolina State University; and Judy Day and Suzanne Lenhart, University of Tennessee, Knoxville

Comparing intervention strategies for reducing Clostridium difficile transmission: An agent-based modeling study

The spore-forming, gram-positive bacteria *Clostridium difficile* can cause severe intestinal illness. A striking increase in the number of cases of *C. difficile* infection (CDI) among hospitals has highlighted the need to better understand how to prevent its spread. I will discuss the development and structure of an agent-based model of nosocomial *C. difficile* transmission that explicitly incorporates healthcare workers (HCWs) as vectors of transmission, tracks individual patient antibiotic histories, incorporates varying risk levels of antibiotics with respect to CDI, and tracks contamination levels of ward rooms by *C. difficile*. Using model simulations, I compare the efficacy of a variety of control interventions and combinations of interventions on reducing *C. difficile* nosocomial colonizations and infections. The simulated control techniques included two forms of antimicrobial stewardship, increased environmental decontamination through room cleaning, improved HCW compliance, and a preliminary assessment of vaccination.

Presenter: William D. Weakley, Purdue University Fort Wayne

The value of unique representation for permutations

In a typical first course in abstract algebra, it is shown that a permutation of a finite set can be represented as a product of disjoint cycles. Unfortunately, this is only unique up to order of cycles and order inside each cycle, so each permutation has several representatives. We show a (known) method of choosing a unique representative for each permutation, and how that leads to solution of a difficult probability problem.

Presenter: Michael Xue, Vroom Laboratory for Advanced Computing

Boost the performance of rocket without calculus

Boosting a two-stage rocket's flight performance is a non-trivial optimization problem typically solved by calculus. This presentation will show an alternative way that only requires high school mathematics, with the help of a computer algebra system (CAS). This non-calculus approach places more emphasis on problem solving through mathematical thinking, as all symbolic calculations are carried out by the CAS. It also makes a range of interesting problems readily tackled with minimum mathematical prerequisites.

Presenter: Jihyeon Jessie Yang, Marian University - Indianapolis
MSC 2010: 97D40

Math-Learning through Performance

A major challenge in teaching liberal arts mathematics courses is to motivate the students to learn the beauty and power of the subject. The students are generally taking such courses only because they are required. This challenge is especially tough in lower-level courses such as Introductory Algebra and Precalculus. Reviewing high school mathematics will not inspire these students and their incorrect prior knowledge may hinder learning.

In my current Precalculus course, I tried the idea, "Math-Learning through Performance." In this course, students should learn three fundamental concepts: Real number line, Function, and Limit. From students' feedback, I noticed that students understand that these are important concepts. However the students typically just want to know how to answer the test problems, which are too limited to motivate them due to the level of the course. The first performance, "Human-coordinate plane," was very successful at addressing these challenges. This was further developed into the second one, "Human-graphing." In this talk, I will share the details about them.

Presenter: Zijie Zhou, Purdue University West Lafayette undergraduate student
Faculty Advisor: Jonathon Peterson, Purdue University West Lafayette

Best strategy for each team in the regular season to win champion in the knockout tournament

In *What is the correct way to seed a knockout tournament?* (A. Schwenk, The American Mathematical Monthly (2) **107** (2000)), Schwenk identified a surprising weakness in the standard method of seeding a single elimination (or knockout) tournament. In particular, he showed that for a certain probability model for the outcomes of games, it can be the case that the top seeded team would be less likely to win the tournament than the second seeded team. This raises the possibility that in certain situations it might be advantageous for a team to intentionally lose a game in an attempt to get a more optimal (though possibly lower) seed in the tournament. We examine this question in the context of a four or eight team league which consists of a round robin "regular season" followed by a single elimination tournament with seedings determined by the results from the regular season. Using the same probability model as Schwenk, we show that there are situations where it is indeed optimal for a team to intentionally lose. Moreover, we show how a team can make the decision as to whether or not it should intentionally lose. We did two detailed analyses. One is for the situation where the other teams always try to win every game. The other is for the situation where other teams are smart enough, namely they can also lose some games intentionally if necessary. The analysis involves computations in both probability and (multi-player) game theory.