# ABSTRACTS OF TALKS PRESENTED TO THE INDIANA SECTION OF THE MAA

## 1. Introduction

The Spring 2010 meeting of the Indiana Section of the Mathematical Association of America was held at Franklin College, April 9–10. 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:** Rick Cleary, Bentley University

*Some non-standard applications of mathematics to sports*

Thanks to the popularity of books like *Moneyball* by Michael Lewis, there has been a great increase in public awareness that statistical analysis has become a vital and accepted tool in sports applications. We present some examples in which other branches of mathematics can be used to consider sports related questions. We will investigate several of these less well known applications. Specific instances include: using probability to model rare events; some graph theory and operations research to consider a scheduling question; an optimization problem involving a basketball pool; and maybe even some elementary topology related to the rules of several sports.

**Presenter:** Eric Rowland, Tulane University

Wolfram|Alpha*: inside and out*

Wolfram|Alpha is a "computational knowledge engine," a web site that computes — rather than searches — for answers to user input. It went live in May 2009. Much more than a calculator, Wolfram|Alpha accepts free-form input and outputs not just an answer but related information as well. For example,

```
integrate x^2 log x^2 wrt x
```

returns the antiderivative (along with steps to compute it), some plots, and a few other facts about the integral. I'll talk about the main components of Wolfram|Alpha, giving some idea of what goes on behind the scenes. I'll also try to convey the current breadth of functionality, in mathematics as well as other areas. Finally, I'll address possible consequences for mathematics education of Wolfram|Alpha's ability to perform computations at such low cost to the user.

## 3. Student Workshop

**Presenters:** Crystal Lorch and John Lorch, Ball State University

*The mathematics of sudoku*

The process of completing a newspaper sudoku puzzle is only half of the fun. In this workshop we investigate interesting open mathematical problems involving completed sudoku puzzles, such as counting certain types of puzzles and determining the maximum size of a family of mutually orthogonal puzzles. Along the way we will encounter group theory and linear algebra.

The slides are available online:
`http://www.cs.bsu.edu/homepages/jdlorch/MAAWorkshop.pdf`

## 4. Indiana Project NExT Panel Discussion

**Panelists:** Carl Cowen (IUPUI), Matt DeLong (Taylor University), and David Housman (Goshen College)

*Incorporating undergraduate research into your personal research track*

Undergraduate research has an ever-growing presence in mathematics departments. As a junior faculty member, it can be difficult to balance an undergraduate research program with a personal research agenda. This panel will provide ideas for maintaining and combining both of these areas. Other topics may include finding students to work with, generating research topics for yourself and for your students, guiding students through writing papers and presentations, and more.

## 5. Contributed Talks

**Presenters:** Ryan Bowman and Kris Wease, Vincennes University undergraduates

**MSC2010:** 97

*Examining the relationship between teachers' images of mathematics and their mathematics history knowledge*

This study reveals what K–12 teachers nationwide ($N > 4,600$) believe about mathematics, what they know about mathematics history, and the significant correlational relationships between level of mathematics history knowledge and beliefs about mathematics. Teachers believe that mathematics is fun, thought-provoking, and intricately connected to the real world. They disagree with statements like "everything important in mathematics is already known" and "mathematics is a disjointed collection of facts rules and skills." Teachers with high history scores were more likely to strongly agree that mathematics is fun, thought-provoking, creative, ever-changing, and makes a unique contribution to human knowledge. Teachers with high history scores were more likely to disagree that mathematics is a disjointed collection of facts rules and skills and that everything important in math is already known. This large-scale correlational study shows that there is indeed a relationship between teachers' knowledge of mathematics history and their images of mathematics as claimed by many theorists and that further research is needed to test a causal relationship.

**Presenter:** Mark Burek, Valparaiso University undergraduate
**Joint work with:** Michael Borchert and Spencer Roach, Valparaiso Univeristy
*Modeling the political stability of neighborhoods in the US*

In a segregation game, the investigator is studying patterns of movement amongst two types of individuals in a community. Individuals are content when they are next to other individuals like themselves. Two types of equilibrium states exist in this game which leaves the community either segregated or integrated together. Previous research has demonstrated that segregated equilibrium states are the only stochastically stable states, but has limited its focus to two types of individuals. Our work extends the segregation game to three types of individuals. We show that given random perturbations of groups in a community, the only stochastically stable states are the segregated equilibrium states.

**Presenters:** Jessi Byl and Rachel De Meo, Taylor University undergraduates
*Investigating determinants and polynomials of weaving knots*

In this talk, we will lay out some of the background material necessary for understanding our research on weaving knots. This discussion will include a description of general knot invariants, and the particular invariants of colorability, determinant and the Alexander Polynomial. We will then present a new method for calculating the determinants of weaving knots. We will use our method to give a simple formula for the determinants of $(m, 3)$-weaving knots, and show that this result aligns with a known result obtained by another undergraduate research team. Finally, we will present preliminary findings regarding the Alexander Polynomials of the $(m, 3)$-weaving knots.

**Presenter:** G. Daniel Callon, Franklin College
*Creating a departmental culture of enriching experiences*

The Department of Mathematics and Computing at Franklin College has constructed an integrated experience for its mathematics majors and minors featuring innovative courses and co-curricular programming. The purpose is to help its students learn about the professional opportunities available in mathematics in keeping with Franklin's mission and the composition of its student body with $35-40\%$ first generation college students.

The courses include a one-hour freshman activity course which introduces students to professional opportunities in mathematics and emphasizes mathematical processes and ways of working, and a junior-senior level semester-long team statistical consulting service project for a local non-profit agency. Co-curricular programming incorporates interaction with fellow students, faculty, alumni, and other professionals. On our campus of 1040 students, the number of mathematics majors and minors is growing (currently about a dozen sophomores have declared majors in mathematics) and attendance at departmental events runs between 35 and 75. This presentation will provide details about the courses and programming as well as tips for putting together such a program on your own campus.

**Presenter:** Adam Coffman, Indiana - Purdue Fort Wayne
**Joint work with:** Yifei Pan, Jiangxi Normal University and IPFW
**MSC2010:** 35R45
*Glaeser's inequality on an interval*

"Glaeser's Inequality" is a theorem of elementary calculus which states that if a function $f$ is non-negative on $\mathbb{R}$ and has continuous second derivative bounded by $M$, then the first derivative satisfies $|f'(x)| \leq \sqrt{2Mf(x)}$ at every point $x$. It is easy to find counterexamples if we change the domain $\mathbb{R}$ to an arbitrary interval, but I will present an analogous pointwise inequality for functions on an interval, which specializes to Glaeser's inequality as a limiting case.

**Presenter:** Melissa Desjarlais, Valparaiso University
**Joint work with:** Jamie Radcliffe, University of Nebraska–Lincoln
*Threshold signed dominating function for trees*

What is the minimum number of queens needed to be placed on a chess board so that every square is "covered" by at least one queen? The strategic placement of pieces on the vertices of a graph illustrates the idea of dominating sets. A vertex $v$ in a graph $G = (V, E)$ is said to dominate all of the vertices adjacent to it, and a dominating set in $G$ is a set of vertices $D$ which dominates all of the vertices not in $D$. Another way to identify a dominating set is to define a function $g : V \to \{0, 1\}$ such that $\sum_{u \in N[v]} g(u) \geq 1$ for all vertices $v \in V$ and closed neighborhoods $N[v]$. The vertices labeled 1 form the dominating set. By changing the vertex labels and the minimum value for a neighborhood, this dominating function can be extended to a threshold signed dominating function. An algorithm is given for finding threshold signed dominating functions on trees.

**Presenter:** Danielle Goodwin, Vincennes University
*Investigating perfect shuffles*

This talk will detail an ongoing mathematical conversation that a group of Vincennes University students, staff, and faculty had during summer 2009 about the minimum number of perfect shuffles required to restore a playing card deck of size $N$ back to its original order.

**Presenter:** Bill Karr, IUPUI undergraduate
**MSC2010:** 15B52
*Eigenvalue distributions of random non-Hermitian matrices with purely real spectra*

Random matrix theory is a well established field of mathematics with wide applications in subjects from number theory to nuclear and statistical physics. In particular, Wigner's semicircle law — which predicts the eigenvalue density of large Hermitian matrices whose entries are drawn randomly from an arbitrary probability distribution with zero mean and a well-defined variance — is the most celebrated and robust result. In this particular case, the matrix is Hermitian with respect to the standard inner product on $\mathbb{C}^N$, i.e. $M = M^\dagger$, where $M^\dagger$ is the complex conjugate of the transpose of the matrix $M$. We explore the eigenvalue density of large random matrices that are Hermitian with respect to a general inner product $(\ ,\ )$

on $\mathbb{C}^N$ defined by a positive-definite function $(u, v) = \sum_{i=1}^{N} f(i) u_i v_i$. The eigenvalues are, as expected, purely real. The eigenvalue density, however, does acutely depend on the function $f$. We present numerical results and heuristic arguments for the eigenvalue density, and point out outstanding questions.

**Presenter:** Wah-Kwan Ku, Indiana University Bloomington graduate student
**Joint work with:** Marlies Gerber
**MSC2010:** 53
*Finite blocking property of surfaces*
Let $M$ be a surface. A pair of points $p$, $q$ on $M$ is said to have the finite blocking property if all geodesics from $p$ to $q$ are blocked by a finite set of points. $M$ is said to have the finite blocking property if every pair of points has the finite blocking property. In a joint work with Marlies Gerber, we proved that most surfaces don't have the finite blocking property. Another standing conjecture is that the flat torus is the only surface with the finite blocking property.

**Presenter:** Phil Mummert, Taylor University
**Joint work with:** Joe Seaborn, Taylor University undergraduate
*A discrete complex calculus*
We consider a finite calculus on the integer lattice of the complex plane. Using a discrete analogue of the Cauchy-Riemann equations, what are the analogous calculus notions of path integrals, powers, and the exponential function?

**Presenter:** Samuel Roth, Grace College undergraduate
*Making infinite series easier via integral transforms*
The typical calculus student has much more practice and savvy in evaluating definite integrals than in summing infinite series. We will examine a technique that converts series into integrals. In particular, when the summand $u_n$ of a series $\sum_{n=1}^{\infty} u_n$ can be recognized as a definite integral in the form $\int_0^{\infty} f(x) e^{-nx} dx$, and when the order of summation and integration can be interchanged, it will be possible to recast the original series as a definite integral. This technique is powerful; it enables us to find closed-form sums for a broad family of main-stream series. We will survey how this technique has been applied in recent literature, and we will extend the technique by applying it to some additional series.

**Presenter:** Melvin Royer, Indiana Wesleyan University
*Gabriel's other equipment*
Gabriel's Horn is the most widely known example of a solid of revolution with an unexpected finitude relationship (infinite surface area but finite volume). This talk investigates other similar solids as well as fractal-like solids, comparing the finitude between volume, surface area, area of the planar generating region, and length of the curve bounding the generating region. The relevant calculations and graphics involved make the topic a good source of computer lab activities in a Calculus II or Real Analysis class.

**Presenter:** Adam Salminen, University of Evansville
*Generalizing some old problems on Abelian groups*
Everyone is familiar with the group of integers $\mathbb{Z}$. A simple exercise in group theory is to show that this is the only infinite Abelian group which is isomorphic to all of its nonzero subgroups. We will discuss this and other defining properties of $\mathbb{Z}$. We will also show how certain duals of these properties define the quasi-cyclic groups $\mathbb{Z}(p^\infty)$. These notions can be translated into questions about modules over commutative rings. Finally, we will briefly survey some recent results in this direction.

**Presenter:** J. Christopher Tweddle, University of Evansville
*An introduction to mathematical modeling of atmospheric dispersion*
Mathematical modeling can be used to predict the dispersion of pollutants from smoke-stack emissions into the surrounding environment. The EPA has developed sophisticated models to use in regulatory capacities. This expository talk will introduce some of the basic mathematical components of dispersion modeling. We will also discuss AERMOD, the current EPA approved technique.

**Presenter:** Chad Waddington, Indiana Wesleyan University undergraduate
*Sinks, saddles, sources: The path to chaos*
Many physical systems commonly encountered in mathematics and the natural sciences are fundamentally chaotic in nature. We endeavor to give a general explanation of what is meant by a chaotic system, how such systems may be quantified, and provide a look at the end behavior of a few chaotic systems. We use information from several research texts to construct a broad mathematical survey of the basics of mapping functions and show how many simple maps display chaotic behavior. We construct several examples of chaotic attractors using a program in C++ to plot the first several thousand iterates of a few well known mapping functions and draw conclusions from this data. We ultimately consider briefly the philosophical implications that chaotic systems have on scientific research.

**Presenter:** Brittany Wagoner, Valparaiso University undergraduate student
**Joint work with:** Samantha Frisk, Patrick Slattery, and Kelsey Watson
*Medians of permutations*
The distance between two permutations can provide insight to situations such as voting and comparing strands of DNA. There are many ways to define the distance between a pair of permutations. We have worked with the distance axioms to define new distances. The Median is a permutation which gives the smallest sum of distances between itself and each permutation in the given set. Given a set of permutations and a distance, $d$, we are interested in computing the Median(s) of that set. For several different distances we are developing theorems to find how many and what medians a set of permutations and a distance, $d$, may have.