

ABSTRACTS OF TALKS PRESENTED TO THE INDIANA SECTION OF THE MAA

1. INTRODUCTION

The Spring 2009 meeting of the Indiana Section of the Mathematical Association of America was held at Indiana University - Purdue University Indianapolis, March 20–21. The abstracts appearing here are based on text electronically submitted by the presenters. Contributed talks are listed in roughly the order in which the presenters submitted their abstracts.

An appropriate bibliographic citation of an abstract here would have a format something like:

J. PRESENTER* and A. CO-AUTHOR, *Talk title* (abstract), Electronic Newsletter of the Indiana Section of the MAA, Spring 2009.

2. INVITED TALKS

Presenter: Dan Teague, North Carolina School of Science and Mathematics

Group testing: A non-standard optimization problem

Suppose you want to test all NCAA athletes for steroid use. Is it possible to pool urine samples from several individuals and test them together? If so, how large should the groups be to minimize the total number of tests required? This talk presents several inventive student solutions to this classic group testing problem. The problem is based on a technique developed by the army during World War II by R. Dorfman. At that time, the issue was one of screening recruits for syphilis by pooling blood samples. In actual practice, by testing first in groups, the army achieved a reduction of 80% in the number of tests required over testing individually. The basic procedure has been modified in a variety of research areas, including screening blood for diseases, for detecting defective parts in production lines, efficient storage and access of punched card catalogues, for minimizing the number of wires in magnetic core memories, for conflict resolution in multi-access channels, and for screening libraries of clones for the human genome project.

Presenter: Dan Teague, North Carolina School of Science and Mathematics

Where are the toads?

Marianne Moore has described poetry as “an imaginary gardens with real toads.” This description works equally well for mathematics. Her metaphor captures the wonderful duality and interplay of theory (the imaginary garden) and application (real toads) that we treasure in our subject. While this depiction of mathematics is appealing, it can set up a false dichotomy with strong advocates for proof and rigor on one side and equally strong advocates for applications on the other. Mathematical modeling, early and often, offers a connecting corridor between proof and application, between garden and toad, and supports a rich and blended view of mathematics and mathematical investigation.

Presenter: Paul Coe, Dominican University

Probability and The Price is Right

Each weekday an applied probability workshop is played out on national TV on a game show called *The Price is Right* (TPIR). Playing along with contestants and scrutinizing their decisions on TPIR is perhaps the closest that many people come to dealing with serious mathematical analysis and strategic decision-making, whether they realize it or not. *The Price is Right* features a collection of games involving, to a greater or lesser extent, skill, knowledge of prices, strategy, and often a bit of luck. The show is broken up into four major segments, and I will discuss strategy in each segment. After hearing this talk, I hope that you will be at least a little better prepared should you ever hear your name with that famous call to “come on down...”.

3. CONTRIBUTED TALKS

Presenter: Danielle Goodwin, Vincennes University

MSC2000: 97

What do IN, IL, MI, KY, and OH teachers believe about mathematics and what do they know about mathematics history?

This study reveals what Indiana, Illinois, Michigan, Kentucky, and Ohio K–12 teachers 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 in these states 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 ($N = 465$) is part of an ongoing national study (with over 2000 respondents so far), which 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: Rodney Lynch, IUPUC (Also IUPUI graduate student)

Roots of a cubic equation with cyclic Galois group

Let θ be a root of $x^3 + ax + b = 0$ where the Galois group of $x^3 + ax + b$ over the rationals is cyclic. Then the other two roots can be expressed in the form $c_1 + c_2\theta + c_3\theta^2$ with c_1, c_2, c_3 rational numbers. I will give explicit formulas for the other two roots in this case.

Presenter: Matt McBride, Indiana University - Purdue University Indianapolis graduate student

Dirac type operators on the non-commutative cylinder

It is a well known fact that the analytic index of any linear transformation in a finite dimensional vector space is zero. It is also known that operators in infinite dimensional vector spaces do not always have index zero. In particular the Dirac type operator $D = a(\rho)e^{-i\varphi} \frac{\partial}{\partial \bar{z}}$ on the commutative cylinder has non-zero index. Working with these operators in the continuous setting is not always easy, thus it is interesting to study its discrete analogue in the non-commutative cylinder case, and it turns out that they have the same index.

Presenter: Mark Burek, Valparaiso University undergraduate student

Joint work with: Brian McDonaugh, Spencer Roach, and Brit Wagoner, Valparaiso University undergraduate students

Faculty Mentor: Rick Gillman, Valparaiso University

MSC2000: 91D10

Segregation game: Isolation and contentment in neighborhood segregation patterns with three types

In *Individual Strategy and Social Structure*, Young describes a particular version of The Segregation Game. This paper begins to extend the work of Young to configurations involving three types of individuals. Seven scenarios representing different possible biases amongst the three types are identified, and contentment levels at equilibrium for each scenario are investigated. Surprisingly, holding biases against other types increases the likelihood of being isolated.

Presenter: Deborah Beals, Valparaiso University undergraduate student

Joint work with: Robert Thompson, Valparaiso University undergraduate student

Faculty Mentor: Zsuzsanna Szaniszló, Valparaiso University

4-equitable graph labeling

A labeling of a graph is a function L from the vertex set to some subset of the natural numbers. The image of a vertex is called its label. We assign the label $|L(u) - L(v)|$ to the edge incident with vertices u and v . In a k -equitable labeling the image of L is the set $\{0, 1, 2, \dots, k - 1\}$. We require both the vertex labels and the edge labels to be as equally distributed as possible. We examine 4-equitable labelings of caterpillars.

Presenter: Kurt Bryan, Rose-Hulman Institute of Technology

MSC2000: 35R30

The mathematics of cloaking

Cloaking and invisibility are staples of popular fiction, especially science fiction. The pseudo-explanation usually given is that “the selective bending of light rays” (to quote Mr. Spock) around the object to be cloaked can render the object invisible. But with the laws of physics in the real world, is this really possible, even in theory? Scientists and mathematicians have recently found that the answer to this question is a qualified “yes.” In this talk I’ll give a quantitative, but accessible, account of the essential mathematical idea behind cloaking, in the context of an electromagnetic imaging technique called “impedance imaging.”

Presenter: Ryan Bowman, Vincennes University undergraduate student

MSC2000: 01

A “skeleton” overview of John Napier and Napier’s bones

John Napier (1550–1617) was a Scottish mathematician who developed the first documented effort toward formalizing the concept we now recognize as logarithms. Observations that may have led to Napier’s discovery will be presented. Napier developed a tool, known as Napier’s bones, for performing mathematical operations; a demonstration will be offered.

Presenter: David Housman, Goshen College

Modeling a biological auction

Two animals vie for a prize: territory, food, or a mate. They display their prowess and may even fight. Eventually a winner emerges and the loser sulks away. This is analogous to an auction where the loser, as well as the winner, must pay his bid. A mathematical model of this scenario and its solution involves concepts and techniques from undergraduate probability and calculus II: probability density, mathematical expectation, function maximization, fundamental theorem of calculus, inverse functions, and the derivatives of inverse functions. A complete derivation and a surprising conclusion is given.

Presenter: Kris Wease, Vincennes University undergraduate student

MSC2000: 97

Inquiry-based interactive mathematics: The king’s courtyard

What is inquiry-based teaching? Could inquiry-based teaching be right for my mathematics classroom? A sample inquiry lesson, called “The Marching Strip” or “The King’s Courtyard” from the eleventh grade year of the Interactive Mathematics Program (a National Council of Teachers of Mathematics standards-based high school mathematics program funded by the National Science Foundation) will be used to show inquiry in action. Come explore a neat high school problem with us!

Presenter: Jeffrey A. Oaks, University of Indianapolis

Diophantus rediscovered and incorporated: Arabic and Italian incarnations of Greek algebra

Diophantus of Alexandria wrote his *Arithmetica* in Greek sometime around the third century CE. It was rediscovered by Arabic algebraists in the ninth c., after Arabic algebra was well established. Al-Karaji incorporated many of Diophantus’ problems in his algebra text *al-Fakhri* (early 11th c.). When Diophantus was rediscovered again during the European Renaissance, Rafael Bombelli similarly appropriated large portions into his *L’Algebra* (1572). In this talk I walk through one problem of Diophantus, comparing the Greek, Arabic, and Italian versions.

Presenter: Vesna Kilibarda, Indiana University Northwest

MSC2000: 97D30

Mathematics PRAXIS II — Deep understanding of simple concepts

A year ago, several colleagues and I received a grant to help us better prepare our secondary school mathematics pre-service teachers to pass the Praxis II math test required for teacher’s licensure in Indiana. Our students indicated that the exams

were different from what they expected based on the test preparation materials and needed our help to be more successful on the exams. Two of us took the Mathematics: Content Knowledge exam as a part of the grant. We also reviewed some of the available preparation resources. Based on our experience we report several ways that could insure better preparation of our students for these exams. The major component of our curriculum that we identified for improvement is solving problems by integrating knowledge from different areas of mathematics.

Presenters: Jennifer Beineke, Western New England College; and Lowell Beineke, IPFW

MSC2000: 05C

Splendor in the graphs

Graph theory can provide an entertaining analysis of certain games and puzzles. In this talk, we share some examples that we have found successful in talks to math clubs and in the classroom. Using elementary results, we will explore brainteasers such as Dots-and-Boxes, Bridg-It, Paradoxical Pennies, and Perplexing Prisoners. That should be preparation enough to set us off on a mathematical sort of safari.

Presenter: David Benko, University of South Alabama

A random walk on Wall Street

The stock market plays a crucial role in today's economics and politics. This "gigantic roulette wheel" affects your life even if you don't have any investments. How many zeros are there on this wheel...? I will explain the mathematical model of stock prices and arrive at a surprising conclusion. I will also discuss some myths that you might have heard from financial advisors.

Presenter: Josh Meek, Hanover College undergraduate student

Web based computer lab imaging with Grimioire

We present Grimioire, a web-based frontend for the disk imaging software Clonezilla. Grimioire was created to maintain computer labs in an academic setting. Each class had different needs for software and operating systems, yet classes compromise on what is installed so they can coexist in the same lab. Reinstalling the operating systems on the lab computers simply takes too long to be done daily, for each class. Labs, which are maintained by the professors, also face the problem of malfunctioning computers, and the time needed to troubleshoot the issue or reinstall the computer's operating system is often not available during the semester. Grimioire allows administrators to restore and maintain an entire lab of computers, rather than a single computer or a single homogenous image. Administrators can create a lab configuration for each use of the lab, and restore them with a single option. Grimioire stores configuration data for each computer in each class, allowing lab configuration to contain heterogeneous images. Finally, Grimioire is web-based and provides administrative control over the entire imaging system, as well as user level control over a single client computer. Professors can modify entire labs with one operation. Students can repair the computer they are logged into.

Presenter: Herb Bailey, Rose-Hulman Institute of Technology

Fetching water with least residues 101

We begin with a clip from the movie *Die Hard III* where Bruce Willis is given a 3 gallon jug, a 5 gallon jug and a water source. He is to get exactly 4 gallons as quickly as possible. We solve some problems with other jug sizes using results involving least residues. The discussion will be motivational and includes a contest pitting faculty against students. If you find yourself motivated, please stay for the next talk which includes some proofs.

Presenter: Herb Bailey, Rose-Hulman Institute of Technology

Fetching water with least residues 301

Given a water well, an M gallon jug and an N gallon jug, with M and N relatively prime and $N > M > 0$, we prove

- a) With a suitable pouring sequence, one can draw exactly x gallons for any integer x between 0 and $M + N$.
- b) There are exactly two distinct sequences to accomplish this.
- c) The ‘faster’ sequence can be determined by solving a linear congruence.

Presenter: Jeremiah Farrell, Butler University

Joint work with: 4 students: Darrin Ferry, Michael Hill, Timothy Rogers, Marcus Such, Butler University

Flocks of birds — A new combinatorial game

We collect several “BIRDS” into a flock for a game between two players who alternately simplify BIRDS of their choice. The standard Sprague-Grundy function has unexpected fluctuations that are eventually tamed with a few key theorems.

Presenter: Brian Murphy, Ivy Tech Community College - Lafayette

Mathematical Platonism and Zeno

Mathematical Platonism asserts mathematical objects exist and are abstract non-spatiotemporal entities. Furthermore, mathematical objects are independent of us, our minds and language. An epistemological problem with Platonism is the question is how one can obtain knowledge of independent abstract objects. An argument addressing this problem is that knowledge of abstract mathematical objects might be acquired from confirming the truth of empirical scientific theories in which applied mathematics is indispensable. The indispensability argument is examined in the context of Zeno’s paradoxes and Zenonian supertasks.

Presenter: David Redett, Indiana - Purdue Fort Wayne

Joint work with: James Tung

Invariant subspaces in Bergman space over the bidisc

In this talk, we will begin with a brief introduction to the invariant subspace problem for the shift operator on ℓ^2 . Motivated by this, we introduce the invariant subspace problem in $H^2(\mathbb{D})$ with respect to the operator of multiplication by the coordinate function. We then consider the multivariate version of this problem, highlighting the work of V. Mandrekar. It is this work that inspired the research associated with this talk. We investigate Mandrekar’s doubly commuting condition in the Bergman space over the bidisc. Our work relies heavily on the recent work of S. Shimorin. We find that under this doubly commuting condition the invariant

subspaces have a description similar to that of the univariate case given by A. Aleman, S. Richter and C. Sundberg.

Presenter: Josh Holden, Rose-Hulman Institute of Technology

Braids, cables, and cells: An interesting intersection of mathematics, computer science, and art

The mathematical study of braids combines aspects of topology and group theory to study mathematical representations of one-dimensional strands in three-dimensional space. These strands are also sometimes viewed as representing the movement through a time dimension of points in two-dimensional space. On the other hand, the study of cellular automata usually involves a one- or two-dimensional grid of cells which evolve through a time dimension according to specified rules. This time dimension is often represented as an extra spatial dimension.

Therefore, it seems reasonable to ask whether rules for cellular automata can be written in order to produce depictions of braids. The ideas of representing both strands in space and cellular automata have also been explored in many artistic media, including drawing, sculpture, knitting, crochet, and macramé, and we will touch on some of these.

Presenter: Jason Sauppe, Rose-Hulman Institute of Technology undergraduate student

A tabu search algorithm for the bandwidth multicoloring problem

The bandwidth multicoloring problem is a generalization of the graph coloring problem where nodes receive multiple colors and the difference between colors assigned to adjacent nodes must be at least the weight of the edge joining them. The goal is to find a coloring that minimizes the difference between the smallest and largest colors used, or the color span. We present a tabu search algorithm for solving this problem that starts with a greedy initial coloring and iteratively searches for colorings with a smaller color span. Results from our approach are compared with the best solutions reported in the literature.