

ABSTRACTS OF TALKS PRESENTED TO THE INDIANA SECTION OF THE MAA

1. INTRODUCTION

The Fall 2012 meeting of the Indiana Section of the Mathematical Association of America is meeting at Butler University, October 27. 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: Sam Wagstaff, Department of Computer Science, Purdue University West Lafayette

The Search for Aurifeuillian-Like Factorizations in the Cunningham Tables

We describe the Cunningham tables (they list factors of numbers $b^n \pm 1$) and tell how we searched through them for new algebraic factorizations similar to those discovered by Aurifeuille. A naive search would have been too slow. We accelerated it enough to make it feasible. Many interesting results were found.

Presenter: Paul Zorn, MAA president, St. Olaf College

Picturing Analysis

“Thinking in pictures” is standard operating procedure in teaching and learning geometry, graph theory, elementary calculus, and other visually rich areas of mathematics. Less obvious, but no less valuable, are visual insights into key ideas and theorems from real and complex analysis. It’s one thing to know what, say, differentiability and integrability mean, but how do they look? How do poles and essential singularities of complex functions look in color? Can countability be seen? I’ll give examples and suggest implications for better teaching, learning, and understanding.

3. INDIANA PROJECT NEXT PANEL DISCUSSION

Panelists: Mindy Capaldi, Valparaiso University; Dana Ernst, Northern Arizona University; Robert Talbert, Grand Valley State University.

Moderator: Stacy Hoehn, Franklin College

Inquiry Based Learning

We will discuss inquiry based learning, inverted classroom models, peer instruction, and other alternatives to lecture-based instruction. Panelists will give a brief intro of their experience in these areas, followed by an extended time of Q&A with the audience. This panel is open to all meeting participants.

4. CONTRIBUTED TALKS

Presenter: Ron Benbow, Taylor University

Explore international math opportunities for teaching, scholarship, and service

There are numerous overseas opportunities in which to apply your knowledge and interest in mathematics teaching. These international experiences allow you to expand your scholarship, to extend your teaching skills, to offer service to K-12 teachers or other university instructors, and provide personal enrichment as well. Examples from recent experiences in Liberia, Haiti, Guatemala, and Ecuador will be shared and information regarding Fulbright Specialist grants, MAA study tours, and other appropriate organizations will be provided.

Presenter: Yizhou Bo, DePauw University undergraduate student

Faculty Advisor: Naima Shifa, DePauw University

Estimating the abundance of clustered animal population by using adaptive cluster sampling and negative binomial distribution

To maintain balance in nature, to meet the challenges of sustaining life on earth, or to provide sound and effective public policy, researchers always would like to estimate the density or the total of natural populations. It is not always easy and straightforward to obtain the abundance of animal populations when the study area is vast and animals are clustered and mobile. In this research work, we propose a multistage sampling design for estimating animal populations that are spread over an extensive area, and highly clustered. This model is based on adaptive cluster sampling (ACS) to identify the location of the population and negative binomial distribution to estimate the total in each site. To identify the location of the population we consider both sampling with replacement (WR) and sampling without replacement (WOR). Some mathematical properties of the model are also developed.

Presenter: James Carter, Indiana University - Purdue University Indianapolis graduate student

Roshambo and other games

In this presentation we discuss the basic ideas and terminology of Game Theory as it relates to several games, including both discrete and continuous games. Various methods to arrive at winning strategies for these games will be discussed. Several applications to economics and social interaction will be presented. Finally, a connection to graph theory is demonstrated with the game of Nim.

Presenter: Dennis Collins, University of Puerto Rico, Mayaguez (retired)

Toward the maximum and minimum symmetry of order 24 groups — “bug” analogy

This paper continues the speaker’s 2011 work *Measuring the symmetry of a finite group* by studying the symmetry of some 6 out of 15 non-isomorphic order 24 groups, looking for maximum and minimum symmetry. The symmetry is based the distribution pattern of the number of transpositions needed to get from one group element to another. The maximum symmetry occurs when the distribution is concentrated on only one or a few transposition numbers, whereas the minimum symmetry (maximum entropy) occurs when the distribution is spread out as evenly as possible. Transitive group presentations of the same group over different degrees (i.e. number of base symbols) can have different symmetry. For example the symmetric group S_4 over 4 symbols (degree 4) has symmetry 13758; over 6 symbols, symmetry 23262; and over 24 symbols, symmetry 12894. It is conjectured that 23262 is the maximum symmetry over all order 24 groups and 6414 is the minimum symmetry of order 24 groups for the group $\mathbb{Z}_6 \times \mathbb{Z}_4$ over 10 symbols (degree 10). The different degrees can be considered as different “ecosystems” for the “bugs” (transitions) to live in. There is a Mathematica program to calculate symmetry and the 6 groups studied are those which can be obtained by Mathematica cycles by the author at present.

Presenter: Mark Gruenwald, University of Evansville

Joint work with: David Dwyer, University of Evansville; Joe Stickles, Millikin University; Mike Axtell, University of St. Thomas; Ken Luther, Valparaiso University; Nick Baeth, University of Central Missouri

Resequencing calculus: an early multivariate approach

The first phase of the Resequencing Calculus project (supported by NSF CCLI grant 0836676) involved the development and implementation of a redesigned three-semester calculus sequence at the University of Evansville. The primary goal of this project was to reorder and reprioritize topics so that material prerequisite for upper-level STEM courses would be front-loaded into the first two semesters and so that there would be a more natural progression of difficulty throughout the three-course sequence. This has been accomplished, in part, by introducing multivariate calculus in the second semester and postponing infinite series to the third semester. A key benefit is that Calculus 1 and 2 now form a strong two-course sequence for students in the life sciences, economics, and chemistry, all of whom are likely to encounter multivariable models in later courses within their disciplines. Moreover, students successful in Calculus 2 may enter directly into not only Calculus 3, but also differential equations, linear algebra, or calculus-based probability. The restructuring eases time pressure in Calculus 3, thus facilitating a thorough treatment of vector calculus through Stokes’ Theorem and the Divergence Theorem while maintaining a rigorous treatment of the material. The second phase of the project (supported by NSF TUES grant 1225566) will involve completing and refining a text that supports the redesigned sequence and piloting the sequence at four other universities (Valparaiso, Millikin in Illinois, St. Thomas in Minnesota, and Central Missouri). The presenter will discuss progress to date and plans for the second phase. Details can be found at <http://www.resequencingcalculus.com>.

Presenter: Derek Linn, Franklin College undergraduate student

Why did I ever choose this major?

Choosing a major is a very difficult and important task as sets you down a career path for the rest of your life. I want to know why people are comfortable in certain areas of study, so I chose to delve into how students learn and their majors. This study prompts students at Franklin College to take a test that assesses their learning styles. This data, along with each respondent's respective demographic information, is analyzed to see similarities or differences and to possibly prove a relationship between learning styles and academic majors. These results can be used to help professors better understand the educational needs of the students. They could also be used by admissions offices to give undecided students an idea of what majors are best for their learning styles.

Presenter: Horia Petrache, IUPUI Department of Physics

Coset extensions of real numbers

The set of real numbers is extended by using the concept of coset products from group theory. This approach is intended for students with minimal knowledge of group theory but with an interest in number systems. In algebra over fields, various extensions of real numbers are obtained by choosing a base and by specifying multiplication rules for basis elements. Such constructions give rise to the usual complex numbers, quaternions, and so forth. However, the choices of multiplication rules (including the values for structure coefficients) appear ad hoc. Here it is shown that multiplication rules and structure coefficients are obtained naturally from coset group closure and exhaust all possibilities of hypercomplex numbers. The cases corresponding to small groups generating 2, 3, and 4 dimensional number systems will be shown as examples.

Presenter: Drew Reisinger, University of Evansville undergraduate student

Joint work with: Kyla Baldwin, Indiana University undergraduate student

Faculty Advisor: Matthias Weber, Indiana University Bloomington

An abstract encoding of surfaces tiled by parallelograms

With an eye toward understanding and classifying periodic polyhedral surfaces in space, this presentation describes and demonstrates an intuitive and compact combinatorial encoding of abstract surfaces tiled by quadrilaterals that generalizes the concept of zones from the study of zonohedra. Such representations, augmented by a finite set of vectors, yield parametrized spaces of periodic surfaces tiled by parallelograms that share the same combinatorial structure. The case of periodic tilings of the Euclidean plane is explored in more depth, and algorithms for classification and visualization of such tilings are demonstrated in Mathematica.

Presenter: Barbara Sanborn, Rose-Hulman Institute of Technology

Quantum mechanics from a geometric point of view

The theory of geometric quantum mechanics describes a quantum system as a Hamiltonian dynamical system, with the natural inner product on a complex projective vector space playing a central role. This talk explains the fundamentals of this approach to quantum mechanics, and shows how the concept of a symplectic structure is useful for understanding both classical and quantum dynamics. Geometric quantum mechanics emphasizes that the quantum state space is endowed with an extra metric structure not found in classical mechanics; this additional structure makes an appearance in the uncertainty principle specific to quantum systems. Recent work gives a geometric interpretation of the covariance matrix corresponding to the measurement of two quantum observables.

Presenter: Derek Thompson, Indiana University - Purdue University Indianapolis graduate student

Board and card games in finite mathematics

We emphasize to our education majors the importance of kinesthetic learning, but often fail to find time for it within university coursework. One way to incorporate kinesthetic learning into a college math course is through board and card games. In recent years, such games have advanced greatly in the amount of strategy and mathematical thinking required for play. I will point out games that have direct relations to probability, logic, and graph theory. I'll also give examples of associated homework appropriate for a college course in finite mathematics, including courses for non-majors.

Presenter: Michael Xue, Vroom Laboratory for Advanced Computing

An algebraic approach to geometric proof using a Computer Algebra System

Geometric proof is often considered to be a challenging subject in mathematics. The traditional approach seeks a tightly knitted sequence of statements linked together by strict logic to prove that a theorem is true. Moving from one statement to the next in traditional proofs often demands clever, if not ingenious reasoning. An algebraic approach to geometric proof, however, aims to computationally produce values that imply the thesis statement of the theorem. This presentation will demonstrate the algebraic approach to geometric proof through examples.

Presenter: Matthias Youngs, Indiana University Bloomington graduate student

Joint work with: Prof. David Hoff, Indiana University.

MSC 2010: 35M30, 76N10

Solutions to a model for heat conducting flow

We describe a mathematical model for a compressible, heat conducting flow using the Navier-Stokes equations. We give a definition of a weak solution to accommodate discontinuities that could develop for a dense set of times. The problem and physical background is discussed. Then we state the main result, outline the key ideas to deal with challenges associated to the nonlinear PDE, and highlight arguments in the proof.

Presenter: Lirong Yuan, Purdue University West Lafayette undergraduate student

The probability that a polynomial with integer coefficients has all real roots

It is natural to use polynomials with integer coefficients for examples and exercises in an algebra course. However, not all such polynomials have all real roots. We ask a question: what is the probability that a random polynomial with integer coefficients has all real roots? We use some tools from probability theory and complex analysis to reduce the problem to studying the roots of random polynomials with real-valued coefficients instead. We discover that the probability that a polynomial of degree n with integer coefficients has real roots is equal to the probability that a polynomial of degree $n - 1$ over real coefficients has real roots. In certain cases this allows us to use calculus to obtain an exact answer.

Presenter: Hengshuo Zhang, DePauw University undergraduate student

Estimating the total number of STD patients in a large community by using multistage sampling techniques

The estimation of the total number of an infectious disease population is of great importance in society, for both Government and the public, for treating, preventing, protecting and providing a healthy environment to the community. Not everyone is at risk of acquiring a sexually transmitted disease (STD). Different people live different lives, and those lives contain different levels of STD risk. According to the Center for Disease Control and Prevention (CDC) there are approximately 19 million new STD infections each year and about half of them are young adults. The cost of STD to the US health care system is estimated as \$15.9 billion annually. It is, therefore, very important to obtain an accurate estimate of the abundance of the STD patients in a society to facilitate the health care policy properly. Since the spread of STD is directly affected by social and economic behavioral factors, in this research work we consider the habitat of the diseased population, that is, we focus on those communities where the rate of STD is high. We select the communities in the study based on adaptive addition criteria; we follow negative hypergeometric distribution to obtain the estimated STD population in that particular community. We also prove the mathematical properties of the proposed estimator.