# ABSTRACTS FOR THE 2014 KME NATIONAL CONVENTION

## Friday, April 4, 2014

**9:30 am** **"The Rubik's Cube in the Mathematics Classroom"**
Christopher Vaughn, Alabama Alpha, Athens State University

Abstract:
Invented as a manipulative tool for descriptive geometry instruction, the Rubik's Cube has been used as an educational tool at virtually every level of mathematics. This writing will demonstrate the usefulness of this common toy as a teaching tool through the discussion of mathematical toys and games, the development and history of the Rubik's Cube; the underlying mathematics of the Rubik's Cube Set and its applications in the study of group theory, the use of mathematics and computer programs to determine the solution to the "God's Number" Problem for the standard Rubik's Cube, as well as a discussion of the value and application of the Cube as a tool in the mathematics classroom.

**9:55 am** **"Benefit Reserves in Actuarial Mathematics"**
Summer Lyons & James Wood, Rhode Island Beta Bryant University

Abstract:
The objective of this presentation is to explain the concept of reserving in actuarial mathematics. We will begin with a brief review of the following probability concepts: probability density functions, cumulative distribution functions, survival functions, and expected values, including the law that E(aX) = aE(X). We will then extend this explanation into the concepts of continuous insurances and continuous life annuities. A continuous whole life insurance is defined as the expected present value of a death benefit, where the present value discounting factor is the random variable and the density function is a life density function. A continuous whole life annuity is defined as the expected present value of a stream of payments, where the present value of an annuity certain is the random variable and the density function is a life density function. One main purpose that life annuities are used for is calculating the expected amount of money to be received from a customer that is paying for something over time because each payment is contingent upon survival.

We will then build upon these concepts by defining a reserve as the difference between the expected value of an insurance benefit to be paid and the expected value of premium payments to be received from the insured. We will demonstrate the aforementioned concepts through a sample problem, where a discounting factor, life density function, benefit amount and premium amount are given and the reserve for a point in time is to be calculated. The continuous whole life insurance and continuous whole life annuity would be calculated as expected values as mentioned above, and to calculate the reserve at a point in time, you would multiply the benefit by the expected present value of the insurance and the premium by the expected present value of a life annuity, which is mathematically accurate per the expected value probability law mentioned above. The goal of this presentation is to take basic probability definitions and demonstrate how they are applicable to everyday problems that professional actuaries encounter.

**10:20 am** **"First-Order Sigma-Delta Algorithm"**
Alexander Dunkel, Alabama Epsilon, Huntingdon College

Abstract:

We will investigate first-order sigma-delta algorithms for quantizing signals. The signals can be vectors in $\mathbb{R}^2$ or more generally $\mathbb{R}^n$. It is useful to use frames to sample such vectors. A set $\{\vec{f}_n\}_{n=1}^{N} \subseteq \mathbb{R}^d$ is a frame for $\mathbb{R}^d$ if and only if span $\{\vec{f}_n\}_{n=1}^{N} = \mathbb{R}^d$. Between the original signal and the reconstructed signal will be an error, which will be defined as the Euclidean distance between the original and the reconstructed signal. We will show how to improve the sigma-delta algorithms by changing the order of the frame elements and multiplying the previous error with constants so that the Euclidean distance between the two vectors decreases. We will also prove the stability of the algorithm.

**11:00 am only** **"Tips for Applying for Graduate School"**
Larry Scott, Moderator, Kansas Beta, Emporia State University
Falynn Turley, Graduate of Alabama Theta, Jacksonville State University
Amy Bretches, Kansas Beta, Emporia State University
Phuong Minh N. Do, Pennsylvania Mu, St. Francis University

Abstract:

Students will give their advice on successfully applying for graduate school. They will discuss preparing for the GRE and the application process. Bring your questions!

**11:00 am/1:15 pm** **"Project Math"**
Tom Leathrum, Alabama Theta, Jacksonville State University

Abstract:

The objective is to demonstrate how computer "project" (or "maker") platforms can be used to bring hands-on experiments with solid mathematical content into a math classroom. The demonstrations here will use a (very inexpensive) Raspberry Pi "system-on-a-chip" computer to run and record the experiments and display the results. For example, with two temperature probes attached to the Pi, one measuring room temperature and the other measuring the temperature of a cup of hot water, the Pi can run a simple script to record the difference in temperatures between the two probes over a period of time as the water cools, then plot the results to show exponential decay as described by Newton's Law of Cooling.

**11:00 am/1:15 pm** **"Coding Theory in your Mailbox"** (original author, J. Kevin Colligan)
Dale Bachman, Missouri Beta, University of Central Missouri

Abstract:

A Cryptanalyst is a person who breaks codes. Maybe you've seen people do this in movies like A Beautiful Mind, or TV shows like Sherlock, and the person who does it is usually portrayed as some sort of genius. But is codebreaking really a talent that some people are born with, or is it a skill that can be learned? The answer is, as usual, a little bit of both. In this workshop we'll learn a little bit about cryptanalysis by deciphering a common code -- the sequence of short and long lines that the post office prints on the front of letters. We won't do this by "looking in the back of the book"; rather, we'll figure it out as a group by . . . well, by doing some analysis. This will give us some experience in how a codebreaker thinks. In particular, it will leverage our "mathematical OCD", that is, our need to understand the causes behind patterns.

**2:15 pm** **"Lambda Calculus and its application to functional programming in Haskell"**
Adam Petz, Kansas Beta, Emporia State University

Abstract:

This presentation explores the basic principles of the Lambda Calculus, how and where these principles appear in some of the core features of the increasingly popular functional programming language Haskell, and some examples of these features in use. The Lambda Calculus is a formal system for expressing computation based on function abstraction and application. Its power lies in its expressiveness and elegance, despite providing only a limited number of primitive constructs. Haskell captures and extends concepts of the Lambda Calculus within a computer language, allowing them to be executed over time. It is natural to use mathematical techniques such as induction to prove properties of Haskell functions. This promotes their reliable use in diverse contexts, and has many interesting applications in Trusted Computing and Artificial Intelligence, among others.

**2:40 pm** **"Colorfully Complex; Visualizing Complex Numbers using Domain Coloring"**
Brandon Marshall, Kansas Delta, Washburn University

Abstract:

Graphs are one of the most used and known mathematical tools that people today are familiar with and graphs been taught as part of the core lessons for basic math curriculum for years. But when dealing with the complex field, graphing functions becomes much more difficult and near impossible to visualize completely. In this presentation I will talk about how, by using the color wheel, we can partially graph the 4 dimensional functions of the complex field into a vibrant mathematical image. Using comparative analysis we can then study the graphs and complex function behavior.

**Keynote Address** **"Secrets of Mental Math"**
Arthur Benjamin, Harvey Mudd College, Claremont, California

Abstract:

Dr. Arthur Benjamin is a mathematician and a magician. In his entertaining and fast-paced performance, he will demonstrate and explain how to mentally add and multiply numbers faster than a calculator, how to figure out the day of the week of any date in history, and other amazing feats of mind. He has presented his mixture of math and magic to audiences all over the world.

## Saturday, April 5, 2014

**8:30 am** **"Calculating Population Centers"**
Allison Russell & Kaitlyn Flagg, Alabama Zeta, Birmingham-Southern College

Abstract:

How beneficial would it be to know the most strategic location of a headquarters based off of clientele population distribution? While much research has been done finding population centers using Euclidean distances, little research exists that uses the distance on the earth to calculate population centers taking into account curvature. With this contribution to the field, future mathematicians and businesses could implement this method into standard facility location problems, specifically the minisum problem. We generated a Matlab script that utilized the Vincenty distance formula and the Nelder-Mead search method to calculate the minimum of weighted distances of cities in the U.S. The regions that we analyzed, using U.S. Census Bureau data from 2010, were Alabama, Texas, the Southeast (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia), and the United States. We plotted our results through Google Maps for each of the regions. Specifically for the United States, we found the Euclidean population center to be

Jasper, Indiana, and the Vincenty population center to be Highland, Illinois. Our Matlab script could be used by national companies to place an optimal headquarters. This project has the possibility to be extended through either examining Southern hemisphere populations, using alternate distance measurements, or using a different search method to find the minisum, such as the gradient search method.

**8:55 am** **"An Algebraic Method of Constructing the Zero Divisor Lattice of $\mathbb{Z}/n\mathbb{Z}$"**
Jim Crowder, Alabama Zeta, Birmingham-Southern College

Abstract:

This study investigated the zero divisor lattices of finite commutative rings with identity, with all definitive results concerning the finite integer rings $\mathbb{Z}/n\mathbb{Z}$. The zero divisor lattice is a graphical representation of a ring that emphasizes the annihilators of elements and is ordered by set inclusion of annihilator sets. One observation of interest made during this study was that it seems that in $\mathbb{Z}/n\mathbb{Z}$, $[x]$ and $[y]$ have the same annihilators if and only if $[x]$ and $[y]$ are associates. Though similar results are true in $(\mathbb{Z}/n\mathbb{Z}[X]) / P(X)$ for certain $n$ and $P(X)$, this is not generally the case. Also, no method of constructing the zero divisor lattice of such finite polynomial rings was discovered, despite important structural similarities in these two types of rings. However, this work does outline an efficient algebraic manner of constructing the zero divisor lattice of $\mathbb{Z}/n\mathbb{Z}$ based on the prime factorization of $n$; importantly, this algorithm does not require the computation or comparison of sets of annihilators for the elements of the rings, as opposed to the definitional construction scheme for zero divisor lattices. Furthermore, this method illuminates why the roots of the zero divisor lattice of $\mathbb{Z}/n\mathbb{Z}$ are cut vertices in the compressed zero divisor graph of $\mathbb{Z}/n\mathbb{Z}$, and provides an algebraic (rather than graphical) avenue of approach for studying the zero divisor lattice of $\mathbb{Z}/n\mathbb{Z}$.

**9:20 pm** **"Analysis of a Novel Numerical Scheme for GR-type Non-linear Wave Equations"**
Huda Qureshi, Alabama Zeta, Birmingham-Southern College

Abstract:

The collision of two black holes produces a phenomenon known as gravity waves. In order to model these gravity waves we require the equations of General Relativity. However, the particular equations used to study gravity waves contain many complex non-linear partial differential equations. Analytic solutions are impossible to find unless many simplifications are introduced. As a result, physicists employ numerical schemes to arrive at numerical solutions instead. Before a numerical method can be used, it must first be tested for its stability, dispersion and dissipation properties, and its computational cost. In this paper we compare and test the properties of a novel numerical scheme, the Modified Taylor Series (MTS) with four methods (Iterative Crank-Nicolson, 3'rd and 4'th order Runge-Kutta and Courant-Fredrichs-Levy Non-linear) studied in a paper by Khoklov, Hansen, and Novikov. We utilize MatLab to code the numerical schemes and perform various numerical tests that study the relative phase error, the amplification, and the relative error for both perturbed and non-perturbed solutions. We find that the novel MTS method may be more stable than the Courant-Friedrichs-Levy-Nonlinear (CFLN) due to the damping it exhibits at the Nyquist frequency. The MTS method also utilizes very few steps in order to evolve the solution compared to the ICN, RK3, RK4, and the CFLN. Overall, the MTS may be a more stable, effective, and computationally inexpensive method.