ABSTRACTS FOR THE
KME 40th BIENNIAL CONVENTION and
CENTRAL FLORIDA UNDERGRADUATE MATHEMATICS CONFERENCE

Friday, April 10, 2015

9:30 am **"Dynamics and Bifurcations of a Cholera Epidemiology Model"**

Meagan Leppien & Mena Whalen, Missouri Alpha, Missouri State University

Abstract:

A model of epidemiology that incorporates an environmental reservoir of *V. cholera* is studied. Previous results concerning local stability of the disease free equilibrium have been extended to include global stability analysis of such point, as well as existence and stability of an endemic equilibrium point. An appropriate Lyapunov function is constructed, and LaSalle invariance principle is used to prove global stability. Existence of a transcritical bifurcation of the model is also proved. Numerical calculations help illustrate the main results. One main difference between this and classical SIR and SIER models is that the dynamics of the bacteria is explicitly included in the model, which allows exploring the role of the aquatic reservoir on the persistence of endemic cholera. This presentation should be accessible to undergraduates with some linear algebra and introductory differential equations background.

9:30 am **"The Brachistochrone Challenge: Traveling from Here to There in the Shortest Time"**

Grace Chester, Missouri Lambda, Missouri Western State University

Abstract:

While the shortest path between two points is a straight line, the path of quickest descent between two points at different heights is not. In 1696, Johann Bernoulli challenged his contemporaries to determine this path of quickest descent, and within one year, he had acquired five solutions from the most talented mathematicians of his time. This talk presents the historical context of the brachistochrone challenge and one solution of the problem from the perspective of the calculus of variations. A brief description of how the solution to this problem from the past applies to modern athletic events and mechanics will also be given.

9:55 am **"Spatial Filtering on Digital Images"**

T.J. Huettenmueller, Kansas Beta, Emporia State University

Abstract:

The first usage of digital image processing came about in the 1920's with images sent to and from newspapers for printing. The goal was to clarify the image in order to be able to print the image. Today, digital image processing is used in all sorts of fields and studies, ranging from a host of medical topics, outer space imaging, and for personal use in our digital cameras.

Filtering is a technique that is used to smooth, blur, or sharpen an image, or to detect the edge of an image. There are two common types of filtering applied to images: spatial domain filtering and

frequency domain filtering. A spatial filter is an image operation where each pixel value is changed by a function of the intensities of pixels in the neighborhood of that pixel. For this project we examined the mean filter, the median filter and the non-local means filter and we demonstrated how to use these filters to remove digital noise. The presentation includes a description of each one of these filters, as well as a representation of the mathematical concept behind each of the filters. We will explain how each filter works. There are also copies of an original image, a noisy image, and an image filtered by each of these three filters to enable the viewer to see how well each filter clarifies the image.

9:55 am **"Factoring Quartic Polynomials"**

Brionna Benjamin, Bethune-Cookman University

Abstract:

Polynomial functions are among the simplest expressions in algebra (Sullivan et al, 2015). Since they are easy to manipulate, they are often used to approximate other, more complicated functions. To find the zeros of a polynomial function, which is important for graphing the function, the polynomial must be factored. The most common method for factoring a polynomial is the Factor and Rational Root Theorem. However, some quartic polynomials cannot be factored using the Factor and Rational Root Theorem because a quartic polynomial may factor into a product of two quadratic polynomials but have no roots in $\mathbb{Q}$. To determine whether or not a quartic polynomial without rational roots is reducible, we need to know whether it factors into a product of two quadratic polynomials (Brookfield, 2007). Using Gary Brookfield's paper titled, "Factoring Quartic Polynomials: A Lost Art", this paper explores an algorithm for factoring quartic polynomials.

10:20 am **"Mathematical Modeling on an Open Limestone Channel"**

David Wolfe, Pennsylvania Mu, Saint Francis University

Abstract:

Acid mine drainage is the outflow of acidic water from metal mines or coal mines. When exposed to air and water, metal sulfides from the deposits in the mines are oxidized and produce acid, metal ions and sulfate, which lower the pH value of the water. At this point, the water becomes dangerous to living organisms and unfit for human consumption. An open limestone channel is a passive and low cost way to neutralize acid mine drainage. The chemical process involves the diffusion of calcium from the limestone into the bulk, acidic water. Once there, the calcium will precipitate the harmful metal sediments from the water and allow the pH of the water to return to normal conditions. A mathematical model has been created to numerically determine the change in pH of the water and the concentrations of species from the rate of dissolution of calcium on the surface of the limestone into the acidic water. This model is based on the chemical kinetics involved with the calcium dissolution through the armoring layer of sediment built up on the limestone after a period of use. The concentrations of the individual metal and chemical species were found for a set of given initial conditions and applied to the rate equation of calcium dissolution. The final concentrations of the species were then found numerically. Using data collected from a local site during the course of research, the model was verified to be able to accurately predict the final conditions of an open limestone channel. The model was then used to predict the conditions in which an open limestone channel would be an effective solution for acid mine drainage. Effective ranges were determined for the concentrations of calcium and iron in the bulk water, as well as the pH and velocity of the water. Using the gathered data the effective ranges of operation of a channel similar to the one studied, the ranges were found to be 2.30 to 4.00, 0.001 to 10 ppm, 2.806 to 20.00 ppm, and 0.05 to 2.6 m/s for pH, iron concentration, calcium concentration, and water velocity, respectively. The data indicates that the model could be used to quickly make a ruling for as to whether an open limestone channel could be a solution after preliminary testing of a site. Data collected from

additional sites of operational limestone channels could be collected and used to consolidate the ranges more accurately using multiple data sets.

10:20 am "Generalizations of the Comparison Test"

Alexis M. Taylor, Bethune-Cookman University

Abstract:

In this presentation we follow "The Comparison Test - Not just for Nonnegative Series" by Michele Longo and Vincenzo Valori. We show how Longo and Valori generalize the Comparison Test to generic series. One such generalization of the comparison test is usually stated for nonnegative series in the calculus book. We also use a generalization of the Comparison Test to determine some convergence of certain series. The generalization of the Comparison Test uses transformations to analyze the original series. We transform the series by applying a polynomial -like function with a degree k. The convergence and divergence of the series $\sum f\,(a_n)$ and $\sum(a_n)^k$ are related, and this relation depends on whether k is odd or even.

11:00 am/1:15 pm "Iterative Constructions Using GeoGebra"

Steve Klassen, Missouri Lambda, Missouri Western State University

Abstract:

An introduction to working with GeoGebra. GeoGebra is an easy to use Dynamic Geometry Software (DGS) but also provides basic features of Computer Algebra Systems (CAS), helping to bridge the areas of geometry, algebra and calculus. Students are encouraged to participate in a few hands-on activities, ranging from creating animations for illustrating concepts of Calculus to the iterative construction of Bezier curves defined by a set of control points. This workshop does not assume previous experience using GeoGebra.

11:00 am/1:15 pm "LaTeX Workshop"

C. Altay Özgener, Robert Shollar, Leon Hostetler, State College of Florida

Abstract:

LATEX is especially nice for typesetting mathematical work. It has beautiful mathematical fonts and extremely powerful tools for handling tables of contents/figures/etc, citations, bibliographies and indices. The interface is more like programming than the Word-like "WYSIWYG" approach, but the initial learning curve is not too steep and is worth the effort. We will discuss the basics of certain presentation packages such as Beamer, PS-Tricks, TiKZ.

11:00 am/1:15 pm "The Mathematics Behind Cryptography"

Joe Yanik, Kansas Beta, Emporia State University

Abstract:

This workshop will focus on the mathematics behind cryptography. It will review a number of different cryptosystems including those that use private keys and describe the Number Theory that makes it work. It will include hands-on activities for the participants.

2:15 pm "The Black-Scholes Formula in Risk Management"

Casey Cornelius, Missouri Alpha, Missouri State University

Abstract:

Everyone seems to stress the importance of saving and investing as much of your earnings as possible, but investing in different financial markets can be so confusing and time consuming, not to mention risky! As college students studying mathematics, it's not always easy to feel confident investing

in highly volatile investment options. Wouldn't it be nice to somehow guarantee that the money you invest will see positive gain? Although we haven't yet come up with a model for completely eliminating the risk in investment options, we have come very close. In this presentation, the Black-Scholes formula - a partial differential equation used for estimating the price of European options over time - will be explored in great detail.

After evaluating the assumptions, calculations and limitations of the formula, a more mathematics-savvy approach to investment options will be discussed. The accuracy of this mathematical model earned the mathematicians responsible for discovering it the 1997 Nobel Prize in Economics.

2:15 pm "Some Different Ways to Sum a Series"

Leon Hostetler and Robert Shollar, State College of Florida

Abstract:

In 1644, Pietro Mengoli posed the famous Basel problem. Named after the hometown of the great Leonard Euler, the Basel problem withstood attacks by many outstanding mathematicians of the time including the efforts of the Bernoulli brothers. It took the great mind of Euler to tame this problem in 1734. Ever since then, mathematicians from a variety of different fields have found new and exciting ways of solving this age old problem. We will investigate several of these famous solutions that range from the classic Eulerian style to more modern techniques. Join us in discovering a bit of history behind solving $\zeta(2)$.

2:40 pm "Japanese as a Set Theory Construct: Verb Conjugation"

Naimul Chowdhury, State College of Florida

Abstract:

In this presentation I will discuss the potential for Japanese language to be constructed with sets and subsets of words. The high regularity of Japanese allows for the language to be treated mathematically. I will specifically talk about verb tensing, and describe an easily defined set of functions that allows someone with no knowledge of Japanese to transform the word into formal present, past, and future tense.

2:40 pm "Triphos: An Alternative Coordinate System"

Paula Egging, Kansas Gamma, Benedictine College

Abstract:

In this presentation, we will investigate characteristics and properties of the Triphos coordinate system, an alternative, two-dimensional coordinate plane consisting of three axes evenly spaced 120° apart. The idea of this coordinate system came from students at Emporia State University. After hearing a talk on the topic from Keely Grossnickle, we were inspired to further research. We will examine similarities and differences between the Triphos system and the traditional Cartesian coordinate system, explore its algebraic and geometric properties, and discuss some advantages and applications of this unique coordinate system.

4:15 pm Tour of Wave Motion Lab

Andrei Ludu, Embry-Riddle Aeronautical University

Description:

The Mathematics Department has a cutting-edge Nonlinear Waves Lab which allows students, faculty and industry to experiment and use the facilities for hydrodynamics and navigation research, resulting in numerous internal grants, and external grants from industry and from the National Science Foundation. The completely transparent wave tank is 32 feet long and can hold 4,000 gallons of water,

which can be circulated simulating a river with velocity up to 3 feet per second. The installations include a fast towing system with velocity up to 45 feet per second, a wave maker, several soliton/tsunami generators, and various diagnostic systems involving power laser and ultra-rapid stereo photography.

Keynote Address **"Mathematics in the Game of SET©"**
Liz McMahon, Lafayette College, Easton, Pennsylvania

Abstract:

The card game SET© is played with a special deck of 81 cards. There is quite a lot of mathematics that can be explored using the game. We'll look at questions in combinatorics, probability, linear algebra, and especially geometry. The deck is an excellent model for the finite affine geometry $AG(4,3)$ and provides an entry to surprisingly beautiful structure theorems for that geometry. If you'd like some practice before the talk, go to www.setgame.com for the rules and a Daily Puzzle.

Saturday, April 11, 2014

8:30 am **"NFL Combine Correlation Analysis"**
Brian Mosier, Kansas Beta, Emporia State University

Abstract:

Athletes are often told about the difference between fast twitch and slow twitch muscles. For endurance athletes, slow twitch muscles are designated as the more important of the two to train because it allows them to exert themselves for extended periods of time. In sports where sprinting and jumping are crucial, fast twitch muscles are emphasized as they are important in acceleration.

The goal of this analysis is to compare three different events that are associated with fast twitch muscles, namely the forty-yard dash, the vertical jump, and the broad jump. This analysis will show whether or not there is correlation between the three events. This will show how closely these fast twitch muscle events are related to each other.

8:30 am **"Factorization Theory in $\mathbb{Z}/n\mathbb{Z}$"**
James Mixco, Missouri Beta, University of Central Missouri

Abstract:

It is well known that the irreducible elements (elements that cannot be factored) of the ring of integers are, up to multiplication by -1, the set of primes. Moreover, the Fundamental Theorem of Arithmetic says that every integer factors uniquely, up to order and sign of the terms, as a product of primes. We consider factorization in the ring $R = \mathbb{Z}/n\mathbb{Z} = \{\bar{0}, \bar{1}, \dots, \overline{n-1}\}$; the set of congruence classes modulo some integer n. We first classify the associates and strong associates of each element in R. We then classify the irreducibles and strong irreducibles and discuss the uniqueness and nonuniqueness of factorization in R. Preliminary results on factorization lengths will also be discussed.

8:55 am **"Classification of Instances in a National Climatic Data Center Precipitation Dataset"**
David Armas, Florida Delta, Embry-Riddle Aeronautical University

Abstract:

This report outlines the processing and analysis of a National Climatic Data Center (NCDC) data set. The set consists of precipitation data for Florida and Colorado with a 15 minute temporal resolution. The data was cleaned to remove bad data and pre-processed in a way that attempts to maximize the classification information available in it. It was then converted to the Attribute-Relation File Format (ARFF) for analysis in the Waikato Environment for Knowledge Analysis (WEKA). Algorithms for the classification of each instance as Florida or Colorado were then tested for performance. The algorithms

tested were numerous but one from each class was chosen as the best of its type and one was determined as best overall. The algorithm chosen as the best overall was the OneR algorithm. The OneR was not only the most accurate of all the methods tested, it was also one of the quickest to run. It was shown that, given sufficient data pre-processing, the WEKA can quickly and easily produce efficient and accurate algorithms for the classification of large data sets. Once the algorithms have been created, they can then be implemented to automatically classify big data in real time.

8:55 am **"Making Hard Problems Easy: On a New Integral Transform, Its Properties, and Applications"**
John Vastola, University of Central Florida

Abstract:

Finding a good integral representation of the reciprocal gamma function is a problem that arises naturally from a certain method of evaluating infinite sums. After finding such a representation, and observing that its form is suggestive of an integral transform, we naively define one, and go on to explore its properties. While our transform as we initially define it turns out to be problematic, we demonstrate how to redefine it so that important properties (reminiscent of the Laplace and Fourier transforms) are preserved. Of particular interest is that we may transform any entire function, and that the values of the transform at the nonnegative integers correspond to the coefficients of the function's Taylor expansion about a certain point. We may also transform large classes of continuous and meromorphic functions, and a formula is given for the meromorphic case. Interestingly, the aforementioned relationship between a functions transform and a function's Taylor series can be exploited to calculate analytic 'approximations' to transformable functions. Other topics, like defining the transform for real and complex arguments, and the geometry of transformed functions, are considered. Applications to ordinary differential equations and some physical problems are discussed.

9:20 am **"Modeling Hantavirus Cytokine Activity with Stochastic Differential Equations"**
Annabel Offer, Texas Alpha, Texas Tech University

Abstract:

Over twenty-one hantaviruses, rodent-borne viruses with potential high lethality in humans, have been identified around the world. These viruses cause serious illness in humans, hantavirus cardiopulmonary syndrome (HCPS) and hemorrhagic fever with renal syndrome (HFRS), when transmitted from their rodent reservoirs. HCPS causes severe pathology and disease, which may lead to death in approximately 40% to 50% of cases.

Hantavirus infects the endothelial cells in tissues of the lung, spleen, and kidney. Three different outcomes observed in the three different hosts, rodent nonreservoirs, rodent reservoirs, and humans, have been associated with the differential early innate immune response after exposure to hantavirus. Rodents that develop symptoms but eventually clear the virus are called nonreservoirs (Case 1). Rodent reservoirs carry and spread the virus without showing signs of pathology (Case 2). Humans that become infected, develop severe symptoms, and in some cases die (Case 3). High levels of pro-inflammatory and anti-inflammatory cytokines are an indication of an unhealthy host. As a first approach to modeling the three distinct immune responses, only the pro-inflammatory P and anti-inflammatory A cytokines are modeled, using a system of ordinary differential equations and a new system of stochastic ordinary differential equations to account for the variability in the responses.

The system of ordinary differential equations exhibits several stable equilibria that represent low and high levels of pro-inflammatory and anti-inflammatory cytokines, which characterize healthy and unhealthy states. In the nonreservoir rodent, if pro-inflammatory cytokine levels are high due to an infection (unhealthy state), anti-inflammatory cytokines are able to control the infection, and both P and A return to normal healthy levels as the infection is cleared (healthy state, low level equilibrium) (Case 1). In rodent reservoirs, cytokine levels of P and A may be higher than normal at times because of the

persistent infection and viral shedding and at other times may be low when there is no shedding (bistable equilibria) (Case 2). In humans, the pro-inflammatory response P is especially high, resulting in severe pathology (unhealthy state, high level equilibrium) (Case 3).

The system of stochastic ordinary differential equations accounts for the potential variability in the responses, which may be due to environmental stress. In the bistable case of the rodent reservoir (Case 2), the stochastic model allows cytokine levels to switch between high and low equilibrium levels. Cytokine levels are low when the virus is under control, but under random environmental stress, viral loads and cytokine levels may show a transient increase until they return to normal levels.

By developing models and testing them against data on the timing and magnitude of the immune response in rodents and humans, we gain a better understanding of how the immune response effectively controls the infection. In addition, we move closer to finding methods for control and prevention of hantavirus disease in humans.

9:20 am **"Permanent of a Matrix"**

Nitish Aggarwal, Florida Delta, Embry-Riddle Aeronautical University

Abstract:

The permanent of a square matrix is a function derived from its entries, similar to the determinant. Despite the similarity, permanents seem to be more difficult to compute. In this talk, we define the permanent and present some of its properties, as well as some applications in combinatorics.