**Abstracts**

**“Global Stability Analysis of Zika Virus Dynamics”**

Savannah Bates, Jacksonville University, and Hayley Hutson, Missouri State University

Faculty Advisor, Dr. Jorge Rebaza, Missouri State University

The very few mathematical models available in the literature to describe the dynamics of Zika virus are still in their initial stage of development, and they were in part developed as a response to the most recent outbreak that started in Brazil in 2015, which has also confirmed its association with Guillain-Barre Syndrome and microcephaly. The interaction between and the effects of vector and human transmission are a central part of these models. This work aims at extending and generalizing current research on mathematical models of Zika virus dynamics by providing rigorous local and global stability analyses of the models. In particular, for disease-free equilibria, appropriate Lyapunov functions are constructed using a compartmental approach and a matrix-theoretic method, whereas for endemic equilibria, a relatively recent graph-theoretic method is used. The possible existence of bifurcations is also discussed, and some Matlab numerical simulations help illustrate the main results.

**“The Game of Seepage”**

Julie Anne Bowman, Southwest Baptist University

Faculty Advisors: Dr. Robert Bell, Michigan State University, and Dr. Steve Bowling, Southwest Baptist University

The game of Seepage, first described by Clarke, et al. in 2009, is played by two players, Sludge, *S*, and Green, *G*, on a directed acyclic graph with a single source and several sinks. *S* and *G* alternately claim vertices of the graph, which subsequently cannot be claimed by the opponent. Sludge begins by claiming, or ‘contaminating”, the source. Afterwards, in sequence, *G* can claim, or ‘protect’, any vertex on the graph, while *S* can contaminate any vertex adjacent to an already contaminated vertex. *S* is said to win if any sink is contaminated; otherwise, *G* wins. The generalized version of this game allows *G* to claim multiple vertices each turn. The *green number* of a graph *H*, *gr*(*H*), is defined to be the minimum *k* such that *G* can guarantee victory with at most *k* moves on each turn. Graphs are called *green-win* if *gr*(*H*) = 1, *sludge-win* if *gr*(*H*) > 1 and *k*-*green-win* if *gr*(*H*) = *k*. In their paper, Clarke, et al. characterized green-win and *k*-green-win rooted trees *T*, providing a polynomial time algorithm for determining if *gr*(*T*) = *k*. I will introduce ideas and concepts of a more generalized algorithm that determines if *gr*(*H*) = *k* for any directed acyclic graph, as well as methods to reduce the number of vertices and edges of a graph without changing the green number. This presentation will mainly focus on when Green has only 1 move per turn or *k* = 1.

**“Simplexes in an N-Dimensional Cube”**

John Carter, Mathematics.

Faculty Advisor: Dr. Les Reid, Missouri State University

Given a unit *n*-dimensional cube, we investigate the distribution of the measures of *k*-dimensional simplexes whose vertices are vertices of that cube. This includes determining the *k*-simplexes of largest and smallest measure as well as an analysis of the average value of these measures. We obtain an exact formula for the average length of 1-simplexes in an *n*-dimensional cube and show that asymptotically this length is . The distribution of the measures of higher-dimensional simplexes is more complicated, but we believe that the average measure of a *k*-dimensional simplex in a unit *n*-dimensional cube is asymptotically proportional to  . We present numerical evidence to support this claim.

**“Rainbow Arithmetic Triples”**

Rafael Ceja, California State University, Sacramento, Kathryn Cook, Evangel University, and Karissa Hayden-Gill, University of California, Davis

Faculty Advisor: Dr. Steven Senger, Missouri State University

We present some conditions on colorings of the field of integers modulo a prime that guarantee the presence of configurations like  and , where each element comes from a distinct color class.

**“Delay Differential Equations for Population Modeling”**

Nathaniel Covey, Lyon College

Faculty Advisor: Dr. Joseph Stover, Lyon College

In nature, organisms may have a time delay before reaching reproductive maturity. We are interested in what effects this time delay has on population dynamics. This delay is not captured by ordinary differential equations; therefore, we use delayed differential equations to study this phenomenon. The specific model we study is where *r* is a reproductive rate, is a time delay, and *d* is a death rate. We use Octave (Matlab) to perform numerical simulations of the model, but we also carry out some analytical calculations. We find that diversity in both the death rate and in the time delay will make the total population increase.

**“Mathematical Modeling of Japanese Knotweed”**

Jessica Linton, Benedictine College

Faculty Advisors: Dr. Shilpa Khatri, University of California, Merced, and Dr. Karin Leiderman, Colorado School of Mines

Every year, invasive species cause irreversible damage to economies and ecosystems worldwide. Preventing the spread of such species is an important step toward reducing impact on native flora and fauna, along with preserving local economies. A noteworthy example is Japanese knotweed, *Fallopia japonica*, a perennial native to Eastern Asia. It was introduced to the United States in the 1870s as an ornamental plant and has since displaced native vegetation and clogged rivers. Since fragments from the main plant can generate new sprouts, transport of such fragments by river networks may play a key role in its spread. To better understand the spread of Japanese knotweed, we applied the Crank-Nicolson time splitting method to a reaction-diffusion model and compared our results with field data to assess its accuracy.

**“Investigating Graphs Based on Relationships of Three 3 Vertices”**

Jon Mangum, Missouri State University

Faculty Advisor: Dr. Les Reid, Missouri State University

In this talk, we investigate graphs with *n* vertices having a given numbers of edges between any three vertices. Specifically, given a fixed subset *X* of , we wish to characterize those graphs having the property that between any 3 vertices, the number of edges is an element of *X*. For example, if , we obtain precisely the empty graphs and if , we obtain all graphs. In this talk we examine these graphs for each possible *X*.

This is a generalization to Problem 4067 from Crux Mathematicorum (where ). We begin with a basic introduction to graph theory, and give several pertinent definitions. Some basic properties of graphs will be highlighted, and explanations given where needed.

**“Predator-Prey Models with Harvesting”**

Jacob Perkins, Lyon College

Faculty Advisor: Dr. Joseph Stover, Lyon College

Studying the dynamics of predator and prey populations is important for developing an understanding of natural populations. Learning to manage predator-prey populations is especially important when humans harvest them for resources. We investigate how harvesting affects population dynamics. We use differential equations to create models of the predator-prey populations and examine two systems of differential equations: (1) with a per-capita harvest rate with no density-dependence and (2) with a per-capita harvest rate with density-dependence in the prey population. We determined that, under certain conditions, harvesting can cause extinction in the populations.

**“Some Applications of Additive Combinatorics in Finite Fields”**

Mengqing Qin, Missouri State University

Faculty Advisor: Dr. Steven Senger, Missouri State University

We use some recent results to prove some novel estimates in additive combinatorics in finite fields. We focus on bounds for , , and  for  a finite field with *q* elements, and bounds for the set of dot products of a subset of a two-dimensional vector space over a finite field.

**“Integer Partition Theory”**

Jon Rehmert, College of the Ozarks

Faculty Advisors: Dr. Brandt Kronholm, University of Texas, Rio Grande Valley, and Dr. Al Dixon, College of the Ozarks

The partition function counts how many ways a natural number can be written as the sum of natural numbers. The restricted partition function counts how many ways a number can be written as the sum of a fixed number of natural numbers. This paper examines divisibility properties of these functions including original results proven by the author.

**“Analyzing the Stability of Ebola Models Using Dynamical Systems”**

Tommy Stoller, Wichita State University

Faculty Advisor: Dr. Jorge Rebaza, Missouri State University

The 2014 Ebola epidemic in West Africa has been a major topic in recent disease modeling. Several models have been proposed since the start of the epidemic for the purpose of studying the disease progression. However, the local and global stability of these models have not been studied at all in the literature. I will analyze the stability of the models that have been proposed by Shen et al. Additionally, I will consider the possibility of endemic Ebola cases using a generalized version of the model proposed by Shen et al. To study the stability of these models, the graph theoretic method described by Shuai and Van Den Driessche in 2013 and the matrix theoretic methods described by Van Den Driessche throughout the literature will be used. Finally, I will analyze numerical simulations of these models and how real-life parameters relate to these results.

**“Differential Equations as Physical Models”**

Morgan Webb and Jacob Perkins, Lyon College

Faculty Advisor: Dr. Joseph Stover, Lyon College

Differential equations serve as mathematical models for a variety of physical systems. We investigate the accuracy of using differential equations for modeling liquid solution mixing. We set up an experiment to record the change in the dye concentration in water over time due to the mixing of two different solutions. Then, we constructed and solved differential equations with parameter values derived from our experiments to model the change in dye concentration over time. We compared the theoretical model to the experimental data and found that the differential equation modeled the experimental data accurately in some cases but less so in others.