**Abstracts**

**“A Picture is Worth a Thousand Words”**

by Dr. Kevin Hopkins, Southwest Baptist University

As one thinks about ways to visualize research, either for presenting it or just getting a handle on some of the questions, a picture can often be helpful.  This talk will show how GeoGebra can help produce such a picture.  In the process of producing the picture, one can discover other research ideas or be led to insights about why certain theorems might be true.

**“The Banach-Tarski Paradox”**

by Dylan Beck, Missouri State University

One of the most perplexing and incredible results in mathematical history remains the Banach-Tarski paradox, which states that any ball in Euclidean space can be cut into finitely many pieces that can then be reassembled into two exact copies of itself. Rooted deeply in the work of Guiseppe Vitali and Felix Hausdorff, Banach and Tarski’s revolutionary result employs the notion of Vitali sets, paradoxical decompositions of a set, the free group, and the Axiom of Choice to arrive at a fresh, new, and puzzling result. We explore in this talk the historical background of Banach and Tarski’s legacy as well as the mathematical foundations that enabled it, and ultimately, we supply a proof of the paradox.

**“The Derivation of the Conservation Equation”**

Alexa Busch, Drury University

Faculty Advisor: Dr. Bob Robertson, Drury University

In this presentation, I will talk about partial differential equations and their practical applications in biological settings. The main concept I will discuss is the derivation of the conservation equation, or balance equation, using calculus topics such as partial derivatives, flux, surface integrals, and the Divergence Theorem. I will show how to solve the one-dimensional diffusion equation, which is a special case of the conservation equation.

**“Comprehending Higher Dimensions”**

Jonah Henry, Missouri State University

Faculty Advisor: Dr. Jorge Rebaza, Missouri State University

This presentation will begin with the construction of the dimensions and their axes, beginning with a point. I will then introduce elementary concepts that can be used to comprehend objects which inhabit higher dimensions:

* *Spatial Content* (SC*n*) - The amount of space an object occupies in its inhabited dimension, *n* (i.e. Length = SC1 *,* Area = SC2 , Volume = SC3). This will include examples for *n-*dimensional cubic and tetrahedral shapes, giving general formulas for SCn.
* *Reference Structures* - Shapes are formed by lower dimensional versions of themselves, called reference structures. This will be explained using cubic, tetrahedral, and spherical shapes, and how they are built.
* *Interaction -* How we observe our own dimension. What constraints and advantages do we have when observing lower and higher dimensions?

These concepts will hopefully bring about some intuitive questions to end the presentation. While having taken Calculus 1 is helpful, this topic is open to anyone. There is some computation involved but the presentation is mostly visual.

**“A Theoretical and Numerical Analysis for Second Order Nonlocal Models”**

Lauren Lewandowski, Missouri State University

Faculty Advisor: Dr. Petronela Radu, University of Nebraska, Lincoln

A fairly recent reformulation of classical partial differential equations into nonlocal partial differential integral equations has yielded models that accurately describe physical phenomena, such as dynamic fracture of bodies, not captured by the classical equations. We have obtained results concerning preservation of nonnegativity, regularity, a strong maximum principle, and energy decay estimates of solutions of nonlocal heat equation:

 

on a bounded domain for an integrable kernel  with compact support. These results are supported by numerical evidence. The simulations were obtained using finite difference methods analogous to those employed in the local case.

**“The Art Gallery Problem”**

Aaron Ogle, Missouri State University

Faculty Advisor: Dr. Les Reid, Missouri State University

The art gallery problem asks, what is the minimum number of guards needed to watch over an art gallery? The question was first posed by mathematician Victor Klee in 1973, and in 1975 Chvatal proved that $\left⌊\frac{n}{3}\right⌋ $guards are sometimes necessary and always sufficient to cover a polygon of n vertices. We will investigate a proof of the Art Gallery problem, and also take a look at variations of the problem that have been created over the years. We will look at what happens if we have orthogonal art galleries, guards with different properties, and the Fortress Problem.

**“How to Make Anyone Hate You in 10 Minutes with 17 Cards”**

Jon Rehmert, College of the Ozarks

Faculty Advisor: Dr. Al Dixon

Suppose you are sitting in your favorite coffee shop, and some stranger sits down at your table and slaps a twenty dollar bill on the table. He smiles and tells you that if you can beat his game, you win the money. He then places down three stacks of cards; the first stack has 3 cards, the second has 5, and the third has 9. The rules are simple: you can take as many cards as you want, as long as you take from only one stack. The two of you will take turns taking cards, and whoever takes the last card loses. He lets you pick whether or not you will go first each time, yet despite this advantage, you always lose. After an hour of playing this game, you eventually leave without a twenty dollar bill. I intend to analyze this game and its strategies and reduce it to a mathematical system. The strategies become theorems, complete with proofs, and eventually one can use this system to guarantee victory. I also will investigate generalizing this system into stacks of any number of cards per stack or any number of stacks. In addition, I will investigate patterns in successful strategies and possible correspondence and application to established mathematics.

**“Average Intensity of the Distribution of Complex Zeros of a Class of Random Polynomials”**

Spencer Smith, Southwest Baptist University

Faculty Advisor: Dr. Andrew Ledoan, University of Tennessee at Chattanooga

We establish for the average intensity of the distribution of complex zeros of the random polynomial $P\_{n}\left(z\right)=η\_{0}ω\_{0}+η\_{1}ω\_{1}z+η\_{2}ω\_{2}z^{2}+ . . . +η\_{n-1}ω\_{n-1}z^{n-1}$ with $z\in $ ℂ and for any sequence of real constants $ω\_{j}$ and standard normal independent random variables $η\_{j}$. We further obtain the limiting behavior of this intensity function as $n$ tends to infinity for various sequences $ω\_{j}$.

Our project is the result of research carried out during the summer 2015 REU program at University of Tennessee at Chattanooga under the supervision of Dr. Andrew Ledoan. My presentation includes a brief refresher on complex zeros, as well as an intuitive explanation of the meaning of our research.

**“A Short Introduction to Fourier Series and Their Applications in Partial Differential Equations”**

Jonathan Stacy, Missouri State University

Faculty Advisor: Dr. Matt Wright, Missouri State University

Jean-Baptiste Joseph Fourier (1768-1830) found some interesting results while writing *Théorie* *Analytique de la Chaleur* (The Analytic Theory of Heat). The study of heat transfer led him to systems of partial differential equations. The years during and after his death, George Green (1793-1841) Johann Dirichlet (1805-1859), Georg Friedrich Bernhard Riemann (1826-1866), Carl Gottfried Neumann (1832-1925), Augustin-Louis Cauchy (1789-1857), Jules Henri Poincairé (1854- 1912), Henri Leon Lebesgué (1875-1941) and Laurent Schwartz (1915-2002), along with many others, made major contributions to the areas of complex analysis and, what is now known as, Fourier analysis. Some of these beautiful contributions and results such as the Riemann-Lebesgue lemma, some interesting inequalities, and Fourier series convergence will be demonstrated through theorems, proof, and examples.

**“Stein’s Paradox”**

by Mena Whalen, Missouri State University

The Stein paradox comes from within statistics where a normal distribution with mean unknown, with *n* greater than or equal to 3 then sample mean becomes inadmissible while the James Stein estimator strictly dominates. This means the James Stein estimator is a better guess for the unknown, unobservable mean than the sample mean which is obtained through observable data. Then elaborating on how to find and show that the James Stein estimator does strictly dominate, the squared loss and the risk functions are used. The James Stein estimator also allows for any random variables.  For example, a better estimate for the mean of data including baseball players' batting averages and college attendance rates can be determined using the James Stein estimator.

**“Disease Survival in a Branching Process Model”**

Hope Woods, Lyon College

Faculty Advisor: Dr. Joseph Stover, Lyon College

Diseases can often be passed on to children from their parents. We seek to understand how infectious such a disease must be in order for it to persist within a population. The branching process is used to model a population starting with a single infected individual where the disease can only be passed on from infected individuals to their offspring. We study the relationship between reproduction and infection parameters which allow the disease to persist. R was used to simulate the model with several offspring distributions and various probabilities of infection. Using known results for the branching process we show that for the infection to have a chance of persisting, the quantity $p\_{i}\left(p\_{1}+2p\_{2}\right)$ must be greater than 1 where $p\_{i}$ is the probability of an infected parent transmitting the infection to offspring, and $p\_{0}$, $p\_{1}$, and $p\_{2}=1-p\_{0}-p\_{1}$ is the offspring distribution.