**Abstracts**

**“Convergence of a Generalized Midpoint Iteration in the Plane”**

Daniel Bradley, Wheaton College

Faculty Advisor: Dr. Xingping Sun, Missouri State University

We define a generalized midpoint iteration on sets of points in the plane. Contrary to the classical derived polygon midpoint iteration, this new iteration generates an increasing number of points at each step. We prove that the generalized midpoint iteration on a set converges to a set of positive area, not to a single point as in the derived polygon iteration. This result may be related to the problem of convergence of a "derived polyhedron" centroid iteration in space.

**“A Variation Buffon's Needle: Geometry and Probability”**

Cody Crossley, Missouri State University

Faculty Advisors: Dr. Yungchen Cheng, Missouri State University and Dr. Les Reid, Missouri State University

This presentation demonstrates how calculus and differential geometry can be utilized for elementary problems in probability. Here, we'll develop a variation of the classical Buffon's Needle problem: what is the probability that a coin dropped at random in a rectangular region will intersect an arbitrarily drawn curve in this region? Given a fixed rectangular region and a fixed coin size, it turns out that this probability depends only on the length of the curve in question. A brief overview of this derivation is given, and the result is used to develop an approximation of π​, which is a natural consequence from the circularity of the coin.

**“Genera of Subgroup Intersection Graphs”**  
Joe Dillstrom, Missouri State University, and Gwen McKinley, University of California, Davis  
Faculty Advisor: Dr. Les Reid, Missouri State University  
  
In this project, we determine the genera of various subgroup intersection graphs. For a given graph , it is natural to consider what surfaces it can be embedded on. We extend this idea to graphs which represent information about a group and its subgroups. Given a finite group , we determine the lattice of its subgroups and truncate this lattice to form the subgroup intersection graph. Then, using group-theoretic and graph-theoretic tools, we attempt to classify finite groups whose subgroup intersection graphs are of orientable or non-orientable genus 1.

Our project is the result of research carried out during the summer 2014 REU program at MSU under the supervision of Dr. Les Reid. Our presentation includes a brief introduction to group theory and graph theory, and an explanation of some of the techniques we used to solve these problems. We also present our results.

**“Triphos: An Alternative Coordinate System”**

Paula Egging, Benedictine College, and Erica Johnson, Benedictine College

Faculty Advisor: Dr. Leah Childers, Benedictine College

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 properties, and discuss some advantages and applications of this unique coordinate system.

**“The Powers of Roots”**  
David Gillie, Southwest Baptist University

Faculty Advisor: Dr. Steve Bowling, Southwest Baptist University

This presentation will discuss some numerical methods for determining fractional powers of numbers.  When dealing with fractional exponents, an iterative approach for approximating the value of a number raised to a fractional power must be used.  I will review some known methods for approximating some integer roots of a number, discuss some attempts to extend a method for finding square roots to the finding of other roots,  and then propose  a way to use known methods for finding square roots to approximate the value of a number raised to any fractional or decimal power.  My approach is a computational approach as opposed to a theoretical approach.

**“Fun with Bases Part II – Getting to the Root of the Problem”**  
Jacob Jones, Southwest Baptist University

Faculty Advisor: Dr. Steve Bowling, Southwest Baptist University

This presentation will be reporting over how to find square roots accurately in different bases, mainly in base ten and base two. In this presentation, different methods for finding square roots without the use of a calculator will be discussed. The methods discussed during the presentation will be compared for their efficiency. By investigating one of these methods in base two, we can better understand how calculators and computers can find accurate approximations for square roots while doing less computational work. This is more of an expository rather than a theoretical presentation.

**“Dynamics of Networked Connectivity Models of Waterborne Disease Epidemics”**

Dayna Mercadante, Franklin Pierce University

Faculty Advisor: Dr. Jorge Rebaza, Missouri State University

A networked connectivity model of waterborne disease epidemics originally introduced by Gatto et al. is studied. Following the ideas presented by Shuai and van der Driessche, we prove global asymptotic stability of the disease-free equilibrium point using LaSalle Invariance Principle and constructing an appropriate Lyapunov function, and we prove the existence of an endemic equilibrium point when the disease-free equilibrium is stable. We also prove the existence of a transcritical bifurcation at the disease outbreak, and we prove that under certain conditions no periodic solutions can exist. Numerical simulations illustrate the obtained results.

**“Uniform Convergence of Midpoint Curve Sequences”**

Alvin Moon, University of California, Berkeley

Faculty Advisor: Dr. Xingping Sun, Missouri State University

Let *f* be a continuous piecewise linear plane curve parameterized by the closed interval . We define a midpoint iteration on *f* in and obtain convergence results in the metric for the case when *f* has three vertices.

**“Fun with Bases: All About That Base”**Abraham Pascoe, Southwest Baptist University

Faculty Advisor: Dr. Steve Bowling, Southwest Baptist University

This presentation will discuss the four basic arithmetic computations in bases other than base 10 with an emphasis on multiplication and division. Primarily, the presentation will focus on binary and octal bases and why it can be rather simple for computers to do multiplication and division in these bases. This is more of an expository presentation rather than a theoretical presentation.

**“Species Heterogeneity in the Lotka-Volterra Model”**

Wesley Perkins, Lyon College

Faculty Advisor: Dr. Joseph Stover, Lyon College

Interspecific competition refers to the competition between multiple species for a limiting resource, such as food, space, etc., and interspecific competition is readily modeled by systems of differential equations. A popular model for interspecific competition is the Lotka-Volterra Model (owing to its relative simplicity). I explore how splitting the growth rate into distinct birth and death rates affects the dynamics of the Lotka-Volterra model. Additionally, one of the species is separated into two distinct subpopulations (where each subpopulation has a different death rate) in order to see how this heterogeneity affects the model’s dynamics. Separating the growth rate into distinct birth and death rates and introducing heterogeneity in the death rate changes both the maximum population size of each species and the sizes of the two populations when they reach a stable coexistence.

​

**“Heterogeneous Susceptibility in the SIR Population Model”**

Hope Woods, Lyon College

Faculty Advisor: Dr. Joseph Stover, Lyon College

Due to genetic and environmental factors, some individuals are less likely to become infected with a disease. We are interested in how heterogeneity in susceptibility changes the dynamics of an epidemic. By modifying the SIR population model, we were able to numerically compare a population with 2 different susceptibilities to a population with homogeneous susceptibility. Our results show that the maximum number of individuals infected at the peak of the epidemic is lower and occurs sooner in the heterogeneous model when compared to the homogeneous model with the same mean susceptibility. Understanding these results is important in order to properly prepare resources needed during an epidemic.