**Abstracts**

**Invited Talk: “Tilings”**

Dr. Les Reid, Missouri State University

In this talk, we explore a variety of tilings of the Euclidean plane by polygons, investigate tilings of other topological spaces, and examine the influence of tilings on the art of M.C. Escher.

**Faculty Talk: “Miller Half Rule; Extended and Applied”**

Dr. Dean Priest and Laurie P. Walker, Harding University

In April, 2011, Mr. Bert Miller discovered his half-rule while solving some simple, well known 2D max/min problems.  Extensions of this rule will be made into 3D, 4D, and beyond. Then, these extensions will be applied to formulas related to various geometric objects in order to obtain formulas similar to the derivative of the formula for the area of a circle being equal to its perimeter and the derivative of the formula for the volume of a sphere being equal to its surface area.

**“Zombie Attack! A Mathematical Model of the End of the Human Race?”**

Amanda Bright, Westminster College

Have you considered the outcome of zombies attacking the world? This mathematical model includes factors such as the rate an infected person will 'zombify' and the success rate humans need in encounters with zombies to sustain the human population as a coexistence with or an annihilation of the zombie population. The four classes used are defined as

Susceptibles: living humans,

Mostly Dead: infected humans or decaying corpses,

Zombies: fully zombified humans, and

All Dead: defeated zombies or fully decayed corpses.

We will be looking at the relationships between these classes in order to find a possible scenario in which humans survive and the strategies we would need to successfully exterminate zombies.

**“Cops and Robbers on Graphs”**

Daytona Davis, Missouri State University

Faculty Advisor: Dr. Matt Wright

What does the game “Cops and Robbers” look like when played on a finite graph? How many cops are needed on a particular graph to guarantee that a robber is captured? This talk will explore these questions with specific examples and also discuss how various properties of graphs can affect the number of cops necessary to capture the robber.

**“An Iterative Construction of Bases for Finitely Generated Abelian Groups”**

Zach Deskin, Missouri State University

Faculty Advisor: Dr. Paula Kemp

The existence of a set of linearly independent generators (i.e. a basis) for a finitely generated abelian group *G* (i.e. a generalization of the Fundamental Theorem of Finite Abelian groups) is proved here in a well-motivated way which starts by choosing from all possible sets of generators of *G* a set *X* of generators of *G* such that *X* has a smallest number of generators and such that *X* also contains an element, say *b* of minimal order. Shenkman gave a short proof of this theorem but didn’t put in all the details. The proof of the basis theorem for finitely generated Abelian groups should be of interest because of its simplicity and because of a result from matrix theory on which it is based.

**“Circles in 𝔽****”**

Jacob Haddock, Wesley Perkins, and John Pope, Lyon College

Faculty Advisor: Dr. Jeremy Chapman

In Euclid's *The Elements*, a unique circle in ℝ 2 is determined by three noncollinear points. This is proven geometrically by constructing a triangle from the three points and showing that the intersection of the perpendicular bisectors of two sides of the triangle gives a point that is equidistant from all three vertices of the triangle. This point is said to define the center of a circle which circumscribes the triangle formed by the points. In our research, we demonstrate that circles can be similarly determined in 𝔽, the two-dimensional vector space over the finite field 𝔽. However, the properties of 𝔽 cause some interesting cases to arise. Among these is the possibility for two distinct points to have zero distance. Nevertheless, we were able to show that three distinct noncollinear points which have nonzero distance from each other determine a unique circle of nonzero radius.

**“**[**Convergence and Orchestrated Divergence of Polygons”**](http://people.missouristate.edu/lesreid/reu/2013/ericsidrachel.html)

Eric Hintikka, Washington University, and Rachel Robinson, Willamette University

Faculty Advisor: Dr. Xingping Sun

In 1932, Martin Rosenman proposed the following problem in the American Mathematical

Monthly:

*Let  be a closed polygon in the plane with vertices. Denote by*

*the midpoints of the sides , respectively. Using  as vertices, we derive a new polygon, denoted by. Apply the same procedure to derive the polygon . After n constructions, we obtain polygon. Show thatconverges, as , to the centroid of the original points .*

Although the problem was solved fairly quickly, several generalizations are still of interest.

For example, what happens if, rather than choosing the midpoint of each edge to create a new polygon, we allow more freedom in our choice of new vertices? If the sequences of new polygons converges to a point, where specifically is that point? Conveniently, such polygon transformations can be represented by products of matrices. This perspective, however, begs more questions: which transformation matrices result in a sequence of converging polygons, and which result in something completely different?

In our talk, we explore these questions and a few others using circulant stochastic matrices, the characteristic polynomials of different matrices, Perron's theorem, a little bit of Fourier analysis, and coefficients of ergodicity

**“Pyramid of Pegs”**

Karl Kreitlein, University of the Ozarks

Faculty Advisor: Dr. Matt Myers

In this talk, we explore the solutions of the Triangular Peg Puzzle game made popular by Cracker Barrel. We give an algorithm for solving the standard five row puzzle and then address the question of whether or not a triangular board of infinite size could also be solved in similar fashion. We then address the case of finite triangular boards of *n* rows and provide a proof for solvability based on the values of *n*.

**“Characteristic Polynomials of Non-Commuting Graphs”**

Colleen Robichaux, Louisiana State University

Faculty Advisor: Dr. Les Reid

In this research project, we find the characteristic polynomials for all complete *k*-partite graphs. In order to apply our findings, we classified all groups whose non-commuting graph is a complete *k*-partite graph with .

**“Data Mining Techniques and Their Applications”**

Brittany Street, Missouri State University

Faculty Advisor: Dr. Matthew Willyard

This project, based on research done at an REU at Worcester Polytechnic Institute in Summer 2013, focused on gleaning information from large databases from a sponsor company for information that may improve their operations. Companies are now able to acquire a vast amount of data but it is useless unless patterns can be obtained and interpreted. Techniques of summary statistics such as box plots and graphs were used along with data mining techniques including association analysis, decision trees, clusters and regressions. In this talk I will explain how these techniques work and how they apply to solving problems dealing with large data in industry.

**“[Krylov Subspace Methods to Calculate PageRank](http://people.missouristate.edu/lesreid/reu/2013/ben.html)”**

Ben Vadala-Roth, Boston University

Faculty Advisor: Dr. Jorge Rebaza

Using numerical linear algebra techniques to understand Google's algorithm for ranking relevant websites of a given web search. Specifically, studying Arnoldi methods used for constructing Krylov subspaces, which are then used to approximate an eigenspace of a large matrix. The goal is to find a faster way to compute Google's Page-Rank Vector and to find a sound explanation for the positive effect that matrix reorderings have on the rate of convergence of the Arnoldi methods.

**“**[**Dynamics and Bifurcations in Variable Population Interactions**](http://people.missouristate.edu/lesreid/reu/2013/jordan.html)**”**

Jordan Whitener, Truman University

Faculty Advisor: Dr. Jorge Rebaza

The type of interaction between two species is not necessarily fixed, but may vary depending on population densities, environmental conditions, or other biological factors. In this research, parabolic functions will be used to model the interspecific relationship. Existence and local stability of equilibria, bifurcations, periodic orbits, and boundedness are studied. Examples illustrating the results are given and the impact of harvesting is discussed.

**“Chromatic Polynomials of Complete *K*-Partite Graphs”**

Rebecca Wood, Missouri State University

Faculty Advisor: Dr. Les Reid

Colorings of graphs have been studied for many years. This area of study began in the 20th century with work on map colorings and has more recently been used for scheduling in production plants, airline flight plans, computer programming, and Sudoku puzzles. My presentation focuses on complete *k*-partite graphs. My curiosity in this project originated while looking at properties of non-commuting graphs of groups at Missouri State University’s summer REU program. In this talk we determine the chromatic number and chromatic polynomial of complete *k*-partite graphs.