Poster 1 Plane Application of Orbifold Classification, William Baynard, College of Charleston

Abstract: The classification of objects and tilings of the plane through symmetry is an algebraic application used in chemistry, physics, and mathematics. In 1990, Conway formulated a classification system based on Thurston’s geometric notion of an “orbifold”. The sophisticated orbifold approach to analyzing symmetry resulted in an elegant, more simplified classification scheme. The following paper is an exposition of Conway’s orbifold system with detailed application to the well known wallpaper groups.

Poster 2 "New Math": The History of a Movement in Mathematics Education, Kerri Bernhardt, Western Carolina University

Abstract: One turning point in the United States mathematics education program was when it was discovered that the soldiers lacked enough math skills to be trained properly in radar and navigation in World War II. Another was when the Soviets launched Sputnik, the first satellite into space, bringing to light the fact that the U.S. felt they were behind in mathematics and science education when compared to other countries. The United States responded to these two problems with the new math movement in the 1960s. This new method of teaching mathematics focused on discovery, deduction, and the whys of problem solving instead of memorization. Some of these concepts were very abstract and most students struggled with this new way of learning because the new mathematical terms were foreign to them. Lack of proper training for teachers also contributed to the failure of the new math movement. This poster will discuss the history and struggles of the movement.

Poster 3 The intricacies behind simple problems: How the solution of a separable equation led to a recurrent differential dynamical system, Matthew Brazil, University of Alabama at Birmingham

Abstract: The separable differential equation $y' x^3 - 2y = 0$ with $y(1) = 1$ has an explicit solution $f(x) = e^{1-x^{-2}}$, valid over $(-\infty, \infty)$. The solution’s uniqueness is questioned at zero; an examination of this problem revealed a formula for the $n$-th derivative:
• \( f^{(n)}(x) = \frac{h_n(x)}{g_n(x)} f(x) \), where

• \( g_n(x) = x^{3n} \)

• \( h_n(x) = [2 - 3(n - 1)x^2]h_{n-1}(x) + x^3h'_{n-1}(x) \).

Use of induction and L’Hopital’s Rule reveals this non-analytic function to be smooth over the interval. However, the solution’s uniqueness vanishes at zero. Although the uniqueness of \( f(x) \) was determined, the polynomial \( h_n(x) \) reveals an unexpectedly intricate function: it is a recurrent differential equation. We define \( h_0(x) = 1 \). Studying this polynomial reveals a number of properties; \( h_n(x) \) has exactly \( n \) terms; it appears to have a degree of \( 2(n - 1) \), from which follow the subsequent properties for the coefficients: the formula for the last term in \( h_n(x) \) is given by \( c_n(n) = 2^n \) for all \( n \geq 0, n \in \mathbb{Z} \); the formula for the first term of \( h_n(x) \) for any \( n \geq 1, n \in \mathbb{N} \) is given by \( c_1(n) = (-1)^{n+1}(n + 1)! \); the formula for the \( k \)-th term, for \( k \in [1, n], k \in \mathbb{N} \), for any \( n \) in \( h_{n+1}(x) \), is given by \( c_k(n+1) = 2c_{k-1}(n) - c_k(n)(n + 2k) \). The recurrence can also be viewed as a mapping from \( h_n(x) \rightarrow h_{n+1}(x) \) in the space \( \mathcal{P} \) of polynomials, creating an orbit of a discrete dynamical system on \( \mathcal{P} \). Though we start with \( h_0(x) = 1 \), any polynomial could be the starting point. The rate of growth of the coefficients \( c_k(n) \) reveals opportunities for asymptotic analysis; \( c_1(k) \) increases dramatically as \( n \rightarrow \infty \); the rate of growth of \( c_2(n) > c_1(n) \), and likewise the rate of growth for \( c_3(n) > c_2(n) \). Yet, by the \( n \)-th coefficient \( c_n(n) \), the rate of growth has decreased to a relatively paltry \( 2^n \).

**Poster 4** Mathematics Education in Nineteenth-Century America, Megan Cavanah, Western Carolina University

**Abstract:** Mathematics education in the United States as we know it today is drastically different than it was in the past. This poster will focus on mathematics education in the US during the 19th century. During this century, mathematics was greatly influenced by scientific and philosophical forces. This poster will look at what mathematics was taught and how it was taught at every level of schooling. It will also examine the methods used by teachers and the level of preparation that teachers had during this time period.

**Poster 5** Blaise Pascal: Proving the Existence of God in Mathematics, Laurel Cobb, Western Carolina University

**Abstract:** This poster looks at Blaise Pascal and how he became a leading figure in the mathematical world. It covers some of the factors that influenced him as a young child as well as some of his major mathematical advances. One thing in particular that this poster discusses is Pascals Triangle. The inner workings of this mathematical structure can be seen in my poster. Blaise Pascal is most
associated with the aforementioned triangle, but what else is there to know about this man? This poster delves into his compositions to discover who or what played contributing roles in the math and thought process of Pascal. This display is an overview of the life and accomplishments of Blaise Pascal.

Poster 6 BRT Polynomials of a Link Family, Melissa Cook, Berry College

Abstract: In this project, I explored a family of links and their associated dessins. A dessin is graph together with an embedding on an oriented surface such that the surface minus the graph is a union of 2-discs. From there I looked at the related BRT (Bollobas, Riordan, Tutte) polynomials of the dessins. I discovered some interesting patterns between the BRT polynomials and the specific link. I investigated the orbits of the subdessins used in calculating the BRT under a cyclic action of the edges and again found interesting patterns. I also compared the rank, nullity and genus of the subdessins. The goal of this project is to find patterns between the BRT polynomial and the associated link such that the calculation of the BRT polynomial is simplified.

Poster 7 Sudoku Puzzle Difficulty Models, Shay Ellison, Stephen Strickland, Manan Gupta, Wofford College

Abstract: By representing the Sudoku puzzle board as a mathematical graph with relations representing the rows, columns, and regions, we developed a solution algorithm to determine the uniqueness of all Sudoku puzzles. Because of the complexity of this algorithm we were unable to fully implement it. Of the successful algorithms, one used a randomly pre-created Sudoku board to apply the solution algorithm to hide values while simultaneously determining the difficulty of the newly generated puzzle. This algorithm had a complexity of $O(n^4)$ for all difficulties for $n$ being the size of the puzzle board. The other final algorithm was 800% - 1000% more efficient at creating Sudoku puzzles of a wide variety of difficulties. This algorithm reduced a completed Sudoku board like the previous algorithm except that the initial reductions were based on simple markup techniques. Then depending on the difficulty, the given values on the board would continue to be removed by more complex solution algorithms until no more points could be removed, maintaining a unique solution. This algorithm had a complexity of $O(n)$ for the lowest difficulties and ranged to $O(n^3)$ for the highest difficulties for $n$ being the size of the puzzle board.

Poster 8 On a Model of Vortex Filament Motion: Closed Solutions, and Knot Energy, Kelly Epperson, College of Charleston

Abstract: First we will discuss a model for vortex filament motion, mentioning the assumptions and simplifications necessary to construct a usable model. We will discuss the concept of conserved quantities, their relevance to our model,
and their usefulness as a diagnostic of numerical experiments. We will also mention several solutions to the flow that we generated numerically, discussing the numerical approach as well as the interesting characteristics of the solutions themselves. We will then discuss the special case of Fourier Knots, our search for permanent Fourier solutions, and some knots that remain close to pure Fourier Knots throughout their entire evolution. Finally, we will discuss the concept of Knot Energies and their applications to our flow. These Knot Energies play a role as diagnostic tools, giving us a way to observe changes in Knot Type, as well as the overall level of Knot Complexity. We will conclude by posing some of the open-ended questions in our research as well as mentioning the avenues of research that we are currently pursuing.

Poster 9 Iris Recognition Optimized for Information Assurance, Amanda Eure, Winston Salem State University

Abstract: In an increasingly digital society, the demand for secure identification has led to increased development of biometric systems. We look at the history, purpose, and nature of both physiological and behavioral biometric systems. Iris recognition is the most reliable of the biometric systems used today, in many respects. In this project, we examined the properties and implementation of iris recognition biometric systems.

Poster 10 Cayley Tables and Sudoku, Charles M. Evans & Michael F. Lomuscio, Berry College

Abstract: A study of Sudoku Puzzles whose solutions can be represented by a Cayley table of the group of integers zero through eight under arithmetic modulo nine. We determine the number of puzzles that can be represented by this group and develop an algorithm for solving such puzzles. This research identifies methods that determine whether or not an unsolved puzzle is an element of the group. We also provide examples of puzzles that cannot be modeled by the group and analyze some of their properties.

Poster 11 Steady-State Distributions of Closed Asset Systems, Maria Fedore, Elon University

Abstract: The purpose of this research is to compare certain asset-exchange models to the distribution of household incomes in the U.S.A. Two new exchange rules are shown to have strong promise in overcoming weaknesses previously noted in the literature for such models.

Poster 12 To Steal or Not To Steal: Modeling Kleptoparasitic Behavior in the Dung Beetle Onthophagus Taurus, Meghan Fitzgerald, University of North Carolina Greensboro
Abstract: We have adapted previously-developed game theory models of kleptoparasitism to model brood parasitism in the female paracoprid dung beetle Onthophagus taurus. O. taurus is known to find existing brood balls, destroy the egg, and use the prepared brood chamber to lay her own egg. Using existing literature and our own field and lab studies, we gathered empirical data to estimate parameters of the model, incorporating search and preparation times. We used this data to form a model that can predict the conditions under which a beetle is likely to steal the brood mass verses preparing her own, as well as when guarding the brood mass is optimal. We concluded that if it takes less time to kleptoparasitize then it does to prepare a brood ball for herself then it is advantageous to steal whenever a vulnerable brood ball is found. We also concluded that if she cannot produce a new egg faster than kleptoparasites can find the old one, it is better to guard for the entire time the egg is vulnerable. If the opposite is true, it is better not to guard the egg at all. In addition, we can use the model to predict the proportion of beetles in the population performing certain tasks, such as: resting, searching for a dung pat or an existing brood ball, preparing, kleptoparasitizing, laying the egg, and guarding. We are currently using these proportions to determine the Evolutionary Stable Strategies (ESSs) of the beetles under varying population densities.

Poster 13 Improving Honeybee Division of Labor and Colony Fitness with Genetic Variation in Workers, Robert Gove, University of North Carolina - Greensboro

Abstract: The honeybee, Apis mellifera, exhibits extreme polyandry—queens will mate with approximately 10-12 drones at the beginning of their reproductive life and then never mate again. As a consequence of multiple mating, genetic variability of the colony is increased. One hypothesis as to why this mating behavior is adaptive for honeybees is that the colony will benefit from a more efficient division of labor. In this theoretical study we examine how colony fitness is influenced by worker bees who vary in their genetic make up and the threshold levels needed for response. The general model we developed involved a decision making process by the worker bees based on their genotype and the current colony conditions compared with the optimal colony conditions. There are two versions of this model: In the relative response threshold model the workers perform a given task if the stimulus is too far above or below their response threshold, and in the absolute response threshold model the workers perform a given task only if the stimulus is too far below their response threshold. By approaching solutions of the two models by way of a simulation, we produced two similar sets of results which show that colony fitness improves inverse exponentially as the queen’s mating number increases. The results suggest an optimal number of matings near the actual mating levels.
Poster 14 The Four Primality Tests, Karen Hicklin, Spelman College

Abstract: Since the discovery of prime numbers, a couple of the main questions have been how many are there and how large can they become. As we all know, there is no pattern to finding prime numbers only tests to prove numbers are prime. In this poster presentation, I plan to display four different probabilistic primality tests and explain how they work. These tests are Fermats Test, Miller Rabin Test, Lucas Primality Test, and Extended Quadratic Frobenius Test. These four tests are widely used to check numbers for primeness.

Poster 15 Jon Jackson, Kennesaw State University

Abstract: Domination numbers for the standard square chessboard have long been studied by mathematicians. Much work has been done on the domination number for the Queen’s graph on the square of side n. In this presentation we conduct an analysis of the Queen’s domination number for the cube of side n. Two types of chessboards on the cube will be considered: the $6n^2$ cells that constitute the exterior faces on the cube of side n and the $n^3$ cells that form the interior of the cube of side n.

Poster 16 Music and Ratios: Pythagoras to Present, Jaymi Jeffery, Western Carolina University

Abstract: Throughout history, both mathematics and music have been linked together, while at the same time underestimated by many. Dating back to the 5th century BC, Pythagoras explored the interval between notes using ratios. Archytas made a clear connection when he included music/harmonics as part of the quadrivium. This poster will explore the different approaches to math and music with emphasis on tuning and pitch/frequency. The poster will show the first ideas of pitch by explaining the Pythagorean spiral and its relation to the current circle of 5th’s/4th’s. Connections will be established between math and composition, as well.

Poster 17 Gracefully labeling a new class of trees, Sally Lake, UNC Asheville

Abstract: A labeling of a graph G is a function assigning a natural number to every vertex of the graph. Given a labeling on the vertices V(G) of G, we can induce a labeling on the edges E(G) by defining the label on any edge to be the difference of the labels on the vertices that are connected by that edge. A graceful labeling is a labeling in which the edges in the graph are given different values by the induced labeling. A graph is graceful if there is a graceful labeling of the graphs vertices. There is a longstanding open conjecture in graph theory that claims that every tree (that is, every connected, acyclic graph) is graceful. Although many people have worked on this problem, a general solution is nowhere in sight. We show that if a tree T has a unique
branch point and an odd number of legs such that any two legs differ in length by at most 1, then T is graceful. We discuss some minor generalizations of this result.

Poster 18 **King’s Total Domination on the Square Chessboard of Side $n$, Andy Ligtcap, Kennesaw State University**

**Abstract:** A set $S \subseteq V$ is a dominating set of a graph $G = (V, E)$ if each vertex in $V$ is either in $S$ or is adjacent to a vertex in $S$. A vertex is said to dominate itself and all its neighbors. The domination number $\gamma(G)$ is the minimum cardinality of a dominating set of $G$. In terms of a chess board problem, let $X_n$ be the graph for chess piece $X$ on the square of side $n$. Thus, $\gamma(X_n)$ is the domination number for chess piece $X$ on the square of side $n$. In 1964, Yaglom and Yaglom established that $\gamma(K_n) = \left\lfloor \frac{n+2}{3} \right\rfloor^2$. This extends to $\gamma(K_{m,n}) = \left\lfloor \frac{m+2}{3} \right\rfloor \left\lfloor \frac{n+2}{3} \right\rfloor$ for the rectangular board. A set $S \subseteq V$ is a total dominating set of a graph $G = (V, E)$ if each vertex in $V$ is adjacent to a vertex in $S$. The total domination number $\gamma_t(G)$ is the minimum cardinality of a totally dominating set of $G$. In 1995, Garnick and Nieuwejaar conducted an analysis on the total domination numbers for the king’s graph on the $m \times n$ board. In this presentation we note an error in one portion of their analysis and state a correct general upperbound for $\gamma_t(K_{m,n})$. Furthermore we improve on this upperbound for the square of side $n$.

Poster 19 **The Monte Carlo Method, Truly Lucman, Western Carolina University**

**Abstract:** Monte Carlo is a mathematical-problem solving method which utilizes randomly generated variables in order to approximate a numerical solution. The idea behind it came from the fact that roulette wheels found in the casinos of Monaco are one of the simplest (and probably most common) mechanical devices to generate random numbers. As a problem solving method, Monte Carlo is used to approximate the definite integration associated with the area of a shape or the area under a curve using randomly generated numbers of coordinates. This poster investigates the Monte Carlo method, its implementation, and its accuracy compared to traditional Simpson’s Method.

Poster 20 **Unexpected groups. Sarah Mason, Western Carolina University**

**Abstract:** This poster discusses unexpected groups, based on an article by W. R. Brakes that was published in *The Mathematical Gazette* in 1995. I will show how singular $2 \times 2$ matrices of a particular form: $[[a, a], [a, a]]$ (where $a$ is not equal to zero) can form a group under matrix multiplication. This is not automatically obvious since the identity of most matrix groups under multiplication does not follow the form of our special matrices and therefore cannot be in the group. If the normal identity for matrices under multiplication
is not in the group, we must find another identity in order to form a group. There is also not an obvious inverse for our special singular matrix. This problem can also be solved. Through several theorems and calculations, a group can be formed using just our special 2 x 2 singular matrices.

Poster 21 Julia and Fatou sets, Katelan Price, Western Carolina University

Abstract: In this poster, we look at the history and definitions of Julia and Fatou sets. We consider standard complex functions and see how Julia set definitions relate to these standard complex functions. Most of these standard functions are not usually discussed in a Julia set setting. Then we explore various functions with different types of Julia sets: a disconnected one, a connected one with 1 Fatou component, one with 2 Fatou components, one with an infinite number of Fatou components, and one with no Fatou components. In each case, we discuss typical behavior of the complex mapping.

Poster 22 Hyperbolic Tilings, Mallory Schaffert, UNCA

Abstract: I am studying properties of Hyperbolic tilings. Finding the independence number and the shape of sleeve graphs corresponding to hyperbolic pillows.

Poster 23 The Dottie Number, Theodore Schoen, UNCA

Abstract: Geometric and analytic exploration of this new constant.

Poster 24 Public Key Cryptosystems, Lauren Scott, Spelman College

Abstract: Cryptography started as a way to send secret messages during war times about planned operations. In the present day the military still uses cryptography to send enciphered messages, but another very common use is protecting personal information when buying and selling on the internet. The known methods involve raising the information to large, 100+ digit numbers and using modular arithmetic with 200+ digit numbers, and therein lies my field of study. My presentation will cover some widely accepted public key cryptosystems and point in the direction of possible improvement.

Poster 25 Hurricane Evacuation An analysis of evacuation models on the Houston/ Galveston region, Laura Sinden, Elon University

Abstract: This research analyzes different evacuation models to study the effect and impact of different variables in the models on the traffic flow and speed of an evacuation. The models that will be studied in this research are: steady-state model, one-dimensional cellular automata model, and the space-speed curve. While studying these models, this research computes evacuation statistics for the Harris and Galveston county area keeping in mind any suggestions for future evacuations.
A three-stage model of mosquitofish population dynamics, Luke Stannard, University of Alabama at Birmingham

Abstract: The goal of this research is to study mathematically a three stage difference equation model of the population of mosquitofish (Gambusia affinis). The mosquitofish display cannibalism, generating a very interesting mathematical scenario. This study is based upon prior studies involving two stage models, which generated several student presentations. One version of a two stage model used the equations

\[ A_t = s A_{t-1} + m e^{-k A_{t-1}} J_{t-1} \]
\[ J_t = f A_{t-1} \]

In this model, there are four parameters: \(0 \leq s \leq 1\) is the survival probability of the adult population \(A_{t-1}\) from one time step to the next, \(k\) is the strength of the cannibalism factor of adults on juveniles \(J_{t-1}\), \(0 \leq m \leq 1\) is the maturation probability of the juvenile population, and \(0 \leq f \leq 20\) is the fecundity factor (the number of births per adult in a given time step). A time step of 1 represents the maturation time.

The three stage model is similar to the two stage model. However, an additional stage, fry, has been added.

\[ A_t = s A_{t-1} + m J_{t-1} \]
\[ J_t = g e^{-k A_{t-1}} F_{t-1} \]
\[ F_t = f A_{t-1} \]

It is more complex than the two stage model, but it is more realistic since it has the cannibalism factor \(e^{-k A_{t-1}}\) affecting the fry stage rather than the juvenile stage. Juveniles are too large to be eaten by adults. The additional parameter in this model is the survival probability \(0 \leq g \leq 1\) of the fry. A time step of 1 represents the time for fry to mature to juveniles, and for juveniles to mature to adults, which are approximately equal.

Our ultimate goal is to develop a model to fit to actual experimental data. First we will investigate the three stage model mathematically, both analytically (eigenvalue analysis) and numerically. At a later date, data from experiments currently going on will be available which will allow the model to be parameterized. The population of the mosquitofish will then be manipulated experimentally, and the resulting bifurcations will be checked against the predicted bifurcations from the theoretical model. Other experiments have been done to show it is possible and often advantageous, to use the bifurcation to select the best theoretical model.
Poster 27 **Grbner basis for ideals and some applications**, Shakiera Stembridge, Spelman College

Abstract: We will study the algorithms of Grbner basis theory and apply to ideal membership problems for an ideal $I$ of a polynomial ring, $F[x_1, ..., x_n]$, in $n$-indeterminates over a field $F$. That is determining if a given polynomial $f$ in $F[x_1, ..., x_n]$ belongs to a given ideal $I$. Another application is to solve a system of polynomial equations.

Poster 28 **A Dark Age for Mathematics?**, Ray Swanson, Wester Carolina University

Abstract: The Middle Ages are commonly recognized as a period when all intellectual advancements seemed to be at a standstill. Specifically, it has been said that during those “dark times,” there were no mathematical gains, but is this conception really true? This poster will challenge this conception by discussing some of the mathematical advancements that were made during the medieval period in western Europe.

Poster 29 **Jessica Wehner**, Georgia College and State University

Abstract: Biologists conduct microarray experiments to try to identify the most highly expressed genes out of thousands in a given sample. Generally there are two steps in microarray analysis the first results in a ranked list of individual genes, and the second takes a gene list and uses it to rank known gene sets. Several statistical tests can be used to rank genes; however, each method may produce different rankings, and this can affect conclusions about the sample as well as the direction of further studies. Part of my project was to study the agreement between different methods to try to decide which, if any, are best.

We used t, SAM, B and ODP statistics on the same set of data to generate four gene lists. Using the interclass correlation coefficient to assess agreement, we found these methods to rank the genes similarly in this sample. We then used GSA and GSEA methods to rank known gene sets. We found GSEA produced high agreement for each of the t, SAM and B lists used as input. However, using three different GSA methods Mean, Maxmean, and Absolute Mean we found low agreement between gene set rankings (although the functions of the identified gene sets were similar). Further studies should be made to determine if gene list methods consistently produce similar results, because then the fastest method can be used without significant consequences. Also, it is still possible that even when genes are ranked very differently by t, SAM, B and ODP, gene set analysis may create more stability by at least identifying sets of genes with similar function.