MAA-SE at Elon University, March 26-27, 2010

Poster Session

By Poster Number

Applications and Algorithms of Nonlinear Optimization, Geremy Condra, Francis Marion University
Abstract: Many optimization problems fail to be linear. Nonlinear optimization algorithms are required to solve these problems. In this poster, we will consider two algorithms to solve nonlinear optimization problems, solve a simple example, and consider two applications that lead to nonlinear programming problems.

Classifying Weighted Voting Systems, Annalaissa Johnson, Wake Forest University
Abstract: Just because a voter has more "votes" than another, does that mean he has more power in the final outcome of the decision? "Classifying Weighted Voting Systems" is a mathematical research project that evaluates the relative powers of voters in a voting system (such as the systems "dictator" or "majority rule") by calculating the four major known power indices. In doing so, the project also ranks the various systems from strongest to weakest in partially ordered sets, or "posets," based on the number of voters in each election. After ranking the strength of each system, the project proceeds to model the systems for n voters in n dimensions, graphically showing the domain each system holds for specific percentage weights and quota combinations. Through analysis of different perspectives of the models, the research yields connections between posets and geometric models, and between geometric models and power indices. By connecting all three aspects of voting theory (power indices, posets, and geometric modeling), the project concludes by offering a never before discovered power index found through evaluation of the geometric representation of the voting systems.

Big Bubble Theory, Bethany Wentzky, King College
Abstract: Air bubbles, as they cascade upwards underwater, often tend to coalesce into a big bubble, whose upper part is the upper part of a sphere and whose lower part is a plane. Given a very simple model of the dynamics of water pressure (where the bubble's shape is determined by some convex combination of total force on the bubble's surface and the bubble's height for a given volume of air at a particular depth) we try to recreate such a bubble's shape by approximating this convex combination as a single expression involving n profile points at equally spaced depths. By solving the system of n partial derivatives set to zero, we can find the optimal shape of the bubble. Of course, to solve this system we use a computer algebra system, which provides a fun and powerful demonstration of solving a max/min problem in a vector calculus setting.

The Derivation of the Black-Scholes Equation for a European Call Option, Daniel Huffman, Southern Polytechnic State University
Abstract: European style stock options are contracts based on the underlying value of a stock, with the opportunity either to buy or to sell the stock at a certain price some time in the future. Using Ito's Lemma, a well known result from stochastic calculus, we can derive a deterministic formula, known as the Black-Scholes formula, for any particular type of European option. We will do so for a European call, a contract to buy a stock for a set price (the strike price) at a later date. The Black-Scholes Formula for a European call option is a second-order partial differential equation, similar to a reverse heat diffusion equation, with boundary values determined by basic assumptions about the option.

Behavior of Generalized Logistic Equations on Time Scales, Julia St. Goar, Agnes Scott College
Abstract: In this poster, I show the results of studying the characteristics of generalized logistic and exponential functions on various time scales. The motivation behind this study is that some populations are better modeled by exponential and logistic equations on a particular time scale. However, an unusual characteristic of some logistic equations on time scales is the possibility of producing negative output values, something that is impossible for a population. So my focus is analyzing logistic equations and creating necessary conditions such that the output of these equations on time scales remains greater than zero for all points in the time scale. This research was carried out at the University of Nebraska-Lincoln REU with Kyle Kalail and Paul Weber under Dr. Peterson.

Disjoint Monochromatic Circuits in Complete Graphs, Gregory Ferrin, Western Carolina University
Abstract: We will consider an edge coloring with two colors in the complete graph of order 10 and we will show that there are two disjoint monochromatic circuits of odd length colored with the same color. We will also discuss other complete graphs that have similar property.

Graph Lineage and Graph Generation, Benjamin Casses, Western Carolina University
Abstract: In an attempt to explore some relationships and patterns between simple graphs I found it necessary to create an algorithm that would generate the set of all non-isomorphic graphs with a given number of connected vertices. This algorithm relies upon the binary quality of a graph's adjacency matrix to generate a set of all possible graphs. I make use of several shortcuts in determining if a given graph is isomorphic to a previously found graph.

Graceful Labelings for Several Infinite Classes of Trees, Tso-Chun Meng, The Citadel, Alexander Formato, The Citadel
Abstract: One of the most famous open problems in Graph Theory is the Graceful Tree Conjecture: *Every tree has a graceful labeling.* If T is a tree with m edges, a graceful labeling is a function from the vertex set onto the set $\{0, 1, 2, \ldots, m\}$ such that (1) the induced edge label assigned to edge uv is $|f(u) - f(v)|$ and (2) the edge labels are distinct. We prove using a greedy algorithm that, if a tree is just a path, it has a graceful labeling. Further we show that any path with 1 extra pendant edge also has a graceful labeling, and both algorithms are implemented in MATLAB. We further prove that all caterpillar graphs are graceful using a modified algorithm. The Fibonacci trees, T_n, and the Lucas Trees, L_n, are infinite families of trees which are defined recursively using the Fibonacci Recursion: $F_n = F_{n-1} + F_{n-2}$. We show a number of properties of these families including the fact that graceful labelings exist for small values of n.

Exploring Patterns in Boolean Satisfiability, Shashank Suresh, Davidson College, Annie Temmink, Davidson College
Abstract: We studied Boolean Satisfiability (SAT) problems to help our wet lab team members build bacterial computers. SAT problems are logic problems whose solutions are used in Internet search algorithms and 3D graphics software. Our goal for the summer was to look for patterns and to identify structures within different variations of SAT to make more efficient bacterial computers. With the aid of Mathematica, we developed a set of tools to achieve this purpose by visualizing clause satisfiability with super tables and sorting them by different types. With these tools, we constructed a new method for graphically representing 2-SAT and 3-SAT problems. Our results may lead to new methods of addressing SAT and more efficient biological computers.

Effects of Oxidative Stress on IGF Signaling in Chondrocytes, Pamela Marcott, Wake Forest University

Abstract: Oxidative stress is thought to play an important role in age-related disease including osteoarthritis (OA). IGF-1 is a growth factor in chondrocytes (cartilage cells) that plays an important role in promoting cartilage matrix synthesis and inhibiting cartilage degradation. In OA, chondrocytes show a reduced response to IGF-1 which may be due to an increased amount of oxidative stress in the cells as they age. This study investigated the effects of inducing oxidative stress with tert-butylhydroperoxide (tBHP) on the IGF-1 signaling networks of chondrocytes from three different tissue donors. Western blots were used to collect signaling data for various proteins which were later modeled using a heterogeneous computational algebraic method. It was found that the models were consistent under stimulation with IGF-1 alone, as indicated by a strong positive correlation between their models. However, their response to IGF-1 under conditions of oxidative stress was inconsistent with model correlations close to zero. These findings suggest that oxidative stress induces a chaotic response in the IGF-1 signaling pathway and demonstrates how some cell perturbations may affect the ability of the algorithm to produce consistent computational models from biological replicates.

An Investigation on an Inequality Involving Roots, Tuan Le, Fairmont High School

Abstract: In their article, titled "Simple Trigonometric substitutions with broad results" on "Mathematical Reflections" journal, Campos Daniel and Verdiyan Verdan proposed an interesting inequality which had appeared in several occasions in MathLinks forum. In this paper, we will present two new solutions to this inequality problem. We also consider many generalizations to this inequality from different perspectives. Finally, we will apply the results to solve some other difficult inequality problems.

Exploring Placement Criteria in Freshman and Sophomore Level Undergraduate Mathematics Courses, Justin Sims, University of Tennessee at Martin, Emily Anthony, University of Tennessee at Martin

Abstract: One major obstacle in correctly placing freshmen and sophomore undergraduate students in mathematics courses is deciding a standard that ensures the highest probability of success. Currently the University of Tennessee at Martin places students solely upon their scores on the mathematics portion of the ACT using cutoffs based on previous studies at the university. In this project, we will be analyzing the success rate of the current placement model and will explore various regression and generalized linear models to determine if there exists another model which produces a higher probability of success.

Calibrating the Complexity of Ternary Connectives, William Bradley, Appalachian State University, Alex Dunn, Appalachian State University, Matthew Owen, Appalachian State University

Abstract: We have been exploring the relationship between ternary (three-place) and binary (two-place) connectives in propositional calculus. Familiar binary connectives include "and" and "or". We have determined the minimum number of binary connectives needed to express each particular ternary connective. These minima were calculated by an exhaustive computer search. A number of mathematical lemmas were used to reduce the computation time. This research was funded by the Appalachian Academy of Science, an NSF supported STEP project. Jeff Hirst was the faculty advisor for this project.

Salmonella, William Orndorff, Virginia Military Institute

Abstract: In recent news, Salmonella has come to light as a serious problem around the world. It is estimated that there are approximately 12.5 million cases each year. Through the use of differential equations, a model to describe the dynamics of Salmonella was developed based on parameters available in literature. The model is a modified SIRS model. The value of the basic reproduction number and stability analysis will be presented.

Reverse Mathematics of the Heine Borel Theorem, Jessica Miller, Appalachian State University

Abstract: Reverse mathematics addresses how we can use familiar theorems to prove axioms and which theorems are provable in different axiom systems. We are interested in the reverse mathematics of the Heine Borel Theorem, which for $[0, 1]$ states that any covering of $[0, 1]$ by open intervals contains a finite subcover. Results for the reverse mathematics of the Heine Borel Theorem for $[0, 1]$ and for closed sets of rationals in $[0, 1]$ have been previously published by Friedman and Hirst, respectively. We will extend these results to obtain a more complete picture. Specifically, we will characterize the sets in $[0, 1]$ for which either the Heine Borel Theorem holds or for which the Heine Borel Theorem implies WKL_0. This project was completed with Dr. Jeff Hirst as part of the Graduate Research Associate Mentoring Program, a new program funded by the Appalachian State University Graduate School.

Curves, Knots, and Total Curvature, Matthew Evans, Wake Forest University

Abstract: We present an exposition of various results dealing with the total curvature of curves in Euclidean 3-space. There are two primary results: Fenchels theorem and the theorem of Fary and Milnor. Fenchels theorem states that the total curvature of a simple closed curve is greater than or equal to $2p$, with equality if and only if the curve is planar convex. The Fary-Milnor theorem states that the total curvature of a simple closed knotted curve is strictly greater than $4p$. Several methods of proof are supplied, utilizing both curve-theoretic and surface-theoretic techniques, surveying methods from both differential and integral geometry. Related results are considered: the connection between total curvature and bridge number; an analysis of total curvature plus total torsion; a lower bound on the length of the normal indicatrix.
