UTAH VALLEY UNIVERSITY

Department of MATHEMATICS

MAA Intermountain Section Meetings, March 28-29, 2014

Invited Speakers

Annalisa Crannell, Franklin and Marshall College

Title: Math and Art: The Good, the Bad, and the Pretty

Abstract: How do we fit a three-dimensional world onto a two-dimensional canvas? Answering this question will change the way you look at the world, literally: we'll learn where to stand as we view a painting so it pops off that two-dimensional canvas seemingly out into our three-dimensional space. In this talk, we'll explore the mathematics behind perspective paintings, which starts with simple rules and will lead us into really lovely, really tricky puzzles. Why do artists use vanishing points? What's the difference between 1-point and 3-point perspective? Why don't your vacation pictures don't look as good as the mountains you photographed? Dust off those old similar triangles, and get ready to put them to new use in looking at art!

Title: In the Shadow of Desargues

Abstract: Those of us who teach projective geometry often nod to perspective art as the spark from which projective geometry caught fire and grew. This talk looks directly at projective geometry as a tool to illuminate the workings of perspective artists. We will particularly shine the light on at Desargues' triangle theorem (which says that any pair of triangles that is perspective from a point is perspective from a line), together with an even simpler theorem (you have to see it to believe it!). Given any convoluted, complicated polygonal object, these theorems allow us to draw that object together with something that is related to it— its shadow, reflection, or other rigid symmetries—and we'll show how this works.

Paul Zorn, St. Olaf College

Title: Revisiting Familiar Places: What I Learned at the Magazine

Abstract: Among the perks of editing Mathematics Magazine, as I did from 1995 to 2000, was the chance to see and learn an enormous variety of mathematics. Much of it was familiar, but a surprising amount was new, or different. Can there possibly be anything new to learn about cubic polynomials? Countable sets? Equilateral triangles? Bijective functions? The short answer is yes, and I'll give some examples that worked for me. The Magazine and other MAA journals are rich sources of novel — and often surprising — views of supposedly familiar and thoroughly understood topics from undergraduate mathematics. That such examples exist testifies the depth and richness of our subject, including at the undergraduate level.

Bob Palais, Utah Valley University

Title: Math and Artificial Intelligence

Abstract: Many of the ideas that have now been realized in modern artificial intelligence software - speech and face recognition, chess playing, machine learning, intelligent search, etc., can be traced back to a conference in 1956 that was organized by three mathematicians and an electrical engineer. We will discuss some of the mathematical contributions to this field, including the original AI language, LISP and its connection with an algebraic structure, rooted trees; and the Perceptron, a basic artificial neural network model.

Short Courses: Saturday, March 29, 2014; 11:30 am-12:30 pm

Faculty Workshop CUPM 2015: Modernizing curricula in the mathematical sciences,

Presenter: Paul Zorn, St. Olaf College, SB 263

Abstract: CUPM, the MAA's Committee on the Undergraduate Program in Mathematics, has been compiling and updating curriculum recommendations in mathematics since the 1950s. New versions have appeared about once each decade. After reviewing some CUPM history (What was new in mathematics and teaching in 1955? In 1968?) I'll turn to the upcoming 2015 version, now in preparation. We'll discuss (and together critique) recommendations for the structure and content of mathematics majors that reflect new development in mathematical content, cognitive goals, and design and assessment of courses and programs.

Student Workshop: Math and Artificial Intelligence: The Legacy of McCarthy, Minsky, Shannon and Turing,

Presenter: Bob Palais ,UVU, LA 006

Abstract: Continuation of the featured talk. In this workshop, we will train model neurons to recognize alphanumeric characters. Each model neuron determines on which side of a plane an input stimulus lies. By adjusting the positions of the planes by a simple trial and error correction learning algorithm, we can teach the neurons to recognize different classes of stimuli by the region of space the neuron planes determine.

Contributed Talks- Friday Sessions

Teaching Session, SB 246

Presenter: Matt Lewis (graduate student) (matthew.lewis@aggiemail.usu.edu), Utah State University
Title: Authentic Mathematics on Target

Abstract: Aristotle once said "For the things we have to learn before we can do them, we learn by doing them". As mathematics educators we can inderstand that many aspects of our subject can be taught while other can only be learned. Similar to learning how to swim or play a musical instrument, students of mathematics benefit from using their theoretical knowledge in "real-world" circumstances that interest them. However, in most undergraduate matematics courses students are subjected to contrived examples moonlighting as authentic applications. This study develops an example of an effective Project Based Learning experience focused on projectile motion that can easily be modified to meet the needs of students in pre-calculus through first year graduate level applied mathematics courses.

Presenter: Brendan Kelly (graduate student) (kelly@math.utah.edu), University of Utah
Title: Intermediate Algebra

Abstract: Over the past year, I have worked withEmina Alibegovic to redesign the University of Utah's Intermediate Algebra course. In this talk I will share with you the vision I have for the course, the current materials we have developed, difficulties I encountered, and future work that needs to be done.

Presenter: Piotr Runge (professor) (piotr.runge@usu.edu), Brigham Young University-Idaho
Title: Interactive Visualizations using Geogebra

Abstract: Interactive visualizations are very helpful in explaining and exploring most of the concepts in College Algebra and Calculus. Geogebra, a free software that is constantly developed, extended, and improved, is an easy to use, very accessible, and broadly capable tool that can be used by instructors and students. With a very well grown online community and features including a discussion forum and a huge collection of worksheets created by the users and available for free public use, it provides lots of useful examples, and a chance to report errors and request future features.

Presenter: Danae Romrell (professor) (romrelld@byui.edu), Brigham Young University-Idaho
Title: The Role of Worked Examples in Mathematics Instruction

Abstract: This talk will review recent research on using multimedia and e-Learning to teach mathematics, particularly with the use of examples, in order to determine what techniques have been found to be most efficient

and effective. In particular, we examine the theoretical perspective provided by cognitive load theory, recent research in mathematics education, and recent research on multimedia worked-examples.

Presenter: Richard Pieper (professor) (pieperr@byui.edu), Brigham Young University-Idaho
Title: Common Core State Standards Implications for Higher Education

Abstract: *45 of the 50 states have adopted the Common Core State Standards for Mathematics to be used K-12. The standards have begun to be implemented and assessments that accompany them will be administered in the coming school year. Come join a discussion of the following questions:* What is the universitys role in the K-12 Common Core State Standards for Mathematics? How will the CCSS affect future placement in our math courses? How might successful implementation of the standards (interpreted as large numbers of students experiencing the standards as envisioned by its creators and promoters) impact the content and pedagogy of our current introductory college math courses? In what ways can we better prepare K-12 preservice teachers to successfully teach the standards? How might we contribute to the professional development of inservice teachers?

Presenter: Emma (Turner) Schafer (professor) (emmaturner@suu.edu), Southern Utah University
Title: Counting: As easy as 1-2-6

Abstract: For many mathematics and statistics students, it can be difficult to determine which of the techniques (permutation, combination, etc.) to use when solving counting problems. Often we ask students to determine whether order matters, but this mathematical shorthand can be vague and confusing for students. I will discuss a method for teaching basic counting principles that I developed last summer and tested with my Elementary Education students, which helped those students to think about counting problems in more concrete ways and allowed them to correctly determine which counting method(s) to use.

Presenter: Sum Chow (professor) (schow@math.byu.edu), Brigham Young University
Title: Is There a Pot of Gold in a Metamaterial World?

Abstract: "Metamaterials are realistic materials designed to possess certain unnatural properties such as negative refractive index. In this work we investigate whether a rainbow would form if we shine lights on spherical droplets made of certain hypothetical metamaterial. We also examine if rainbow may be formed in spherical metamaterial droplets enclosing ordinary water inside them. The result is illustrated with some GeoGebra code."

Presenter: Kay Litchfield (LitchfieldK@comcast.com), The Boeing Company
Title: A Significant High School Algebra Exercise Sines (and Cosines) of $3N$ Degrees

Abstract: Often, it is when people make a very serious effort in an area of learning, that they finally progress and even enjoy it. We see this commonly in sports and music. This gives a similar possibility for pre-calculus math.

Applied Session A, SB 263

Presenter: Lennard Bakker (professor) (bakker@math.byu.edu), Brigham Young University
Title: Open sets of diffeomorphisms with trivial centralizers in the C^1 topology

Abstract: The topological nature of the subset of diffeomorphisms of a compact manifold with trivial centralizer is one of Smale's problems for the 21st century. In the C^1 case, it was shown recently for any compact manifold that this set is generic, i.e., it contains a dense intersection of open, dense subsets. We show for low dimension tori that the interior of this set is nonempty, i.e., the interior contains open subsets. This is joint work with Todd Fisher.

Presenter: Jacob Duncan (graduate student) (jacob.duncan@aggiemail.usu.edu), Utah State University
Title: Predicting Severity and Periodicity of Mountain Pine Beetle Outbreaks

Abstract: The relationship between the mountain pine beetle (Dendroctonus ponderosae) and lodgepole pine tree (Pinus contorta) has historically been normative: periodic small scale outbreaks of mountain pine beetle (MPB) would attack and kill old or weakened pine trees which subsequently led to new healthier forest growth. However, since MPB require mode rate winter and warm summer to achieve synchronous emergence and successful attacks (Powell and Logan 2005), outbreaks have been more severe in recent decades due to global warming. These outbreaks can increase wildland fire risk and are likely the primary contributor to recent fires in Colorado. MPB-caused forest destruction may have significant effects on the capability of northern forests to remove greenhouse gas (CO 2) from the atmosphere which can further exacerbate the global climate change phenomenon. In this paper we develop an age-structured forest demographic model that incorporates temperature dependent bark beetle infestation. The model is parameterized using data from a 1995-2005 outbreak in central Idaho (Powell and Bentz 2009). Stability of

fixed points is analyzed as a function of (thermally controlled) growth rates, and indicates the existence of periodic outbreaks that increase with severity as growth rates increase. We devise analytical methods to predict outbreak severity and duration as well as expected time between outbreaks. These approximations match simulation results well and we show that the error in approximate verses simulation outbreak-recovery cycle period follows a power law in MPB growth rate.

Presenters: Sean Bailey (graduate student) (seanbailey@aggiemail.usu.edu) and David E. Brown (professor), Utah State University
Title: Aliens vs. Zombies: An Introduction to Bipartite Dot Product Graphs

Abstract: A *bipartite dot product representation* of a bipartite graph G with $V(G) = X \cup Y$ is a function $f : V(G) \to \mathbb{R}^k$ such that for vertices $x \in X$ and $y \in Y$, $xy \in E$ if and only if $f(x)^T f(y) \geq 1$. We illustrate how these representations may be used to illuminate structure in social and biological networks, especially where there are specified sets within which relationships are ignored. Aliens and Zombies, for example. We will also characterize the (bipartite) graphs with a representation $f : V(G) \to \mathbb{R}^1$; i.e., the graphs with *bipartite dot-product-dimension* 1, and present results for bipartite graphs with bipartite dot-product-dimension $k > 1$.

Presenter: Trevor Williams (graduate student) (johndoe314@gmail.com), Utah State University
Title: The Game of Thrones

Abstract: The game of thrones is a two-player impartial combinatorial game played on an oriented complete graph (or tournament) named after the popular fantasy book and TV series. The game of thrones relies on two types of special vertices, kings and heirs. A king is a vertex, k, in a tournament, T, which for all x in T either k beats x or there exists a vertex y such that k beats y and y beats x. An heir is any vertex that is not a king but becomes a king when some vertex is removed from the tournament. Players take turns removing vertices from a given tournament until there is only one king left in the resulting tournament. The winning player is the one which makes the final move. We develop winning strategies and losing positions for most tournaments.

Presenter: Jianlong Han (professor) (han@suu.edu), Southern Utah University
Title: Long-term behavior and numerical analysis of a nonlocal evolution equation with Kac potentials

Abstract: We study the long-term behavior of the solution to a non- local evolution equation which describes the limit of Ising spin systems with Glauber dynamics and Kac potentials on a bounded domain. We then propose an unconditionally stable, convergent finite difference scheme to this equation. We prove that the scheme is uniquely solvable, inherits the properties of the original equation, and that the numerical solution will approach the true solution in the L_∞ -norm.

Presenter: Ram Neupane (graduate student) (ram.neupane@aggiemail.usu.edu), Utah State University
Title: Mathematical Model of Active Seed Dispersal by Frugivorous Birds and Speed of Invasion

Abstract: Seed dispersal of juniper and pinyon is a process in which frugivorous birds play a dominant role. Birds either consume and digest seeds or carrying and cache them at some distance from the source tree. The transported and settled seeds can be described by a dispersal kernel, which captures the probability that the seed will move a certain distance by the end of the process. To model active seed dispersal of this nature, we introduce handling time probabilities into the dispersal model to generate a seed digestion kernel. Analysis of the tails indicates that the seed digestion kernel decays at a rate intermediate between Gaussian and Laplace seed kernels. Once the kernel was estimated, we use it in an invasion model to estimate speeds that juniper and pinyon forest boundaries move. The speed of seed invasion corresponding to the digestion kernel was the faster than Laplace and Gaussian speeds for more rapidly digesting seeds. For longer handling times the speeds are bounded between the Laplace (faster) and Gaussian (slower) speeds.

Presenters: Sergio Ramirez (Sergio.ramirez@aggiemail.usu.edu) and Katherine Richarson (katherine.richardson@aggiemail.usu.edu) (undergradaute students), Utah State University
Title: Agent Based Modeling Approach for Sterile Insect Technique Simulation

Abstract: There exists a wide body of literature dedicated to deterministic and stochastic models of pest control methods involving the Sterile Insect Technique (SIT). We introduce an agent based model to simulate the population dynamics of a pest and the effect of releasing sterile males. Our interest is in pests such as moths and beetles for which a combination of multiple control methods is usually employed (pheromone traps, pheromone release, etc). When sterile males are released and mate with a female, no offspring is will be produced. While the SIT has been successfully implemented there is no easy way to determine how many steriles will be required for the SIT to work for a particular infestation and the cost of generating sterile males is high. Our model uses specific biological rates such as lifespan, pregnancy time, average eggs produced, etc. along with information such as total area and initial

population size (males and females) to simulate an infestation. The program allows the user to add sterile males to the population in varying quantities and stages to determine the effectiveness of SIT. Pheromone traps can also be tested with or without SIT for efficiency. By implementing our model in actual studies we hope to be able to assess situations that are ideal for SIT and the optimum method needed to reduce costs.

Presenter: Sarah Reehl (graduate student) (reehl.sarahmarie@gmail.com), Utah State University
Title: Errors and Assays: The Story of the Little n That Could

Abstract: ELISAs, Enzyme Linked Immunosorbent Assays, use antibodies to detect the presence of a target substance. Reactions between antibody and target substance participate in a series of reactions that emit a light signal and a machine captures the signal, recording the pixel intensity. After a series of dilutions, the measured pixel intensities are compared to a five-parameter calibration curve to quantify the amount of target substance present. However, each pixel measured comes at a high price, since constructing the ELISA is costly, and thus the more standard measurements required to fit the calibration curve, the less cost-effective the technique. However, the fewer standard measurements used, the more vulnerable the test is to outliers. We wish to fit the calibration curve with as few standard points as possible while remaining resilient to outliers. The industry standard currently minimizes a weighted Sum Squared Error to maximize the likelihood of parameters. We will alternate error structures as well as a Bayesian approach to using prior information, demonstrating that there are ways to make the fitting procedure both more robust and more economical.

Applied Session B, SB 268

Presenter: Ammon Washburn (undergraduate student) (ammon.washburn@gmail.com), Brigham Young University
Title: Modeling wave propagation through metamaterials

Abstract: With the recent surge in interest for metamaterials, there has been an increased interest in modeling such materials to see if we can further understand them. In this effort I have studied some numerical methods to model these equations. Finite difference time domain (FDTD) and the perfectly matched layer (PML) were developed to solve and model Maxwells equations with a finite radiating boundary condition. Since metamaterials follow Maxwells equations, these methods work well with wave propagation through metamaterials. I seek to understand and implement the FDTD and PML methods thereby gaining more insight into metamaterials.

Presenters: Mike Snyder (graduate student) (mikeasnyder@gmail.com) and Dave Brown (professor) (david.e.brown@usu.edu), Utah State University
Title: A dynamic representation of a homeless network

Abstract: Social networks have a structure conducive to applications of graph theory and linear algebra. We investigate the Homeless Network the flow of homeless people from service to service with the hope that we can provide tools for social scientists, via Graph Theory and Linear Algebra, which will help understand the underlying population. A bit more specifically, we present an application of weighted directed multi-graphs and their matrix representations to describe the movement of the homeless population through the homeless services network. While yet untested, well argue that this analytic tool may provide a picture of how changes in the network have affected the underlying population. It may also provide a predictive tool for determining how changes in the network might be made to positively affect outcomes for those experiencing homelessness.

Presenter: Joe King (undergraduate student) (jking@carroll.edu), Carroll College
Title: Burning Down the Cost: A Study to Optimize Wild fire Expenses

Abstract: The cost of wild fires has been climbing drastically. In 2012, the total estimated cost for Montana wild fire suppression was $113.5 million. The goal of this research was to see if it was mathematically possible to minimize wild fire cost while ensuring that a fire is sufficiently suppressed. A linear program(LP) was designed to minimize suppression cost while allocating the required hand, air, and equipment crews to specific stages of a wild fire. Two scenarios are implemented into the linear program, where optimal solutions are found. First, a one wild fire scenario is simulated. Secondly, the most extreme fires of Montana's 2012 wild fire season are simulated. Finally, the LP's optimal results are compared and analyzed with the actual 2012 fire results. Based o_- of the model's outcomes, it was found that dispatch centers with more available equipment had a lower suppression cost. Although the model achieves to meet management requirements, it doesn't account for intangible factors that go into decision making. In conclusion, the linear program provides an optimal solution for wild fire decision management, and under given constraints will efficiently determine the lowest cost while meeting suppression requirements.

Presenter: Alyssa Nugent (undergraduate student) (anugent@carroll.edu), Carroll College

Title: This was part of the COMAP Mathematical Contest in Modeling (MCM), Problem B

Abstract: Sports Illustrated, a magazine for sports enthusiasts, has requested a mathematical model to determine the greatest college coaches, male or female, for each sport in the last century. We created a model to rank college coaches in order to generate a top five list for three different college sports, Basketball, Softball, and Football. Before developing the model, we compiled data about NCAA and NAIA coaches, such as their win-loss-tie records, number of colleges they coached at, number of years coaching, and their national championship titles. Then we utilized the following equation to produce our final results, detailed in the table below. Using the table above, we compared our results to a well-recognized top ten list and found our model mimics the actual list. This model is applicable over both genders and all college sports. Therefore, Sports Illustrated could apply our model to any college sport of their choosing to produce sound top ten lists.

Presenters: Kathleen Schut and Dempsey Rogers(undergraduate student) (drogers@carroll.edu), Carroll College
Title: MCM B. Keep Right Except to Pass

Abstract: Rules of the road have long been studied and analyzed for efficiency. In this paper, we propose two initial models for analyzing the efficiency of the right-most lane rule, the conglomerate of these models is our Pilot Passing Lane Model. This model compares efficiency during both high (slow moving) and low (free flow) traffic density. Our first model uses an ellipse function to predict the trajectory of a vehicle while passing, and a kinematic equations to graphically analyze these relations. The ellipse accounts for fluctuations in angle as the vehicle changes lanes allowing for analysis between the distances traveled in passing and the time required to do so at certain speeds. Our final model, the Gas-Kinetic Adaptation, was adjusted from Boltzmann's Gas-Kinetic traffic model. This model builds on the Pilot Passing Lane Model by accounting for the interaction of lanes and variations in velocities. Our findings from these two models provide sufficient evidence in support that with the right-most rule in place there is a greater efficiency of traffic flow on a four-lane, two-way freeways.

Presenter: Seth Armstrong (professor) (armstrong@suu.edu), Southern Utah University
Title:A Stable Numerical Scheme for System of Competing Species with Diffusion

Abstract: We study a competing species model involving diffusion terms. A nonstandard finite-difference scheme is proposed for analysis of this system. We prove that this scheme is uniquely solvable, stable and that it approaches the true solution uniformly on a finite time interval as time and spatial step-size approach zero.

Presenter: Elise Hardle (undergraduate student) (elisegch@gmail.com), Brigham Young University
Title: Exploring the Wave Equation in Finite Domains

Abstract: To explore waves in infinite domains, Sommerfeldt boundary conditions are imposed at infinity. This ensures well-posedness and uniqueness of the solution, but leads to arduous and lengthy computation that is often impractical. Finite boundary conditions, like Bayliss-Turkel conditions, are imposed to simplify the analysis, ensuring a compromise between accuracy and efficiency without unnecessary complexity. The implementation of these boundary conditions will result in a better understanding of a wave on an infinite domain, as well as finite.

Presenter: David Brown (professor) (david.e.brown@usu.edu), Utah State University
Title: Halls Stable Marriage Theorem revisited and revised to recognize same-sex relationships

Abstract: The typical presentation of Halls Stable Marriage Theorem gives conditions under which a set of boys (or girls) who indicate acceptability of potential pairing with members of the set of girls (or boys) can be paired with the girls (respectively boys) in an acceptable way. This nave configuration which hinges on outdated and unacceptable morals is far from adequate. We present a truer picture of potential partnership among people and indicate, mathematically, why it is unreasonable to expect stability in these pairings. Setting aside the fun had in the semantics of the above abstract we present a slightly more constrained matching problem, than the one to which Halls Theorem applies, whose solution yields a matching (a set of mutually non-incident edges) which respects the possibility of jealousy in partner-pairing and fosters non-competitiveness in work environments where the pairing is of people to jobs. We give some theoretical facts and an argument that this constrained matching problem is NP-Complete (whence the difficulty in creating stable marriages maybe)

Contributed Talks-Saturday Sessions-Pure Math

Graduate Student Session, SB 246

Presenter: Jason Adams (undergraduate student) (jasonradams47@gmail.com), Southern Utah University
Title: Aliens vs. Zombies: An Introduction to Bipartite Dot Product Graphs

Abstract: We study a Predator-Prey model having Holling type II response arising in math biology. The stability of the steady state solutions of this system will be analyzed. Also, we will give some numerical experiments that verify the theoretical results for those steady solutions.

Presenter: Brennon Bauer (baue0793@gmail.com) and Amy Gifford (a1gifford@yahoo.com) (undergraduate students), Southern Utah University
Title: A Stable Semi-Implicit Numerical Scheme for a Competition Model Arising in Math Biology

Abstract: We study a Lotka-Volterra competition model. By using the Nondimensionalization Method, we analyze the stability of the steady state solutions for this system. Using the Principal of Mathematical Induction, we prove the unconditional stability and convergence of our numerical scheme.

Presenter: William Cocke (graduate student) (cocke.william@gmail.com), Brigham Young University
Title: Cohomology of Congruence Subgroups of $SL(3, Z)$ Below the Cohomological Dimension

Abstract: I will demonstrate the conjectured correspondence between Galois representations and the cohomology of arithmetic groups. These objects are not at first related, but their interplay provides a wealth of arithmetic information; for example, the proof of Fermat's Last Theorem is built on an established piece of this correspondence. I will briefly explain an algorithm used to generate new results regarding the conjecture. This algorithm uses a modification of the modular symbol reduction algorithm to calculate the action of the Hecke Operators on cohomology.

Presenter: Skyler Simmons (graduate student) (xinkaisen@gmail.com), Brigham Young University
Title: The Restricted n-body Problem

Abstract: In the standard n-body problem, point masses in space attract each other by a gravitational law formulated by Newton. Under these laws, all bodies are pulled toward each other, even though the motion on one may be very small. For example, in the solar system, we generally think of the earth being pulled around the sun, but the sun is also "pulled" by the earth, albeit in very small amounts. The restricted n-body problem allows for truly "one-direction only" pulling forces between pairs of masses. We examine a particular configuration of the n-body problem and discuss the difficulties in moving between the standard and restricted models, as well as some results shared by both.

Presenter: Andrew Misseldine (graduate student) (emisseldine@gmail.com), Brigham Young University
Title: Primitive Idempotents of Schur Rings

Abstract: In this talk, we explore the nature of central idempotents of Schur rings over finite groups. We introduce the concept of a lattice Schur ring and explore properties of these kinds of Schur rings. In particular, the primitive, central idempotents of lattice Schur rings are completely determined. For a general Schur ring S, S contains a maximal lattice Schur ring, whose central, primitive idempotents form a system of pairwise orthogonal, central idempotents in S. We show that if S is a Schur ring with rational coefficients over a cyclic group, then these idempotents are always primitive and are spanned by the normal subgroups contained in S. Furthermore, a Wedderburn decomposition of Schur rings over cyclic groups is given.

Undergraduate Student Session A, SB 260

Presenter: Matt Brown (undergraduate student) (matthrb@gmail.com), Brigham Young University
Title: An Application of the Group-Weights Theorem

Abstract: In FJRW theory, we use a special type of polynomial and a group of symmetries to construct mathematical models, which are certain types of algebras. The Landau-Ginzburg mirror symmetry conjecture tells us that there should be a matching algebra created from the transposes of each polynomial and group. Recent

advances have provided new ideas into how to prove certain cases of the isomorphism between the two matching algebras. In particular, I will discuss using the Group-Weights Theorem to find cases where an algebra created using a trivial group is isomorphic to one formed from a more interesting group.

Presenter: Christopher J. Bott (undergraduate student) (cjamesbott@gmail.com), Brigham Young University
Title: FJRW Theory: Classification of A-model polynomials and symmetry groups

Abstract: In mirror symmetry, we study isomorphisms between two graded Frobenius Algebras commonly known in theoretical physics as the A-Model and the B-Model. In both theories the inputs to the theory are a quasihomogeneous polynomial and a symmetry group, but it has been shown that the A-model depends only on the weights and the group. I will discuss progress on the problem of identifying of the admissible weights and groups and the classification of the corresponding A-model Frobenius algebras.

Presenters: John Gardiner (johngardiner@byu.net) and Ryan Sandberg (ryan.t.sandberg@gmail.com) (undergraduate students), Brigham Young University
Title: Comparing Chains to Other Polynomials to Better Understand Mirror Symmetry

Abstract: Mirror symmetry is a conjectured relationship between two different algebraic structures, constructed from a polynomial and its symmetry group. While mirror symmetry is well understood for certain classes of polynomials, it is not fully understood for a specific class of polynomials called chains. Finding polynomials with the same groups and weights as those of a given chain gives us insight into the mirror symmetry for that chain. We present our progress in finding polynomials with the same weights and groups as chains.

Presenter: Lisa Bendall (undergraduate student) (lisabendall@gmail.com), Brigham Young University
Title: Defining the Transpose in Landau-Ginzburg Mirror Symmetry

Abstract: I will discuss results related to the construction of a transpose for a special class of polynomials. For the class of invertible polynomials and their symmetry groups, forming the corresponding transpose polynomial and transpose group is well understood, but this is not the case for noninvertible polynomials. However, certain noninvertible polynomials are very similar to an invertible representative, and therefore have many of the same properties of the well-understood invertible representative. I will discuss using this relationship to form the transpose and explore possible extensions to a more general noninvertible polynomial transpose. This has applications to the Landau-Ginzburg mirror symmetry conjecture from theoretical physics, but one need not know the physics to appreciate the interesting mathematical results about groups and polynomials.

Presenter: Nathan Cordner (undergraduate student) (nathancordner91@gmail.com), Brigham Young University
Title: Transpose Polynomials and Symmetry Groups

Abstract: Mirror symmetry is an area of mathematical research stemming from the theories of high-energy particle physics. Landau-Ginzburg mirror symmetry requires a polynomial and an associated group of symmetries to construct higher-level algebraic objects which are conjectured to be isomorphic. A necessary operation to construct these objects is the transpose for both the polynomial and group. A certain class of polynomials, called noninvertible, presents some problems when considering this transpose operation. I will discuss recent progress toward solving the problem of computing transpose polynomials and transpose groups for noninvertible polynomials.

Undergraduate Student Session B, SB 263

Presenter: Kessler, Ian (undergraduate student) (ikessler@carroll.edu), Carroll College
Title: An Exploration of Quadratic Residues in Finite Fields

Abstract: If an element in a given field can be expressed as a product of two equal elements that are also in the field, then this element is a quadratic residue of that field. For the field of rational numbers, the quadratic residues are the ratios of perfect squares. For the field of real numbers, the quadratic residues are the nonnegative numbers. For the field of complex numbers, every number is a quadratic residue. In this talk we will explore quadratic residues of certain finite fields, which are fields with a finite number of elements. Examples of finite fields are ones that operate under modular arithmetic. We can create finite fields using factor rings. By looking at Cayley tables of finite fields, we can identify what elements are quadratic residues of the field. We will explore relationships between finite fields and their quadratic residues. Quadratic residues of finite fields can be used in many areas including computer security.

Presenters: Daniel Adams (11cubed@gmail.com) and Kristen Smith (10465571@uvlink.uvu.edu) (undergraduate students), Utah Valley University

Title: Ends of the Cayley Graphs of $\mathbb{Z}$ with infinite generating sets

Abstract: In this talk we discuss three concepts of ends of graphs: vertex ends, edge ends, and metric ends. It is known that if the graph is locally finite then these three concepts coincide, but for non-locally finite graphs that is not the case in general. The Cayley graphs that we are interested in, $Cay(\mathbb{Z}, \{\pm 2^k\})$ and $Cay(\mathbb{Z}, , \{\pm 3^k\})$, $k = 0, 1, 2, \ldots$, are non-locally finite graphs. Kron [1] showed that these two Cayley graphs have one metric end. Do the vertex and edge ends differ for them? We will answer this question in the negative, by showing that they also have one vertex end, and consequently one edge end. This is a joint work with Daniel Gulbrandsen.

1. B. Krön and R.G. Möller, *Metric ends, fibers, and automorphisms of graphs*, Math. Nachr. 281, No. 1, 62-74 (2008).

Presenter: Daniel Gulbrandsen (undergraduate student) (10637104@uvlink.uvu.edu), Utah Valley University
Title: Hyperbolicity of Cayley Graphs of $\mathbb{Z}$ with Infinite Generating Sets

Duchin and White [1] showed that the identity map is not a quasi-isometry between the Cayley graphs $Cay(\mathbb{Z}, \{\pm 2^k\})$ and $Cay(\mathbb{Z}, \{\pm 3^k\})$, for $k = 0, 1, 2, \ldots$. It is natural to ask if the metric spaces $Cay(\mathbb{Z}, \pm 2^k)$ and $Cay(\mathbb{Z}, \{\pm 3^k\})$ are quasi-isometric, and if not is there a property that is invariant under quasi-isometry that would distinguish them. In this presentation, we turn our attention to a property that is known to be quasi-isometric invariant - hyperbolicity. We use the Gromov's definition of the hyperbolicity of a metric space [2] to show that both spaces, $Cay(\mathbb{Z}, \{\pm 2^k\})$ and $Cay(\mathbb{Z}, \{\pm 3^k\})$, are not hyperbolic.

1. Moon Duchin, Bryan White, Two Presentations of $\mathbb{Z}$ that are not Quasi-Isometric, preprint.

2. M. Gromov, Hyperbolic Groups, Essays in Group Theory, 75–263, Math. Sci. Res. Inst. Publ., 8, Springer, New York, 1987.

Presenter: Steffan Larsen (undergraduate student) (inky1@live.com), Brigham Young University
Title: Space-filling Curves and Their Applications with Metamaterials

Abstract: Metamaterials are materials that are engineered to exhibit specific characteristics namely a negative permeability and permittivity. Wires following a space filling curves are also being used as inclusions in metamaterials. By going up a specified number to steps, known as iteration orders, a curve of great length can be obtained that is held in a specified area. Making antennas that follow a curve such as this will give it a great length, but still held in a specific area. By combining an antenna such as this with a metamaterial ground plane they function as an effective antenna that is cheaper to produce, is more effective in use, and is safer when used in cell phones.

Presenter: Jesse Hicks (graduate student) (j.hicks@aggiemail.usu.edu), Utah State University
Title: Algebraic Properties of Killing Vectors for Lorentz Metrics

Abstract: Four-dimensional space-times with symmetry play a central role in the theory of general relativity. In 1961, in the book Einstein Spaces, A.Z. Petrov gave a complete local classification of four-dimensional space-times based upon their local isometry group, that is, their Lie algebra of Killing vector fields. In this talk we discuss algebraic and geometric properties of these Lie algebras. A database of these properties has been computed for the Lie algebras of Killing vectors found in Petrov. As an application of this work, we present diffeomorphisms between a few pairs of these Lie algebras of Killing vectors.

Combined Faculty and Student Session, SB 268

Presenters: Dakota Hawkins, Newman Knowlton (ntk0213@westminstercollege.edu), and Alex Graves (undergraduate students), Westminster College
Title: O Captain! My captain!

Abstract: Determining the best college sports coach of the past century has been a largely qualitative decision in the past. Here we present a model using linear discriminant analysis and weighted z-scores, developed for the 2014 Mathematical Contest in Modeling, that ranks all college coaches in a given sport throughout the last century. Classification relied on five metrics: championship wins, playoff appearances, career longevity, mentorship and win/loss ratio. Linear discriminant analysis was first trained using data from the National Football League (NFL), and produced a model with 93:75no assumptions of inherent rank, outside of an original binary grouping of NFL coaches, and can easily be applied to any sport across time.

Presenter: T. H. Steele (professor) (thsteele@weber.edu), Weber State University
Title: Attractors for iterated function schemes

Abstract: Many fractals sets are comprised of pieces in some way similar to the whole. The middle thirds Cantor set is the union of two similar copies of itself, and the von Koch curve is made up of four similar copies. These self-similarities not only describe the sets, but can also be used to define them.

We motivate the idea of fractional dimension, and then show how iterated function schemes can generate fractal sets. We conclude with some recent results concerning attractors for iterated function schemes defined on the interval.

Presenter: Scott Lewis (LEWISSC@uvu.edu), Utah Valley University
Title: Constructing Conjugacies Between Unimodal Maps

Abstract: It is well known that the tent map, $T(x) = \begin{cases} 2x & \text{for } 0 \le x \le 1/2 \\ 2-2x & \text{for } 1/2 \le x \le 1 \end{cases}$, is topologically conjugate or semi-conjugate to many unimodal maps $f : [0,1] \to [0,1]$. However, it is very difficult to discover or construct such a conjugacy. We shall use some basic assumptions along with the piecewise linearity of the tent map to construct an infinite piecewise defined conjugacy between the tent map and the Farey map, $F(x) = \begin{cases} x/(1-x) & \text{for } 0 \le x \le 1/2 \\ (1-x)/x & \text{for } 1/2 \le x \le 1 \end{cases}$, defined on sections between mediants of the Farey map.

Presenter: Jonathan Tyler (jonathan.tyler@aggiemail.usu.edu), Utah State University
Title: Quaternions vs. Euler Angles: A Vector Rotation Comparison

Abstract: Rotations in three dimensions are most easily understood using Euler angles. However, implementation of a rotation with Euler angles is not as simple and suffers many drawbacks. Quaternions can be used to describe the same rotations as Euler angles but quaternion rotation is not as intuitive. Their implementation, however, is much simpler and avoids many of the pitfalls of Euler angles. A description of quaternions and quaternion algebra will be given, with emphasis on unit quaternions. It will be shown that quaternions describe the same rotations as Euler angles. Various quaternion interpolation schemes such as SLERP and SQUAD for animating rotations will also be illustrated.

Presenters: Dan Jones (jones1040@gmail.com), Dustin Pierpont (ddpierpomt@yahoo.com) and Yifei Zhu (undergraduate students), Westminster College
Title: Slower-Traffic-Keep-Right Rule

Abstract: In order to promote better traffic flow and efficiency on multi lane roadways, many countries require drivers to remain in the right lane unless attempting to overtake another vehicle. There is little criticism for this "Keep Right Except to Pass" law in the media, only praise, which engendered skepticism of its true effect within our group. Our goal was to analyze whether or not this law does in fact promote traffic flow efficiency and safety in varying, realistic traffic scenarios. We used characteristics of vehicle speeds and sizes, traffic dynamics, and driver behaviors, some generalized from research and others from test-drives in our own vehicles, to generate mathematical models to evaluate the efficiency of this law in both light and heavy traffic. This work was done for the 2014 Mathematical Contest in Modeling.