College of Science and Mathematics

Department of Mathematics

Sixth Annual Kennesaw Mountain Undergraduate Mathematics Conference Program and Abstracts

February 17–18, 2017

Welcome

Welcome to the sixth annual Kennesaw Mountain Undergraduate Mathematics Conference!

We are thrilled that this year KMUMC attracted over **135** participants from **21** universities in **6** states!

We hope you will enjoy the talks, activities, food, great weather, and the beautiful Kennesaw State University campus and come back next year!

We would also appreciate any feedback and any suggestions you have. Please fill out the feedback form included in your registration materials or send comments to Dr. Yuliya Babenko (ybabenko@kennesaw.edu).

Sincerely,
KMUMC Organizing Committee

Yuliya Babenko
Ken Keating
Sandra R. Chandler
David Glassmeyer
Erik E. Westlund
Ludmila Orlova-Shokry
Dhruba Adhikari

Accessing KSU WiFi Network

1. Select "`KSUGuest`" from the list of available wireless networks.
2. Enter "`kennesaw`" as security key.
3. Open a web browser.
4. Login with your email address.
5. You are now connected to the WiFi network.

Note: Guests have limited bandwidth, will only be able to access the Network between 6am and midnight, and are restricted to Internet connectivity through a web browser.

Location of Talks

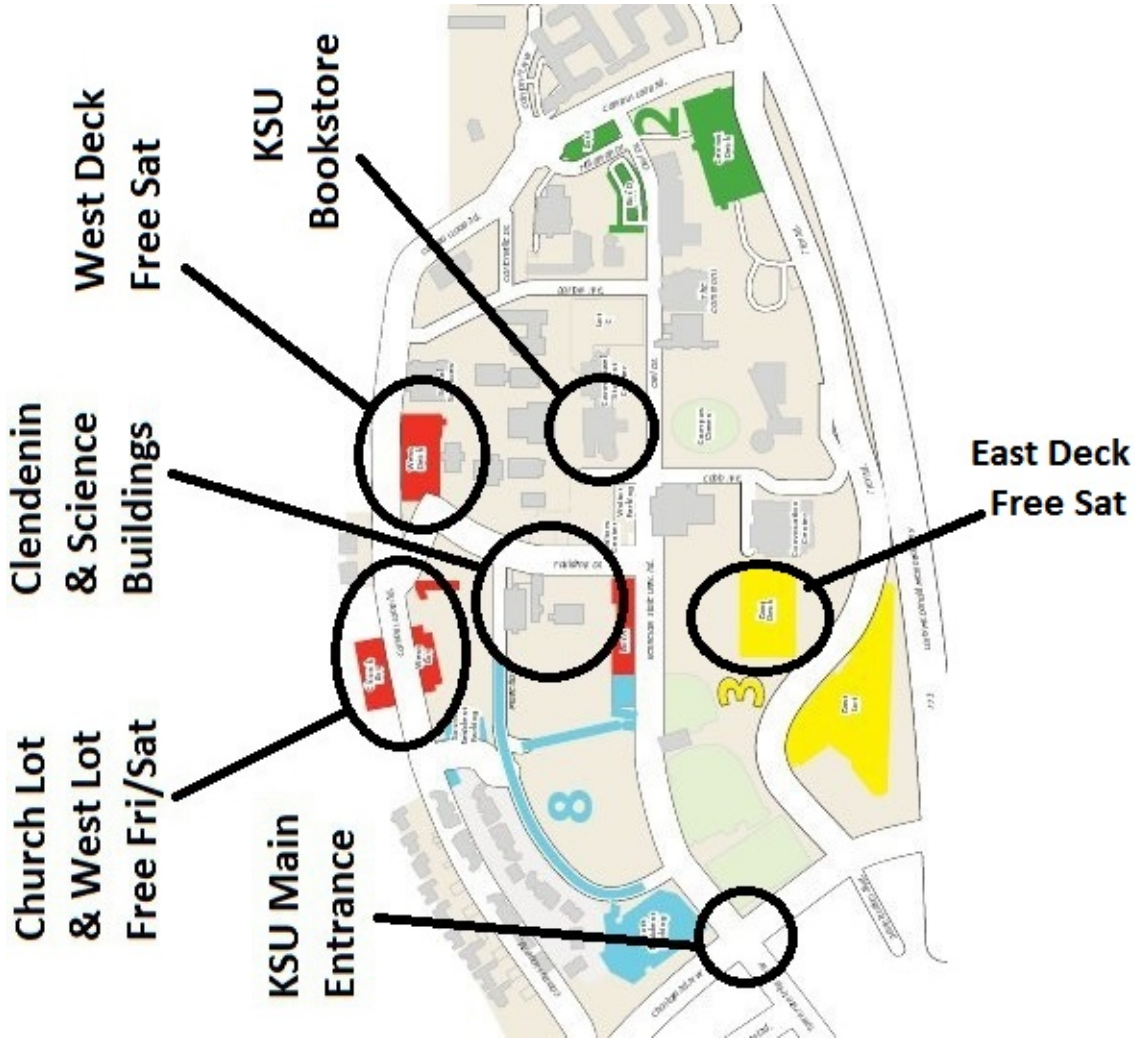
The conference will take place in the Clendenin, Science, and Science Lab Buildings, abbreviated CL, SC, and SL, respectively. See the campus map in your registration packet for directions. Registration and all breaks will be in the Clendenin and Science Lab Building Atriums (CL 1000 and SL 1001).

KSU Campus Bookstore

The KSU Campus Bookstore is located about 200 yards from the main entrance to the Science building (see parking map on the next page). Its posted hours of operation during the conference are:

- Friday 7:30am – 5:00pm
- Saturday 10:00am – 5:00pm
- Sunday closed

Campus Parking Map



On Friday, all visitors can park for free (open parking) in the Church Lot or West Lot Parking (see map above). **The Visitor Parking Lot is not free on Friday.** Saturday parking is free anywhere. We have been asked to use the West Deck, if possible. All these lots are conveniently close to the Science and Clendenin Buildings.

Please take notice, open parking excludes dedicated parking spaces, service vehicle spaces, loading/unloading spaces, handicap spaces, fire lanes, and police spaces.

Friday, February 17

4:00–6:00	Early Registration (SL 1001 Atrium)
5:00–6:00	**Yuliya Babenko** (CL 1010) *When Zombies attack, Or Mathematical model of Doomsday Scenario*
6:00–7:00	**David Glassmeyer** (CL 1010) Alan Turing, the Enigma, and the Pioneering of the Computer Age
7:00–	**Movie** (CL 1010)

Saturday, February 18

8:00–8:30	Registration and Breakfast (SL 1001 Atrium)		
	Morning Contributed Talks		
Moderators:	**Session 1** (CL 1008) Sean Ellermeyer	**Session 2** (CL 1009) Ken Keating	**Pedagogy** [1] (CL 2010) Yuliya Babenko
8:30–8:45	**Patrick Nave** *Topological Data Analysis: An Introduction and a Few Applications*	**Marcus Harbol** *Augmented Happy Function with Complex Variables*	**Jennifer Quinn** (8:30–9:15) *Active classrooms: idea swap*
8:50–9:05	**Qixuan Hou** *Mathematics of Deep Learning*	**Luke Tiscareno** *A Rational Fibonacci to the n Identity*	
9:10–9:25	**Mallory Jennings** *Solving the Yang-Baxter Matrix Equation for a Class of Matrices*	**Welfare Wang** *Fibonacci and Lucas Identity with third and fifth power*	
9:30–9:45	**Jeffrey Ehme** *Making and Breaking the Playfair Cipher*	**Nathan McAnally** *Our process to generalize identities from Fibonacci numbers and Lucas numbers to the GFP*	**George Cazacu** (9:30–9:45) *The quest of finding topics for undergraduate research*
9:50–10:10	Coffee Break (SL 1001 Atrium)		
10:10–11:00	Plenary Lecture 1: **Jennifer Quinn** (SC 109) *Epic Math Battles: Counting vs. Matching*		
11:10–12:00	Graduate School Panel (SC 109)		
12:00–1:00	Lunch (SL 1001 Atrium)		
1:00–1:50	Plenary Lecture 2: **Ronald Gould** (SC 109) *Some Unusual Applications of Mathematics*		
1:50–2:00	Conference Photo		
2:00–2:40	Poster Session (CL 1000 Atrium) **William Bitting** *The Power of ζ_q: Generalizing Hilbert Series for Matrix Groups Isomorphic to $\mathbb{Z}_q$* **David J. George, Simon D. Harris, and John C. Mayer** *Counting Critical Portraits Weakly Bi-Colored Trees* **Fabian Hernandez** *Mathematical Billiards in Triangles using a Markov Process* **Jaime McCartney** *Intersecting Polytopes* **Jackson McDonald** *The Interplay of Pythagorean Religion and Mathematics* **Jessica G. Prince** *μ-rank of Noncommutative Quadratic Forms* **David Richmond** *Fibonacci Number of the Chorded Cycle* **Kayla Shorten** *The Potential Impact of a Prophylactic Vaccine for Ebola in Sierra Leone* **Yutong Yang** *Generalizations of cross-polytope numbers*		
2:40–3:00	Coffee Break (SL 1001 Atrium)		

[1] open to faculty and interested students

	Afternoon Contributed Talks		
Moderators:	**Session 3** (CL 1008) Josip Derado	**Session 4** (CL 1009) Philippe B. Laval	**Pedagogy**[2] (CL 2010) David Glassmeyer
3:00–3:15	**Jason Schmurr** *A Brief History of Rational Billiards*	**David Benko** *Estimating the probability of heads of a fake coin*	**David Glassmeyer** (3:00–3:25) *Using dynamic geometry to foster students' understanding of the tangent function*
3:20–3:35	**James Andrus** *Ensuring Fairly Timed Network Communication*	**John C. Mayer, Patrick B. Hartley and Thomas C. Gerhardt** *Why is Mathematical Modeling Fundamental? Mathematical Modeling: the Experience*	**Susanna Miller** (3:25–3:50) *Catan: Using the Game as a Site to Explore Mathematics*
3:40–3:55	**Shahriyar Roshan Zamir** *Algebraic Properties of Labeled Graphs Joined by j Edges*	**Tyler Bolles** *Linear Water Waves Over Variable Depth and Singular Flow Around Corners*	
4:00–4:15	**Ghanshyam Bhatt** *Reducing the Coherence of the Frame*	**Douglas White** *Time Optimization of a Draining Tank*	**John C. Mayer, Patrick B. Hartley and Thomas C. Gerhardt** (3:55–4:20) *Why is Mathematical Modeling Fundamental?* *Mathematical Modeling: the Experience*
4:25–4:35	**Sean Ellermeyer,** KSU Math Department Chair Concluding Remarks (SC 109)		

[2]open to faculty and interested students

Biographies of Invited Speakers

Jennifer Quinn: Professor Quinn received her Ph.D. from the University of Wisconsin, Madison, in 1993. Since then she taught in and chaired the mathematics department at Occidental College before moving to UW Tacoma in 2007. She is a professor of Mathematics and served four years as Associate Director for the School of Interdisciplinary Arts and Sciences (IAS). She has held many positions of national leadership in mathematics including Executive Director for the Association for Women in Mathematics, Second Vice President of the Mathematical Association of America (MAA), co-editor of MAA's Math Horizons, and, currently chair of MAA's Council on Publications and Communications. She received one of MAA's 2007 Haimo Awards for Distinguished College or University Teaching, the MAA's 2006 Beckenbach Book award for Proofs That Really Count: The Art of Combinatorial Proof, co-authored with Arthur Benjamin. As a combinatorial scholar, Dr. Quinn thinks that beautiful proofs are as much art as science. Simplicity, elegance and transparency should be the driving principles.

Ronald J. Gould: Ronald J. Gould is specializing in combinatorics and graph theory. He is most noted for his work in the area of Hamiltonian graph theory. He had written over 170 research papers and 5 books in the area. His book "Mathematics in Games, Sports, and Gambling: The Games People Play" won the American Library Association award for Outstanding Academic Titles, 2010.
Gould received his Ph.D. in 1979 from Western Michigan University, under the supervision of Gary Chartrand. He is a Goodrich C. White professor in the Emory University Department of Mathematics and Computer Science.

Plenary Talks

1. Title: *Epic Math Battles: Counting vs. Matching*
Speaker: **Jennifer Quinn**
Institution: University of Washington–Tacoma
Email: jjquinn@uw.edu
Abstract: Which technique is mathematically superior? The audience will judge of this tongue-in-cheek combinatorial competition between the mathematical techniques of counting and matching. Be prepared to explore positive and alternating sums involving binomial coefficients, Fibonacci numbers, and other beautiful combinatorial quantities. How are the terms in each sum concretely interpreted? What is being counted? What is being matched? Which is superior? You decide.

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2. Title: *Some Unusual Applications of Mathematics*
Speaker: **Ronald J. Gould**
Institution: Emory University
Email: rg@mathcs.emory.edu
Abstract: In math classes we often see applications of mathematics to other areas such as physics, chemistry, biology, economics and more. But mathematics has applications in many places we might not expect. This talk will show you a variety of applications of mathematics to more unusual problems, puzzles and games.

Contributed Talks & Posters

1. Title: *Ensuring Fairly Timed Network Communication*
Speaker: **James Andrus**
Institution: The Citadel
Email: jandrus@citadel.edu
Abstract: Given the rise in network based collaboration, online stock trading, and competitive online gaming, it has become increasingly important that all parties involved receive information at the same time. We propose an algorithm to fix the issue of unfair delays between different parties participating in a collaborative application. The algorithm proposed applies to networks with a single source and with multiple destinations. It starts with a modified form of Dijkstra's algorithm that ensures that all destinations are leaf vertices. For any destinations that are outside a given delay bound, the algorithm finds a new path from the source vertex to the specific destination vertex within the delay bound if such a path exists. The algorithm works by concatenating simple paths, meaning that no vertex will be used more than twice if cycles arise, ensuring that bandwidth does not become an issue. The process used by this algorithm is similar to a depth first search, recursively exhausting adjacent vertices that meet certain criteria until a suitable path is found or terminating if no such path exists. This algorithm has a variety of direct applications where fair and timely communication is essential, including sending updates to distributed financial databases, maintaining quality of service in video conferencing, or ensuring fairness in online gaming. In our research, we propose this algorithm for fairly timed network communication, provide proof of correctness for the proposed algorithm, and perform simulation experiments to analyze its efficiency.

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2. Title: *When Zombies attack, Or Mathematical model of Doomsday Scenario*
Speaker: **Yuliya Babenko**
Institution: Kennesaw State University
Email: ybabenko@kennesaw.edu
Abstract: In this talk we present various models of a Doomsday scenario if a humankind comes under a zombie attack. We start with analysis of a basic model for zombie infection, determine equilibria and their stability, and illustrate the outcome with numerical solutions. We then modify our model to include various plausible scenarios: a latent period of zombification, effects of possible quarantine, impulsive reductions in zombie population. We demonstrate that only quick, aggressive attacks can save humankind from the collapse as zombies overtake us all.

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3. TITLE: *Estimating the probability of heads of a fake coin*
SPEAKER: **David Benko**
INSTITUTION: University of South Alabama
EMAIL: dbenko@southalabama.edu
ABSTRACT: We tossed a biased coin 2 times and we got 2 heads. What is the probability of heads? The maximum-likelihood method claims it is 1 (i.e., sure thing) but we are unhappy with that answer. We answer the question using game theory and Nash equilibrium. We also explain the situation for more tosses.

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4. TITLE: *Reducing the Coherence of the Frame*
SPEAKER: **Ghanshyam Bhatt**
INSTITUTION: Tennessee State University
EMAIL: gsbhatt@gmail.com
ABSTRACT: The maximum of the absolute values of the inner products of the columns of a matrix is known as the coherence of that matrix. In applications, namely in compressed sensing, the matrix in question is not a square matrix, it is a fat matrix. The set of columns of the matrix is said to be equi-angular if the absolute values of these inner products is a constant for any pair of columns. These are highly desirable matrices but difficult to construct in higher dimensions. The lowest coherence is given by the well known Welch bound. Under mild conditions, these columns form a frame. The optimal (with lowest coherence) ones are known as the Grassmanian frames. In this talk, we look at these columns as a frame and talk about reducing the coherence of the frame.

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5. TITLE: *The Power of ζ_q: Generalizing Hilbert Series for Matrix Groups Isomorphic to $\mathbb{Z}_q$ (poster)*
SPEAKER: **William Bitting**
INSTITUTION: Rhodes College
EMAIL: bitwc-17@rhodes.edu
ABSTRACT: Let ζ_q be a primitive qth root of unity and let $\{a_1, a_2, \ldots, a_n\} \subset \mathbb{N}$ have the following properties: There is at least one a_i such that $\gcd(a_i, q) = 1$ and each a_i is distinct. Consider a diagonal matrix with $\zeta_q^{a_i}$ at position (i, i), and the matrix group that it generates. We would like to know how many invariant polynomials there are with respect to this group of any given degree k. A polynomial $f(\mathbf{x})$ is said to be invariant it $f(\mathbf{x}) = f(\lambda\mathbf{x})$ for any λ in our matrix group. To help find these invariant polynomials, we turn to a formula from Invariant Theory called Molien's Formula. This helpful formula calculates a Hilbert Series, a special type of Taylor Series where the coefficient of t^k is the number of invariant polynomials of degree k. My work focuses on computing a general form for these Hilbert Series, specifically in the case where q is a prime number. Doing so would provide insight into these invariant polynomials and, due to how we have constructed our group, has allowed for progress on methods of solving certain Fourier-Dedekind Sums.

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6. TITLE: *Linear Water Waves Over Variable Depth and Singular Flow Around Corners*
SPEAKER: **Tyler Bolles**
INSTITUTION: Florida State University
EMAIL: a.name@live.com
ABSTRACT: This talk introduces the widely used mathematical model of small amplitude water waves in the context of variable water depth. Lacking exact methods for obtaining solutions to arbitrary water depth, we consider gluing together solutions for separate, constant depths. This method is semi-analytical, using numerical methods only for the inversion of a block tri-diagonal coupling matrix. Our contribution to this classic problem is an insight relating the convergence rate of the eigenfunction expansion for the velocity potential to the bottom geometry. After being partitioned to piece-wise constant segments, the bottom exhibits sharp corners allowing for singularities in the irrotational velocity. Quantitative bounds on the convergence rates are provided through theorems relating the smoothness of a function to the asymptotic decay rate of its Fourier coefficients and conclusions are supported by numerical evidence.

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7. TITLE: *The quest of finding topics for undergraduate research*
SPEAKER: **George Cazacu**
INSTITUTION: Georgia College
EMAIL: george.cazacu@gcsu.edu
ABSTRACT: This work explores some questions related to picking a topic for undergraduate research. Who should pick it, you or the professor? When? How do you know it is good enough yet not extremely difficult (or

worse, simply impossible) to complete? This talk is an attempt at making these questions less intimidating to undergraduate students through some concrete examples from both the universe of mathematics and personal experience of the presenter.

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8. TITLE: *Making and Breaking the Playfair Cipher*
SPEAKER: **Jeffrey Ehme**
INSTITUTION: Spelman College
EMAIL: jehme@spelman.edu
ABSTRACT: Developed in the mid 19th century, the Playfair cipher saw service in both world wars, has appeared in literature and film, and has a connection with John F. Kennedy. We will discuss the cipher's origin and history, explain how to encipher and decipher, and outline a known plaintext attack on it.

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9. TITLE: *Counting Critical Portraits and Weakly Bi-Colored Trees (poster)*
SPEAKER: **David J. George, Simon D. Harris,** and **John C. Mayer**
INSTITUTION: University of Alabama at Birmingham
EMAIL: dgeorge@uab.edu, simondh@uab.edu, jcmayer@uab.edu
ABSTRACT: Weakly bi-colored trees dually correspond to ways of cutting up the unit disk with critical chords. A unit disk with chords of critical length that can only meet at endpoints is called a critical portrait. Critical portraits are a combinatorial/topological way of classifying the connected Julia sets of complex analytic polynomials. By counting weakly bicolored trees, we hope to set limits on the variety of certain classes of Julia sets.

A critical portrait can be viewed as a planar graph with every edge in some loop. The dual graph is a tree. Dynamical properties of the polynomial that produces the Julia set, allow us to color the complementary regions of the critical portrait with two colors corresponding to different dynamics; which in turn, induces a coloring of the dual graph. A graph is defined as weakly bicolored when one color can be adjacent to itself, and the other cannot. We are studying the correspondence between the weakly bicolored graphs and bicolored critical portraits, with the idea that we may use the count of the graphs to establish a count of critical portraits. Thus, we must understand the injective and/or surjective correspondence in each direction.

The action of a complex polynomial on the complex plane is orientation-preserving; therefore, it is important that these weakly bi-colored trees are also orientation-preserving under a homeomorphism of the plane. The addition of this orientation-preserving condition adds some interesting challenges to the counting of weakly bi-colored trees. Understanding the overall count of the graphs requires us to examine special cases: fans, arcs, caterpillars, and lobsters. We have found counts for fans and arcs, and are currently exploring the count of caterpillars. The operating assumption is that the counting of caterpillars will lead to a count for lobsters, which will allow for the counting of super-lobsters. Every tree is representable as a super-lobster.

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10. TITLE: *Alan Turing, the Enigma, and the Pioneering of the Computer Age*
SPEAKER: **David Glassmeyer**
INSTITUTION: Kennesaw State University
EMAIL: dglassme@kennesaw.edu
ABSTRACT: In this interactive session, we will explore the Enigma machine: what was it, why was it important in WWII, and how Alan Turing helped crack the code. Mathematical concepts of permutations will be used to explain why this was a beyond-challenging task. Finally, we will relate these efforts to the start of the computer age

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11. TITLE: *Using dynamic geometry to foster students' understanding of the tangent function*
SPEAKER: **David Glassmeyer**
INSTITUTION: Kennesaw State University
EMAIL: dglassme@kennesaw.edu
ABSTRACT: This session shares a series of technology-driven trigonometric tasks and the impact of these tasks on students thinking about a trigonometry concept. The tasks focused on a tangent-first approach to trigonometry by connecting the concepts of slopes of lines, slope-triangles created on these lines, ratios of side lengths within these triangles, and angles within these slope triangles. The tasks relied on technology by using dynamic geometry sketches that illustrated relationships between these concepts, prompting students to (re)consider the tangent relationship. Come to this session with your laptops or tablet as we will be giving you the sketches to explore for yourself!

12. TITLE: *Augmented Happy Function with Complex Variables*
SPEAKER: **Marcus Harbol**
INSTITUTION: The Citadel
EMAIL: mharbol@citadel.edu
ABSTRACT: Let the Augmented Happy Function with Complex Variables be defined as follows. If $a = \sum_{j=0}^{n} a_j 10^j$ and $b = \sum_{j=0}^{m} b_j 10^j$, then define

$$G_{[c,d,q]}(a+bi) = c + di + \sum_{j=0}^{n} a_j^q + \sum_{j=0}^{m} (b_j i)^q$$

for $a_j, b_j \in \mathbb{Z}$, $0 \leq a_j \leq 9$, $0 \leq b_j \leq 9$.
A fixed point in G is some complex integer $a+bi$ such that for a constant c, d, q, $G_{[c,d,q]}(a+bi) = a+bi$. Given any complex constant, $c+di$, with $c, d \in \mathbb{Z}^+$, there exist a finite number of fixed points in G. We prove properties of fixed points and under what circumstances fixed points can be restricted. We also extend these observations to arbitrary bases.

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13. TITLE: *Mathematical Modeling: the Experience*
SPEAKER: **Patrick B. Hartley** and **Thomas C. Gerhardt**
INSTITUTION: University of Alabama at Birmingham
EMAIL: hartlepb@uab.edu, tcg4583@uab.edu
ABSTRACT: Patrick Hartley and Thomas Gerhardt were, respectively, the teaching assistant and a student in Introduction to Mathematical Modeling, MA 361, at UAB. In this talk we relate our experience in the same course in Spring 2016.

Student (Gerhardt): The study of mathematics to many students can be somewhat dry and seem irrelevant to real world matters. The truth is that math can be applied to an endless amount of real world situations, and it is quite necessary in many cases. Mathematical Modeling aims at taking a real world problem, identifying mathematics that would apply, then incorporating the mathematics in a chosen software program (Mathematica, Excel, or Stella). These programs allow students to visualize what is happening as well as hypothesize about and run tests on the variables in the problem. In this presentation, I will discuss my personal experience in the course as well as how it has affected me as a learner. My commentary on my experience will include: learning the how to use three programs, formulating models for a problem, and a brief overview of the final project in the course and how I have applied what I learned. I will also say a few brief words on how the course has changed my view of both the teacher and the learner.

Teaching Assistant (Hartley): I noticed that in my experience as a Teaching Assistant for Mathematical Modeling, different students would come away having learned somewhat different things depending on the background they came in with. In this presentation, I will discuss the different ideas that I noticed students taking away from the class. I will present three main groups of students that I helped teach: those with a stronger mathematical background, those with a stronger technical or engineering background, and those who fall into neither of the aforementioned groups.

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14. TITLE: *Mathematical Billiards in Triangles using a Markov Process (poster)*
SPEAKER: **Fabian Hernandez**
INSTITUTION: Dalton State College
EMAIL: fhernandez@daltonstate.edu
ABSTRACT: Allowing a point mass to move inside a triangle with elastic collisions gives rise to a dynamical system that is not completely understood. A geometric method called "unfolding" associates a flat surface called a billiard surface to this system, and geometric information about the surface can give insight into the dynamical system. In our project, we approximate the dynamical system with a Markov process. Our goal is to then analyze properties of the resulting matrix to find patterns that relate to the geometry of the surface.

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15. TITLE: *Mathematics of Deep Learning*
SPEAKER: **Qixuan Hou**
INSTITUTION: Georgia Institute of Technology
EMAIL: qhou6@gatech.edu
ABSTRACT: Prediction plays an important role in many aspects of our life. Researchers develop diverse models and methods to predict the trends by analyzing large scale data from the past. Deep learning is a really hot topic right now to extract features, to approximate functions, and to predict future. Deep learning is not a new topic but a advanced version of neural networks, which was inspired by how biological brain solves problems. Even though deep learning seems like a fantastic idea and complicated topic, the math involved actually is not hard. The presentation will focus on how mathematics are used in deep learning.

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16. TITLE: *Solving the Yang-Baxter Matrix Equation for a Class of Matrices*
SPEAKER: **Mallory Jennings**
INSTITUTION: The University of Southern Mississippi
EMAIL: Mallory.Jennings@usm.edu
ABSTRACT: The Yang-Baxter equation is one that has been widely used and studied in areas such as statistical mechanics, braid groups, knot theory, and quantum mechanics. While many sets of solutions have been found for this equation, it is still an open problem. In this project, we solve the Yang-Baxter matrix equation that is similar in format to the Yang-Baxter equation. We try to solve the corresponding Yang-Baxter matrix equation, where X is an unknown matrix, and or, by using the Jordan canonical form to find infinitely many solutions.

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17. TITLE: *Why is Mathematical Modeling Fundamental?*
SPEAKER: **John C. Mayer**
INSTITUTION: University of Alabama at Birmingham
EMAIL: jcmayer@uab.edu
ABSTRACT: Students' beliefs about mathematics and its role in the world can either promote or inhibit learning. Two of the beliefs which have been evidenced by observing students at work (Schoenfeld, "Learning to Think Mathematically" quoted in "The Mathematical Education of Teachers, II") are

- Students who have understood the mathematics they have studied will be able to solve any assigned problem in five minutes or less.
- Ordinary students cannot expect to understand mathematics: they expect to simply memorize it and apply what they have learned mechanically and without understanding.

In part, the UAB course "Introduction to Mathematical Modeling" (MA 361) was developed to address, in a context of applying mathematics to solve "realistic" problems, counterproductive beliefs such as the above. In order to attract students who might stand to gain by providing them with reasons to develop more productive beliefs, the prerequisite was set low, Calculus 1. In part, the course was designed to provide students with the opportunity to use computer technology that they could, and were expected to, understand mathematically to help solve problems.

In this series of presentations, we discuss the evolution of the course over more than a decade, its current incarnation serving multiple roles in the mathematics major, and its effect on students' beliefs about mathematics. In a subsequent presentation, Patrick Hartley and Thomas Gerhardt will talk about their experience in the course from the perspective of the teaching assistant and a student, respectively.

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18. TITLE: *Our process to generalize identities from Fibonacci numbers and Lucas numbers to the GFP*
SPEAKER: **Nathan McAnally**
INSTITUTION: The Citadel
EMAIL: nmcanall@citadel.edu
ABSTRACT: A sequence that satisfies the recurrence relation $F_0(x) = 0$, $F_1(x) = 1$ and $F_n(x) = xF_{n-1}(x) + F_{n-2}(x)$ for $n \geq 2$ is called the Fibonacci polynomial. The Generalized Fibonacci Polynomial (GFP) is a natural generalization of the above-mentioned sequence. Familiar examples of the GFP include Fibonacci polynomials, Lucas polynomials, Pell polynomials, Pell-Lucas polynomials, Fermat polynomials, Fermat-Lucas polynomials, both types of Chebyshev polynomials, Jacobsthal polynomials, Jacobsthal-Lucas polynomials and both types of Morgan-Voyce polynomials. We classify the GFP into two types, namely Fibonacci type and Lucas type. A Fibonacci type polynomial is equivalent to a Lucas type polynomial if they both satisfy the same recurrence relations. In this talk, we will discuss our process to generalize identities from Fibonacci numbers and Lucas numbers to the GFP.

19. TITLE: *Intersecting Polytopes*
SPEAKER: **Jaime McCartney**
INSTITUTION: Dalton State College
EMAIL: jmccart1@daltonstate.edu
ABSTRACT: We address the problem of calculating the maximum number of regions into which space can possibly be partitioned given a collection of intersecting polytopes in $\mathbb{R}^n$. Beginning in $\mathbb{R}^2$ with polygons, we find that the number of intersections and the number of regions created are directly related, and so turn our focus to determining the maximum possible number of intersections. Properties such as convexity, concavity, and the parity of the number of edges are considered when determining the formulae which calculate these maximums. The natural next step will be to answer the same question for polyhedra in $\mathbb{R}^3$.

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20. TITLE: *The Interplay of Pythagorean Religion and Mathematics (poster)*
SPEAKER: **Jackson McDonald**
INSTITUTION: Francis Marion University
EMAIL: jmcdonald7471@g.fmarion.edu
ABSTRACT: While a large amount of modern mathematics is attributed to the Pythagoreans, their endeavors were not just for the sake of advancing the discipline. To the Pythagoreans, mathematics was a part of their religious ritual, a means to achieve spiritual purity and reunion with their god. The purpose of this poster is to examine particular Pythagorean mathematical exercises that stemmed from their notion of number, a metaphysical construct that was the crux of their core religious beliefs. Number was pivotal to their mathematics, so understanding the Pythagorean view of mathematics as a purification will elucidate the interplay between their religion and mathematics.

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21. TITLE: *Catan: Using the Game as a Site to Explore Mathematics*
SPEAKER: **Susanna Miller**
INSTITUTION: Kennesaw State University
EMAIL: smolitor@kennesaw.edu
ABSTRACT: Catan is an internationally popular board game which provides real-worlds examples of many mathematical concepts. During this talk I will highlight ways in which the game supports learning of probability and statistics, game theory, and combinatorics. Variations of the problems presented could provide rich contexts for future undergraduate research collaborations.

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22. TITLE: *Topological Data Analysis: An Introduction and a Few Applications*
SPEAKER: **Patrick Nave**
INSTITUTION: Florida State University
EMAIL: patricknave95@gmail.com
ABSTRACT: Growing ubiquity of not only large but also complex data sets has necessitated the development of increasingly efficient techniques for extracting useful information summaries from these data. Topology offers a valuable approach to such problems by extracting invariants associated with intrinsic "shape" properties of data and disregarding other details which often computationally hinder other types of analysis. This talk will provide a succinct introduction to a subset of tools used in topological data analysis and will briefly discuss a few interesting applications.

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23. TITLE: *μ-rank of Noncommutative Quadratic Forms (poster)*
SPEAKER: **Jessica G. Prince**
INSTITUTION: Tennessee Technological University
EMAIL: jgprince42@students.tntech.edu
ABSTRACT: In 2010, T. Cassidy & M. Vancliff extended the notion of commutative quadratic forms to the noncommutative setting in [CV1]. This led to a definition of a notion of rank, referred to as μ-rank, and was defined for quadratic forms on two and three generators by M. Vancliff & P. P. Veerapen [VV1]. For quadratic forms on four generators, a definition for μ-rank was developed by L. Frauendienst & P. P. Veerapen [LV]. In the poster, we examine this further. We take the field $\Bbbk$ to be an algebraically closed field such that $\mathrm{char}(\Bbbk) \neq 2$.

[CV1] T. Cassidy and M. Vancliff, Generalizations of Graded Clifford Algebras and of Complete Intersections, *J. Lond. Math. Soc.* **81** (2010). 91–112.

[VV1] M. Vancliff and P. P. Veerapen, Generalizing the Notion of Rank to Noncommutative Quadratic Forms, *in* "Noncommutative Birational Geometry, Representations and Combinatorics," Eds. A. Berenstein and V. Retakh, *Contemporary Math.* **592** (2013), 241–250.

[LV] L. Frauendienst and P. Veerapen, Notion of Rank of Noncommutative Quadratic Forms on Four Generators, *Work in Progress.*

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24. TITLE: *Fibonacci Number of the Chorded Cycle (poster)*
SPEAKER: **David Richmond**
INSTITUTION: Kennesaw State University
EMAIL: drichmo1@students.kennesaw.edu
ABSTRACT: In 1982, Prodinger and Tichy defined the Fibonacci number of a graph to be the number of independent sets of the graph. They did so since the Fibonacci number of the path graph is a Fibonacci number and the Fibonacci number of the cycle graph is a Lucas number. Adding a single edge to non-adjacent vertices transforms a cycle into a chorded cycle. This poster establishes formulae and identities for the Fibonacci number of the chorded cycle via algebraic and combinatorial methods.

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25. TITLE: *A Brief History of Rational Billiards*
SPEAKER: **Dr. Jason Schmurr**
INSTITUTION: Dalton State College
EMAIL: jschmurr@daltonstate.edu
ABSTRACT: As a small particle bounces around inside a shape, what can we say about its path? Will we find order, chaos, or something in between? This is the focus of the field of study known as mathematical billiards. In this talk we will discuss some basic concepts in the field of mathematical billiards and survey its presence on the cutting edge of mathematical research.

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26. TITLE: *The Potential Impact of a Prophylactic Vaccine for Ebola in Sierra Leone*
SPEAKER: **Kayla Shorten**
INSTITUTION: Rhodes College
EMAIL: shomk-17@rhodes.edu
ABSTRACT: The 2014 outbreak of Ebola virus disease (EVD) in West Africa was multinational and of an unprecedented scale primarily affecting the countries of Guinea, Liberia, and Sierra Leone. One of the qualities that makes EVD of high public concern is its potential for extremely high mortality rates (up to 90%). A prophylactic vaccine for ebolavirus (rVSV-ZEBOV) has been developed, and clinical trials show near-perfect ecacy. We have developed an ordinary differential equations model that simulates an EVD epidemic and takes into account (1) transmission through contact with infectious EVD individuals and deceased EVD bodies, (2) the heterogeneity of the risk of becoming infected with EVD, and (3) the increased survival rate of infected EVD patients due to greater access to trained healthcare providers. Using parameter values that closely simulate the dynamics of the 2014 outbreak in Sierra Leone, we utilize our model to predict the potential impact of a prophylactic vaccine for the ebolavirus. Our results show that an rVSV-ZEBOV vaccination coverage as low as 40% in the general population and 90% in healthcare workers will prevent another catastrophic outbreak like the 2014 outbreak from occurring.

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27. TITLE: *A Rational Fibonacci to the n Identity*
SPEAKER: **Luke Tiscareno**
INSTITUTION: The Citadel
EMAIL: ltiscare@citadel.edu
ABSTRACT: In my presentation, I will discuss how a colleague, Marcus Harbol, and I solved an open problem from the Fibonacci Quarterly. The problem involves taking the sum of n-power Fibonacci numbers. The problem is stated as follows: Let $n \geq 1$ be a positive integer, compute

$$\frac{F_{n+2}}{F_nF_{n+1}}\left(\frac{F_n^n+F_{n+1}^n-F_{n+2}^n}{F_n^{n-1}+F_{n+1}^{n-1}+F_{n+2}^{n-1}}\right)+\frac{F_{n+3}}{F_{n+1}F_{n+2}}\left(\frac{F_{n+1}^n+F_{n+2}^n-F_n^n}{F_n^{n-1}+F_{n+1}^{n-1}+F_{n+2}^{n-1}}\right)$$
$$+\frac{2F_n+F_{n+1}}{F_{n+2}F_n}\left(\frac{F_{n+2}^n+F_n^n-F_{n+1}^n}{F_n^{n-1}+F_{n+1}^{n-1}+F_{n+2}^{n-1}}\right).$$

In solving this problem, we found additional open problems and their solutions using limits that gave rise to the Golden Ratio.

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28. TITLE: *Fibonacci and Lucas Identity with third and fifth power*
SPEAKER: **Welfare Wang**
INSTITUTION: The Citadel
EMAIL: wwang1@citadel.edu
ABSTRACT: In this presentation, I will discuss how I solved an open problem from the Fibonacci Quarterly. The problem that I solved is an identity involves Lucas and Fibonacci numbers. This problem was submitted for consideration. The problem is stated as follows:

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For any integer n, prove that

$$\frac{L_{n+2}^5 - L_{n+1}^5 - L_{n-1}^5 - L_{n-2}^5}{L_{n+2}^3 - L_{n+1}^3 - L_{n-1}^3 - L_{n-2}^3} = 5 * \frac{F_{n+2}^5 - F_{n+1}^5 - F_{n-1}^5 - F_{n-2}^5}{F_{n+2}^3 - F_{n+1}^3 - F_{n-1}^3 - F_{n-2}^3}.$$

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29. TITLE: *Time Optimization of a Draining Tank*
SPEAKER: **Douglas White**
INSTITUTION: The University of Tennessee at Chattanooga
EMAIL: douglas.white.tn@gmail.com
ABSTRACT: We consider a tank containing a given volume of liquid and suppose that the liquid drains under the influence of gravity through a small orifice at the bottom. We assume the Newtonian liquid to be incompressible, and that the liquid's viscosity and friction at the orifice are negligible. The tank we consider is constructed by revolving a continuous function $x = x(y)$ about the y-axis with its lowest point located at the origin. It should also be noted that we ignore the effects of capillary action. We optimize the time T taken for such a tank to drain.

The velocity of the exiting liquid is given by Torricelli's law. We prove the existence of a certain form of the tank for which the time is arbitrarily large (a short, wide tank) and a certain form for which the time is arbitrarily small (a tall, narrow tank), i.e. the supremum of T is infinity and the infimum is zero.

Additionally, we derive the representation for the draining time based on Torricelli's law. We obtain intuition by considering a specific family of "paraboloid" tanks and a family of cylindrical tanks. Based on this intuition, we ultimately construct a family of tanks for which any draining time on the range of zero to infinity can occur. We also consider a dual problem and prove that for any finite time on the interval from zero to infinity, there exists a tank which drains in this time. We finally consider the optimization problem for some other physical models when Torricelli's law has to be modified.

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30. TITLE: *Generalizations of cross-polytope numbers*
SPEAKER: **Yutong Yang**
INSTITUTION: Kennesaw State University
EMAIL: yyang19@students.kennesaw.edu
ABSTRACT: This project involves investigations in the mathematical field of Combinatorics. The investigations extend and vary results of Professors Steven Edwards and William Griffiths, who recently found a new formula for the cross-polytope numbers. My research is focused on $E_k(n, m)$ and $O_k(n, m)$, which are two distinct combinatorial expressions that are in fact equal and generalizations of the cross-polytope numbers. We proved that E_k and O_k share the same recurrence formula of E and O algebraically by using Pascals identity. Also we found that there exists a reflection in the table and we proved it by algebra. We find that E_k is divisible by $2^{(k-1)}$. Each column of E_k and O_k satisfies a recursive formula.

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31. TITLE: *Algebraic Properties of Labeled Graphs Joined by j Edges*
SPEAKER: **Shahriyar Roshan Zamir**
INSTITUTION: Georgia Gwinnett College
EMAIL: sroshanzamir@ggc.edu
ABSTRACT: Joining any two labeled graphs with j undirected edges can be viewed as a binary operation on the set of labeled graphs. We also define the following relation: two labeled graphs, G_1 and G_2, are j-related if and only if for any labeled graph H, the determinant of the adjacency matrix of G_1 j-operated with H is the same

as G_2 j-operated with H. The paper, *The Determinant of Graphs Joined by j Edges* [Gyurov,Pinzon] gives the determinant of the adjacency matrix of G j-operated with H as a sum of of the determinants of of the adjacency matrices of variations of G and H, for any two labeled graphs G and H. This expression allows us to explore the j-relation equivalence classes for the j-operations and their algebraic structure.

Friday, February 17

4:00–6:00	Early Registration (SL 1001 Atrium)
5:00–6:00	**Yuliya Babenko** (CL 1010) *When Zombies attack, Or Mathematical model of Doomsday Scenario*
6:00–7:00	**David Glassmeyer** (CL 1010) Alan Turing, the Enigma, and the Pioneering of the Computer Age
7:00–	**Movie** (CL 1010)

Saturday, February 18

8:00–8:30	Registration and Breakfast (SL 1001 Atrium)		
	Morning Contributed Talks		
Moderators:	**Session 1** (CL 1008) Sean Ellermeyer	**Session 2** (CL 1009) Ken Keating	**Pedagogy** [3] (CL 2010) Yuliya Babenko
8:30–8:45	Patrick Nave	Marcus Harbol	Jennifer Quinn (8:30–9:15)
8:50–9:05	Qixuan Hou	Luke Tiscareno	
9:10–9:25	Mallory Jennings	Welfare Wang	
9:30–9:45	Jeffrey Ehme	Nathan McAnally	George Cazacu (9:30–9:45)
9:50–10:10	Coffee Break (SL 1001 Atrium)		
10:10–11:00	Plenary Lecture 1: **Jennifer Quinn** (SC 109) *Epic Math Battles: Counting vs. Matching*		
11:10–12:00	Graduate School Panel (SC 109)		
12:00–1:00	Lunch (SL 1001 Atrium)		
1:00–1:50	Plenary Lecture 2: **Ronald Gould** (SC 109) *Some Unusual Applications of Mathematics*		
1:50–2:00	Conference Photo		
2:00–2:40	Poster Session (CL 1000 Atrium) **Presenters:** William Bitting; David J. George, Simon D. Harris, and John C. Mayer; Fabian Hernandez; Jaime McCartney; Jackson McDonald; Jessica G. Prince; David Richmond; Kayla Shorten; Yutong Yang		
2:40–3:00	Coffee Break (SL 1001 Atrium)		
	Afternoon Contributed Talks		
Moderators:	**Session 3** (CL 1008) Josip Derado	**Session 4** (CL 1009) Philippe B. Laval	**Pedagogy**[4] (CL 2010) David Glassmeyer
3:00–3:15	Jason Schmurr	David Benko	David Glassmeyer (3:00–3:25)
3:20–3:35	James Andrus	John C. Mayer, Patrick B. Hartley and Thomas C. Gerhardt	Susanna Miller (3:25–3:50)
3:40–3:55	Shahriyar Roshan Zamir	Tyler Bolles	
4:00–4:15	Ghanshyam Bhatt	Douglas White	John C. Mayer, Patrick B. Hartley and Thomas C. Gerhardt (3:55–4:20)
4:25–4:35	**Sean Ellermeyer,** KSU Math Department Chair Concluding Remarks (SC 109)		

[3] open to faculty and interested students

[4] open to faculty and interested students