College of Science and Mathematics

Department of Mathematics

Seventh Annual Kennesaw Mountain Undergraduate Mathematics Conference Program and Abstracts

November 3, 2018

Welcome

Welcome to the seventh annual Kennesaw Mountain Undergraduate Mathematics Conference!

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 Chairpersons
Yuliya Babenko
Ludmila Orlova-Shokry

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

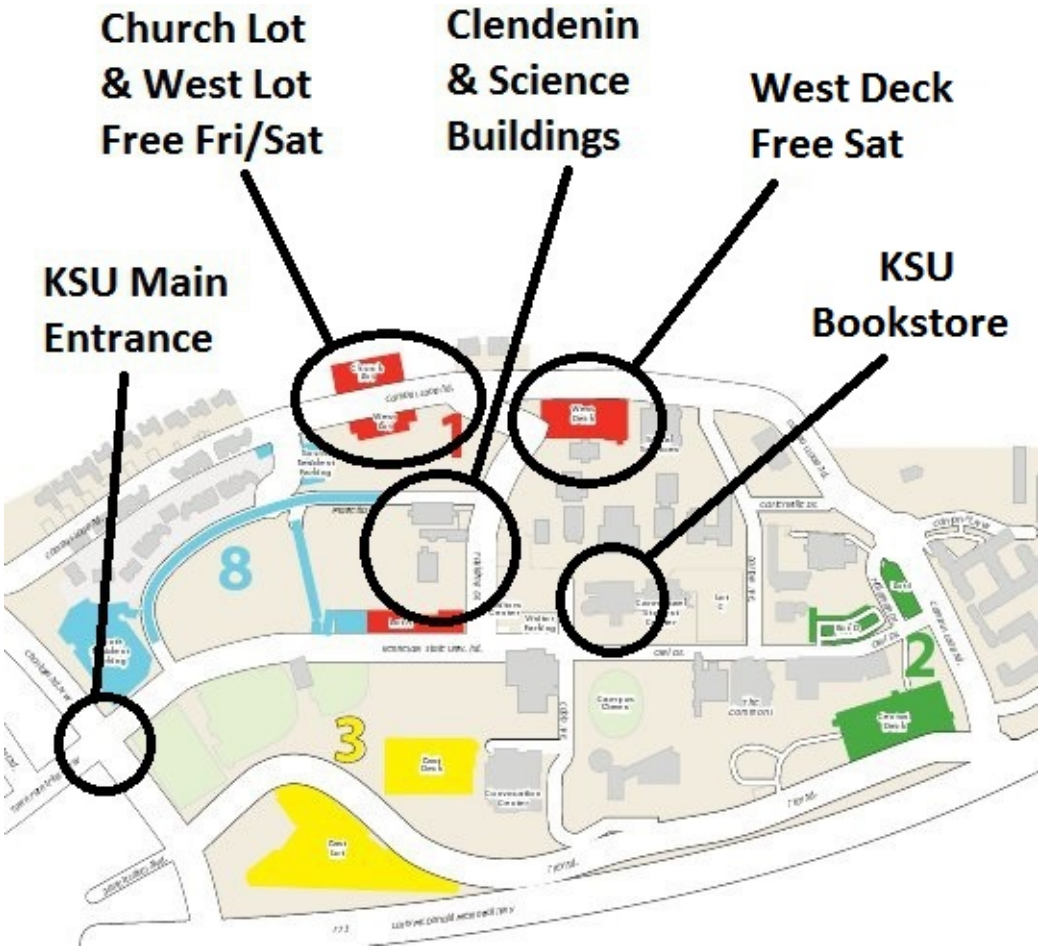
The conference will take place in the Clendenin and Science Lab Buildings, abbreviated CL and SL, respectively. See the campus map in your registration packet for directions. All talks will be held in the Clendenin Building in room CL 2008. Registration and all breaks will be in the Science Lab Building Atrium (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 on the Kennesaw Campus are:

- Monday – Thursday, 8:00am – 6:00pm
- Friday, 8:00am – 5:00pm
- Saturday, 10:00am – 5:00pm
- Sunday, closed

Campus Parking Map



On Friday, all visitors can park for free 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.

Schedule

All talks will be held in room Clendenin 1008.

Registration and all breaks will be held in the Science Lab Atrium 1001.

8:00am – 9:00am Registration (SL Atrium 1001)

A small selection of breakfast items will be available during registration.

9:00am – 9:50am Plenary Talk 1 (CL 1008)

Ulrica Wilson, Morehouse College
"A Matrix in Mathematics and the Matrix of Mathematics"

10:00am – 10:30am Pedagogical Talk 1 (CL 1008)

Evans Harrell, Georgia Institute of Technology
"Mathematics in Motion"

10:35am – 10:45am Coffee Break (SL Atrium 1001)

10:45am – 11:15am Pedagogical Talk 2 (CL 1008)

Rachel Epstein, Georgia College
"Teaching the Mathematics of Gerrymandering and Elections"

11:20am – 12:10pm Plenary Talk 2 (CL 1008)

Neil Calkin, Clemson University
"What Newton Might Have Known"

12:20pm – 1:30pm Lunch and Poster Session (SL Atrium 1001)

Poster 1: Katherine Barrs, Georgia Southern University, *"Hygienic Behavior and Subtask Specialization in Honey Bees through Agent-Based Simulation in MATLAB"*

Poster 2: Jonathan Kelleher, University of Alabama at Birmingham, *"Building Polygons with Congruent Equilateral Triangles"*

Poster 3: Andrew Lounsbury, Tennessee Technological University, *"Singular Value Decomposition"*

Poster 4: Zoe Nelson, Oglethorpe University

1:30pm – 1:45pm Contributed Talk 1 (CL 1008)

Eric Stachura, Kennesaw State University
"From Math to Molecules: Solving Differential Equations in Quantum Chemistry"

1:50pm – 2:05pm Contributed Talk 2 (CL 1008)

George Cazacu, Georgia College and State University
"Measure and Comparison – from real numbers to set theory and topology"

2:10pm – 2:25pm Contributed Talk 3 (CL 1008)

Sam Formichella, University of South Alabama
"Gaussian binomial coefficients with negative arguments"

2:30pm – 2:45pm Contributed Talk 4 (CL 1008)

John Mayer, University of Alabama at Birmingham
"Aligning Pre-Service Secondary Mathematics Curriculum with CCSS-M and MET-II in a Small Department"

2:50pm – 3:05pm Contributed Talk 5 (CL 1008)

Matthew Blair & Hsin-Yun Ching, The Citadel
"Matrices in the Hosoya Triangle"

Plenary Talks

1. Title: *A Matrix in Mathematics and the Matrix of Mathematics*
Speaker: **Ulrica Wilson**
Institution: Morehouse College
Email: uwilson@morehouse.edu
Abstract: In mathematics, a matrix is an array of numbers and I am particularly interested in the combinatorial structure of a matrix — the location of its zero and nonzero entries. In this talk I will share some cool relationships between the combinatorial structure of a matrix and other properties such as its spectrum, eigenvectors, and Jordan structure.

In another context, a matrix is the environment in which people develop (thrive or decline) along with the infrastructure that connects that development to patterns of history, processes, and opportunities. As students, faculty, practitioners, beneficiaries and creators of mathematics, we are all a part of the matrix of mathematics. In this talk, I will share some lessons learned in building diversity in the mathematics community.

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2. Title: *What Newton Might Have Known*
Speaker: **Neil Calkin**
Institution: Clemson University
Email: calkin@clemson.edu
Abstract: We'll explore a story of using experimental mathematics in an undergraduate class, studying how a long forgotten result about the Babylonian or Newton-Raphson's method for finding roots was rediscovered. The talk will be accessible even to those without a calculus background.

Pedagogical Talks

1. Title: *Mathematics in Motion*
Speaker: **Evans Harrell**
Institution: Georgia Institute of Technology
Email: harrell@math.gatech.edu
Abstract: Communicating mathematics through arts partnerships.

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2. Title: *Teaching the Mathematics of Gerrymandering and Elections*
Speaker: **Rachel Epstein**
Institution: Georgia College and State University
Email: rachel.epstein@gcsu.edu
Abstract: Gerrymandering and ranked-choice voting are topics that have been in the news quite a bit lately. They are also topics that involve a significant amount of interesting math. This talk will discuss the speaker's experience of including a unit on the mathematics of social choice in an honors math course for non-majors that introduces students to theoretical mathematics. We will briefly discuss the topics covered in the course. Within voting theory, there are many alternative voting methods and fairness criteria students can evaluate. Within gerrymandering, students can learn how districts are gerrymandered and how to try to detect gerrymandering using various compactness measures.

Contributed Talks & Posters

1. Title: *Hygienic Behavior and Subtask Specialization in Honey Bees through Agent-Based Simulation in MATLAB* (poster)
Speaker: **Katherine Barrs**
Institution: Georgia Southern University
Email: kb08802@georgiasouthern.edu
Abstract: Honey bees (*Apis mellifera*) are eusocial insects known for their complex colony structure and contribution to agriculture through pollination. In recent years, the health of honey bee colonies has declined. The specialized ectoparasitic mite Varroa destructor is considered one of the most significant factors affecting Apis mellifera colonies. Hygienic behavior, the process of removing diseased or dead brood from the hive, is a natural defense against Varroa. Numerous studies have addressed hygienic behavior, but the mechanistic process of this behavior is still poorly understood. By implementing the insights of direct observations from an experimental assay into an agent-based model, we explored the effects of division of labor within hygienic behavior. Our model simulates a bee colony by incorporating bee and mite life-cycles and allows the modification of division of labor among sub-tasks of hygienic behavior. Through specific manipulations of parameters, we compared the efficacy of hygienic behavior in models that either allowed bees to differentially perform the sub-tasks associated with hygienic behavior or not. Experimentally, we found evidence of division of labor within hygienic behavior where a few bees perform the majority of one task and do not participate in the other task. Our simulation suggests hygienic behavior is improved by such specialization specifically by decreasing the frequency of erroneous removal of healthy brood. Our combination of empirical observation and theoretical modeling of an analytically intractable problem finds division of labor in hygienic behavior to exist and to be adaptive. These insights into hygienic behavior can help combat Varroa, a major factor of declining honey bee health, because they suggest that a genetically diverse subset of elite nurse bees may be sufficient for efficient performance of hygienic behavior.

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2. Title: *Matrices in the Hosoya Triangle*
Speaker: **Matthew Blair** and **Hsin-Yun Ching**
Institution: The Citadel
Email: mblair1@citadel.edu, hching@citadel.edu
Abstract: In this talk, we will discuss properties of products of Fibonacci numbers with the use of linear algebra. Specifically, we focus on results of using matrices on the Hosoya triangle. The Hosoya triangle is a triangular array where the entries are products of Fibonacci numbers. When we apply linear algebra techniques on this triangle we can see an infinite family of rank one matrices that is product of two vectors: u and v^T. In fact, both of these vectors are comprised of consecutive Fibonacci numbers and are located on the sides of the triangle. With the use of these rank one matrices, we are able to explore the behaviors of the eigenvalues, eigenvectors, characteristic polynomial, determinants, and their connection with graph theory. These matrices have only one non-zero eigenvalue and this eigenvalue is a combination of Lucas and Fibonacci numbers. In addition, these matrices are diagonalizable where the entries of the eigenvectors are points within the Hosoya Triangle. We can also see an infinite family of graphs when we take the Hosoya triangle mod 2. These graphs are complete graphs with loops attached to each vertex except for a few isolated vertices.

Joint work with Rigoberto Florez, Department of Mathematics and Computer Science, The Citadel and Antara Mukherjee, Department of Mathematics and Computer Science, The Citadel.

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3. Title: *Measure and Comparison – from real numbers to set theory and topology*
Speaker: **George Cazacu**
Institution: Georgia College and State University
Email: george.cazacu@gcsu.edu
Abstract: This work explores the necessity and/or usefulness of introducing new concepts in modern mathematics. The construction of real numbers was an important milestone that also lead to the introduction of point-set topology. ("What is topology, anyway? ...")

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4. Title: *Gaussian binomial coefficients with negative arguments*
Speaker: **Sam Formichella**
Institution: University of South Alabama
Email: sjf1422@jagmail.southalabama.edu
Abstract: Loeb provided us with a way to extend the domain of the binomial coefficients to include all integers

via a description of sets with a negative number of elements. In the same spirit, we can extend the domain of a q-analog of the binomial coefficients called the Gaussian binomial coefficients. These extended binomial coefficients satisfy some of the nice congruences that ordinary binomial coefficients do like the Lucas congruence. Particular sequences of these binomial coefficients and their q-analog satisfy the so-called Gauss congruences as well.

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5. TITLE: *Building Polygons with Congruent Equilateral Triangles* (poster)
SPEAKER: **Jonathan R. Kelleher**
INSTITUTION: University of Alabama at Birmingham
EMAIL: jon99@uab.edu
ABSTRACT: Given an unlimited supply of congruent equilateral triangles with the task of making convex polygons out of these triangles by tiling, what types of shapes can we obtain? The only shapes are triangles, parallelograms, trapezoids, pentagons, and hexagons. This then leads to studying the number of equilateral triangles used to construct these polygons and finding formulas for these numbers. A unifying perspective is using the basic polygon, a larger equilateral triangle, and obtaining other polygons from it by taking away smaller equilateral triangles from the corners:

Polygon	**Formula**	**Conditions**
Triangle	n^2	$n > 0$
Trapezoid	$\binom{n}{2} - \binom{a}{2}$	$n > a > 0$
Parallelogram	$\binom{n}{2} - \binom{a}{2} - \binom{b}{2}$	$n = a + b > 1$
Pentagon	$\binom{n}{2} - \binom{a}{2} - \binom{b}{2}$	$n > a + b > 1$
Hexagon	$\binom{n}{2} - \binom{a}{2} - \binom{b}{2} - \binom{c}{2}$	$n > a + b > 1$ $n > a + c > 1$ $n > b + c > 1$

A fundamental question for this study is what numbers of triangles can be used to build each polygon. The answer is known, and relatively easy to obtain, for triangles, trapezoids, and parallelograms. The answer is known, but only settled in the last decade, for hexagons. The answer is not known for pentagons. Because our study is geometrically motivated, we are led to investigate how to obtain a polygon with the same number of unit equilateral triangles, but with non-congruent geometric representation. We focus on the results we have obtained for trapezoids. A representative result is: given an N in the positive integers, there is a number R of triangles that can be used to build a trapezoid in at least N different ways. The plan is to apply the same study to pentagons and hexagons as we continue.

Funding Acknowledgment: UAB Mathematics Fast-Track Program, Advisor: Dr. John C. Mayer

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6. TITLE: *Singular Value Decomposition* (poster)
SPEAKER: **Andrew W. Lounsbury**
INSTITUTION: Tennessee Technological University
EMAIL: awlounsbur42@students.tntech.edu
ABSTRACT: The Singular Value Decomposition (SVD) provides a cohesive summary of a handful of topics introduced in basic linear algebra. SVD may be applied to digital photographs so that they may be approximated and transmitted with a concise computation.

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7. TITLE: *Aligning Pre-Service Secondary Mathematics Curriculum with CCSS-M and MET-II in a Small Department*
SPEAKER: **John C. Mayer**
INSTITUTION: University of Alabama at Birmingham
EMAIL: jcmayer@uab.edu
ABSTRACT: Motivated by the recommendations of the "Mathematical Education of Teachers, II" (MET-II), and by the "Common Core State Standards Standards for Mathematical Practice" (CCSS-M), how can a small mathematics department align its mathematics curriculum in such a way as to permit prospective high school teachers to experience in their major courses the process and content standards embodied in CCSS-M and MET-II? The solution lies in adopting a path of modifying certain existing courses to serve multiple purposes. At UAB we have taken this direction: the courses modified, and the (non-strict) sequence in which they should be taken, are: Mathematical Modeling, Euclidean Geometry, Modern Algebra, and Advanced Calculus I-II. We have long taught Advanced Calculus as an inquiry-based course and Modeling as a project-based course. The changes made in the other two courses make them inquiry-based as well and align the curriculum, particularly in Geometry and Modern Algebra, with "school mathematics from an advanced viewpoint."

8. Title: *TBA* (poster)
   Speaker: **Zoe Nelson**
   Institution: Oglethorpe University
   Email: znelson@oglethorpe.edu
   Abstract: TBA

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9. Title: *From Math to Molecules: Solving Differential Equations in Quantum Chemistry*
   Speaker: **Eric Stachura**
   Institution: Kennesaw State University
   Email: estachur@kennesaw.edu
   Abstract: Density Functional Theory (DFT) encompasses a widely popular set of methods used by theoretical physicists and computational chemists to understand the electronic structure of various molecules. In this talk, I will introduce some of the basic ideas in DFT from a rigorous mathematical point of view. Our starting point will be the Schrödinger equation from quantum mechanics; along the way, we will see how various areas of mathematics come into play when analyzing the Schrödinger equation in the context of DFT. In particular, we will explore the beautiful mathematics underpinning classical observables in quantum mechanics.
