14th Annual

Shenandoah

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Undergraduate

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Mathematics and

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Statistics

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Conference

October 13, 2018

9:00 - 10:00 Registration and Breakfast

<div align="right">2nd floor hallway</div>

If you registered online, you should pick up your name tag at the registration table. If you still need to register, please do so at the same table.

Poster presenters should take their posters to the table near EnGeo 2201 for check in.

Be sure to come to the Prize Session at the end of the day; all presenters and volunteers will be awarded prizes!

10:00 - 10:10 Opening Remarks

<div align="right">auditorium 2301</div>

Join Dr. Marcus Davis, Associate Dean: Integration of Teaching & Scholarship for the College for Science and Mathematics at James Madison University, and the conference organizers as we welcome you to the SUMS 2018 extravaganza.

10:10 - 11:00 Opening Address

<div align="right">auditorium 2301</div>

Frosting Fairness, Finally!

Dr. Alissa Crans
Loyola Marymount University

Many of us are familiar with how to slice a cake ensuring equal sized slices for all. But what about those of us who want an equal amount of frosting as well?! This question is a classic with the problem solvers amongst us. In 1975, Martin Gardner considered a square cake cut into 7 pieces in his Scientific American column. More than a decade earlier, H.S.M. Coxeter posed the problem for a square cake sliced into 9 pieces as an exercise in his book, Introduction to Geometry. Together, we will solve this problem for a square cake cut into 5 pieces, and investigate the other cake shapes for which the same procedure will produce slices with equal cake and frosting.

SUMS 2018 TIMETABLE

When	What & Where				
9:00-10:00	Registration 2nd floor hallway				
10:00 - 10:10	Welcome Dr. Marcus Davis (JMU) 2301				
10:10 - 11:00	Opening Talk Dr. Alissa Crans (Loyola Marymount University) 2301				
	Parallel Session I				
11:10 - 11:25	Grad Panel 1208	B. Gramp 2202	M. Lei 2204	M. Sarver 2208	A. Mulyar 2210
	Parallel Session II				
11:30 - 11:45	Grad Panel 1208	R. Anderson 2202	B. Wild 2204	N. Marzolf 2208	A. Umana 2210
	Parallel Session III				
11:50 - 12:05	REU Panel 1208	J. Westhoven 2202	R. Journigan 2204	S. Gholson 2208	C. Webber 2210
	Parallel Session IV				
12:10 - 12:25	REU Panel 1208	A. Hamakiotes 2202	B. Concepcion 2204	S. Manning 2208	R. Shoemaker 2210
12:30-1:45	Lunch and Poster Session Hallway				
	Parallel Session V				
1:45-2:00	Career Panel 1208	A. McAllister 2202	S. Sun 2204	S. Choudhary 2208	R. Gabidoulline 2210
	Parallel Session VI				
2:05-2:20	Career Panel 1208	M. Hartt 2202	S. DiRocco 2204	N. Backes 2208	R. Ascoli 2210
	Parallel Session VII				
2:25-2:40		J. Guenther 2202	G. Collins 2204	A. Gary 2208	E. Yarmy 2210
	Parallel Session VIII				
2:45-3:00		C. Harper 2202	J. Berkompas 2204	I. Hill 2208	S. Neerchal 2210
3:00-3:15	Afternoon tea Hallway				
3:20-3:30	Prize session 2301				
3:30 - 4:20	Closing Talk Dr. Kimberly Sellers (Georgetown University) 2301				

1208 Panel Session on Graduate School in Math, Stats and Math Ed
Channing Parker, University of Pittsburgh
Noah Watson, Miami University
John Harnois, The University of Virginia
Nicholas Granered, University of Pittsburgh
What is graduate school really like? How do you apply? What schools should you consider? How important is the GRE subject test? Find out from this panel of grad students!

2202 A Bilevel Optimization Approach to Variational Models
Brendan Gramp, George Mason University
We present a bilevel optimization approach to image denoising. The inner problem is the Total Variation (TV) based minimization problem and the outer problem identifies the regularization parameter. In the latter case two different objective functions are considered: (i) machine learning based; (ii) statistics based.

2204 Iterated Prisoner's Dilemma on a Continuous Adaptive Network
Mengting Lei, The College of William & Mary
We examine Prisoner's Dilemma on a network with continuous links. Agents divide their resources into different portions for different opponents, and link weights update based on payoff. The long-time behavior of agents and the distribution of their connections to individual opponents are studied.

2208 Presenting Math through the Fine Arts
Malia Sarver, James Madison University
Alexander McAllister, James Madison University
Math Connections Theatre discusses their experience producing shows that mix math and comedy to present math in a fun and digestible way.

2210 Learning Under Class Skews with Hybrid Decision Trees
Andriy Mulyar, Virginia Commonwealth University
Decision trees (DT) are among the most popular machine learning algorithms. Like many discriminative learning algorithms, DT's struggle to be predictive when learning under class skews. This talk explores the concept of local class imbalance in DT induction and proposes algorithmic modifications to it's alleviation.

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2202 Implementing Machine Learning to Improve Bertini 2.0
Riley Anderson, University of Mary Washington
The purpose of this research is to decrease the run time of Bertini, a program that approximates roots of polynomial systems. Bertini can be run more efficiently if it is known whether a polynomial is singular or non-singular. We use a machine learning algorithm to classify polynomials into these two categories.

2204 The Game of Best Choice with Restricted Candidate Rankings
Becky Wild, James Madison University
We study the game of best choice under the assumption that the set of possible candidate rankings is restricted. We seek a set of rankings that defines a game of best choice for which every positional strategy has the same probability of success.

2208 Geometric Probability for Two Points in Spheres
Nicole Marzolf, Longwood University
In this presentation, we considered a pair of spheres separated by some center to center separation distance. We determine an analytic solution for the probability density for the distribution of distances between points chosen from each sphere.

2210 Viscous Gravity Current Flow in Confined Channels
Angel Umana, George Mason University
Viscous gravity currents characterize a large class of fluids. One regime for these fluids is in the case of a channel confining the fluid flow. In this project, a model is developed for such fluids. This model allows us to study different channel geometries. Numerical solutions are explored for different geometries.

1208 **Panel Session on REUs and Summer Programs**
Hala Shehadeh, James Madison University
John Webb, James Madison University
Gexin Yu, The College of William & Mary
Sophie Mancini, James Madison University
Want to learn more about Research Experience for Undergraduates programs and other summer opportunities in mathematics? Come ask this panel of students and faculty your questions!

2202 **Expanding Linear Discriminant Analysis to Continuous Input**
Josh Westhoven, George Mason University
Dimensionality reduction is crucial for accurate results in reasonable time on large datasets. To this end, we have generalized linear discriminant analysis to a continuous output variable by sorting training data into some number of categories based on output.

2204 **The Turing-Welchman Bombe**
Rebecca Journigan, Radford University
Alan Turing and the other codebreakers at Bletchley Park employed an electromechanical device known as the bombe to read German encrypted messages during WWII. This talk will describe the logic behind how the bombe exploited the German Enigma cipher.

2208 **Classification of** $(0,2)$ **LG Field Theories with** $C < 3$
Sean Gholson, James Madison University
Our research classifies the possible forms of super-potential for 2-dimensional Landau-Ginzburg field theories with a (0,2) super-symmetry and a central charge less than three. We have done this by applying constraints from (0,2) theories to non-singular, quasi-homogeneous ideals with two variables and two generators.

2210 **Time-scale Calculus and Darboux Calculus**
Caleb Webber, Virginia Commonwealth University
Time-scale calculus unifies the study of differential equations with difference equations. Darboux calculus is an alternative approach to real analysis modeled after the concept of the Darboux integral. The goal of this talk is to show that time-scale calculus can be incorporated into the framework of Darboux calculus.

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2202 Eta-Quotients of Prime/Semiprime Level and Elliptic Curves
Asimina Hamakiotes, Macaulay Honors at Baruch College
We found a condition for the existence of an eta-quotient as a modular form for prime levels, and generalized this for semiprime levels. In addition, we investigate representing modular forms associated to elliptic curves in terms of linear combinations of eta-quotients, and provide some new examples.

2204 Turing Patterns on Networks
Ben Concepcion, George Mason University
Turing patterns, or network induced instabilities, are important subjects for a variety of disciplines. They are often treated on continuous local domains. This research looks at instabilities on arbitrary graphs with non-local connections. We use graphons, functions that create graphs, to analyze these graphs.

2208 Circle Packing of Unequal Radii on a Square Flat Torus
Susanna Manning, University of Alabama in Huntsville
The study of maximally dense packings of disjoint circles is a Discrete Geometry problem. In this presentation, we explore packings of three circles of two radius classes onto a square flat torus. Using pictures, we introduce basic concepts, illustrate maximally dense arrangements, and outline the proofs of optimality.

2210 Modeling a Chaotic Billiard
Randy Shoemaker, James Madison University
A Bunimovich stadium billiard is a chaotic dynamical system. In this talk we discuss the difficulties in creating a computer model of this system due to finite precision. We examine how its chaotic nature can aide in computing the image of a set of close trajectories and how this can simplify the modeling process.

LUNCH: If you have a star on your name tag, pick up your boxed lunch near the registration table at 12:30. (If you do not have a star, you may check for unclaimed lunches after 1:00).

POSTER SESSION: Students will be near their posters during lunch. Please stop by to see their excellent work! Poster judging will start by 12:40.

Differential Invariants in the Lorentz-Minkowski Plane *Jordan Berkompas, Longwood University*

Predicting Parameters for Bertini Using Neural Networks *Makenzie Clower, University of Mary Washington*

A Numerical Analysis of the SIV Model for HIV *Amy Creel, University of Mary Washington*

Mathematical Aspects of Quantum Complexity Theory *Shawn DiRocco, Virginia Commonwealth University*

Geometric Tiling in the Plane *Abigail Eget, James Madison University*

Applications of Spherical Geometric Probability in Physics *Nicole Marzolf, Longwood University*

Number Machines *Max Misterka, Home School (Harrisonburg)*

Deep Learning Methods of Cancer Growth for Cancer Therapy *Joshua Smith, Governor's School at Innovation Park*

Chemo-Viro Cancer Therapy *Andrew Tran, Virginia State University DaLisa Denham,Virginia State University*

Combining Biquandle Knot Invariants *Vilas Winstein, The Ohio State University Adu Vengal,The Ohio State University and Will Hoffer, The Ohio State University*

Banach-Tarski Paradox *Matthew Wisniewski, James Madison University*

1208 **Career & Industry Panel**
Mary Morsch, Director, Career & Academic Planning at JMU
Reginald Ford, IDEMIA
Maria Annone, Dept. of Defense
What can you do with a math or a statistics degree? What kinds of companies and institutions value your talent? This panel of people has experience using mathematics and statistics outside of academia, so come ask questions!

2202 **Exponential Matrix Solutions of Differential Equations**
Alexander McAllister, James Madison University
Alfred Williams, James Madison University
For linear differential equations, we will show that a well-known sufficient condition for having an exponential matrix solution is also a necessary condition.

2204 **Fractional Separation Dimension of Perfect Binary Trees**
Shouzhuo Sun, The College of William & Mary
The fractional separation dimension (FSD) of a graph G, defined by Loeb and West, is the minimum of q/s such that in total q linear orderings (repetition allowed), separate each pair of disjoint edges at least s times. We use integer linear programming and column generation to study the FSD of perfect binary trees.

2208 **Mathematical model to determine focal point of a convex lens**
Sanjana Choudhary, University of Texas at Arlington
A closed-form mathematical model to understand the movement of the focal point of a convex lens for an arbitrary angle of incidence. This work presents a closed-form mathematical model based on analytic geometry for calculating the position of the focal point of a convex lens for arbitrary incidence.

2210 **Pricing Options with Quadratic Optimization**
Ruslan Gabidoulline, University of California, Berkeley
This research developed an optimization approach to finding the probability distribution of an underlying asset, which is used in pricing options. Different optimization methods were explored: we concluded that interior point method was most effective, and we numerically implemented it with examples of options data.

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2202 **A Proof of Bertrand's Postulate**
Martha Hartt, Randolph-Macon College
In this talk we prove that there is a prime number between n and $2n$ for all natural numbers. This proof is done in a style similar to that of Erdos. However, it differs in that it proves the main result for all numbers greater than 32 without checking special cases.

2204 **A Geometric Algorithm for the Quantum Satisfiability Problem**
Shawn DiRocco, Virginia Commonwealth University
In classical complexity theory, mathematical problems are classified by the estimated amount of elementary operations required to calculate a solution employing a specific algorithm. The quantum complexity theory is analogous to the classical complexity theory. This study is important to create efficient algorithms.

2208 **Multi-Skein Invariants for Welded and Extended Welded Knots**
Nick Backes, University of Minnesota–Twin Cities
Emma Peterson, University of Minnesota–Twin Cities
The theory of welded and extended welded knots and links generalizes classical knot theory. We present a new class of invariants for welded and extended welded knots and links. Following Z. Yang's multi-skein approach for virtual knots, we find sufficient conditions for invariance under the extended Reidemeister moves.

2210 **Richardson Extrapolation for Kernel Density Estimation**
Ruben Ascoli, Thomas Jefferson High School for Science and Technology
This research aims to show the capabilities and limitations of Richardson Extrapolation (RE) for Kernel Density Estimation (KDE). It outlines the process of using RE to improve KDE, works out the optimal order RE to use with a Gaussian distribution, and presents a possible future approach to optimize this method.

2202 **Adaptive Parker-Sochacki Method**
Jenna Guenther, James Madison University
Morgan Wolf, James Madison University
The Adaptive Parker Sochacki Method produces better accuracy while being an order of magnitude more efficient in time and steps when contrasted to Runge-Kutta algorithms, including MATLAB's renowned ODE45 solver. Several examples are given, including a 2-degree of freedom example related to missile defense.

2204 **Sangaku in Non-Euclidean Geometry**
Geneva Collins, North Carolina State University
Lucas Perryman-Deskins, Willamette University
During the Edo period (1603-1867 CE) a Japanese tradition was to hang tablets of new theorems in Euclidean geometry, known as sangaku, in the eaves of a temple as an act of devotion. We explore the generalization of one of these ancient theorems from Euclidean geometry into both spherical and hyperbolic geometries.

2208 **Visualizing Cubic Moduli Spaces**
Ajeet Gary, University of Maryland College Park
$SL(2,C)$ character varieties allow us to represent hyperbolic metrics on topological surfaces on two generators as certain cubic surfaces. We investigate dynamics and ergodicity on these surfaces, as well as their other geometric properties.

2210 **Predicting Olympic Medal Counts**
Emmy Yarmy, University of Lynchburg
We used variables unrelated to athletic ability (GDP per capita in US dollars, a dummy variable measuring whether or not the country has a socialist history, and the latitude of the countries capital city) to predict medal counts in the Summer and Winter Olympics using a zero-inflated negative binomial regression.

2202 **Generalized action graph and convolutions of Catalan numbers**
Julia Bergner, The University of Virginia
Cedric Harper, The University of Virginia
Mathilde Rosi-Marshall, The University of Virginia
Ryan Keller, The University of Virginia
We show that generalized action graphs with larger initial graphs, produce self-convolutions of the Catalan numbers. These self-convolutions arise from certain planar rooted forests, which generalize planar rooted trees. We then demonstrate a bijection between the generalized action graphs and the planer rooted forests.

2204 **Invariants of Curves with the Fels-Olver Moving Frame**
Jordan Berkompas, Longwood University
In this talk we will show how to use the Fels-Olver method of moving frames to investigate the geometry of curves in the Lorentz-Minkowski plane and in a companion three-dimensional geometry. We will demonstrate how to generate differential invariants for curves based only on the transformations of the geometry.

2208 **The Hausdorff dimension of the limit set of a pair of pants**
Ian Hill, James Madison University
Given a 3-holed sphere, there is a natural way to cut the surface so that it becomes an octagon that sits in hyperbolic space. From these "cuts" we may define functions that act on the space and we may consider the limit set of these functions. Its Hausdorff measure is in general unknown and is the subject of the talk.

2210 **Assessing the Descriptive Epidemiology of Clubfoot in Iowa**
Siri Neerchal, University of Maryland College Park
Clubfoot, a common birth defect, has unknown causes. We examine trends in prevalence, estimate associations with child and parental characteristics, and identify geographic hotspots in the state of Iowa using logistic regression, spline models, and multilevel Poisson analyses (through a Bayesian approach), respectively.

3:05 - 3:20 Afternoon tea

2nd floor hallway

Please join us for tasty treats in the EnGeo foyer. This is your last chance to enter the candy contest!

3:20 - 3:30 Prize Session

auditorium 2301

After tea, please join us in the prize session. Speaker awards, poster competition winners, and the candy contest winner will be announced!

3:30 - 4:20 Closing Address

auditorium 2301

CSI: Count on Statistics for Investigation

Dr. Kimberly Sellers
Georgetown University

Discrete data (particularly counts) introduce an added layer of complexity to any sort of statistical analysis. While the Poisson distribution is oftentimesa firstchoice to describe and/or model such data, constraining qualities can limit its use. This talk will introduce alternative models, particularly one with which I have worked heavily to advance the field of discrete or count data modeling.

All events are on the second floor of the JMU EnGeo (formerly HHS) building, except the **panel discussions** which are on the **first floor in Room 1208**.
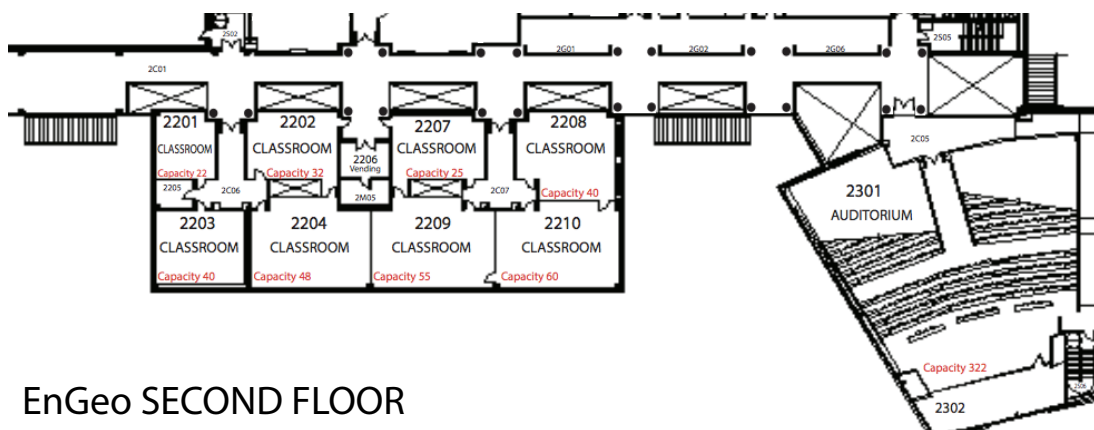
EnGeo SECOND FLOOR

Financial support for the Shenandoah Undergraduate Mathematics and Statistics Conference is provided by:

James Madison University and the Department of Mathematics and Statistics, College of Science and Mathematics, Pi Mu Epsilon, and the Mathematics and Statistics Club.

We would also like to offer thanks to the volunteers who make the conference possible. We are very grateful for the generous contributions of books, puzzles, games, and other prizes from the sponsors of SUMS:

Wireless Network: Log onto "JMU-Visitor"
Username: sums@jmu.edu
Password: 484762
The username and password are case specific.

Follow the Department of Mathematics and Statistics on Twitter `@JMUMathStat`

Photo Contest: Submit your photos from the conference or your preparation on twitter or Instagram with `#JMUSUMS` and `#2018SUMS`. Two winners will be announced at the end of the conference! Good luck!