

9:00 - 10:00 Registration and Breakfast

2nd floor hallway

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 or online by visiting

www.jmu.edu/mathstat/sums/

Poster presenters should check in to room HHS 2201.

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

auditorium 2301

Join Provost A. Jerry Benson and the conference organizers as we welcome you to the eleventh annual SUMS extravaganza.

10:10 - 11:00 Opening Address

auditorium 2301

Intrinsic properties of graphs embedded in \mathbb{R}^3

Erica Flapan
Pomona College



Knot theory is the study of embeddings of simple closed curves in \mathbb{R}^3 . A natural extension of knot theory is the study of embeddings of graphs in \mathbb{R}^3 . However, in contrast with knots, the structure of a graph can be complex, and this can affect all of its embeddings. If every embedding of a graph has a particular property, then we say that property is *intrinsic* to the graph. For example, a graph is said to be *intrinsically knotted*

if every embedding of the graph in \mathbb{R}^3 contains a knot. In this talk I will introduce intrinsic knotting and other intrinsic properties of graphs.

2202 An Analogue of the Median Voter Theorem for Approval Voting

Kyle Duke, James Madison University

We develop an analogue in the context of approval voting. We show that if the pairwise agreement proportion is at least $3/4$, then the median voter interval will contain the approval winner. We prove that under an alternate geometric condition, the median voter interval will contain the approval winner.

2203 Panel Session on Graduate School

Rao Chaganty, Old Dominion University

Michael Lam, James Madison University

What is graduate school really like? What makes a good graduate school application? What schools should you consider? How important are the GREs? Get some answers from this panel of faculty members.

2204 Sums & Products of Regular Polytopes' Squared Chord Lengths

Jessica Copher, Shenandoah University

In this talk, we consider generalizing four theorems about regular polygon chord lengths to regular n-D polytopes. One generalizes to all, another generalizes to most, and the remaining two generalize only to specific n-D polytopes.

2207 Sierpiński and Riesel numbers occurring in other sequences of integers

Trenten Babcock, Washington and Lee University

Elliot Emadian, Washington and Lee University

The integer 78557 is really cool because for any natural number n , the integer $78557 \cdot 2^n + 1$ is composite! Similarly, $509203 \cdot 2^n - 1$ is always composite. These are examples of Sierpiński and Riesel numbers. In this talk, we'll show that there are Sierpiński or Riesel numbers that are also Cullen numbers, Woodall numbers, polygonal numbers, Ruth-Aaron numbers, and more!

2208 Frequency domain analysis of the diblock copolymer equation

James Trichilo, George Mason University

We analyze the diblock copolymer equation, a 4th order parabolic PDE, and numerically simulate it through a Galerkin spectral method. It is observed that in many instances, there is a direct relationship between the largest Fourier coefficient and the number of transition layers.

- 2209 **Ebola modeling and optimal control**
Harout Boujakjian, George Mason University

Understanding the spread and containment of Ebola has become a priority for several countries. We use an SEIR model to simulate the dynamics of the disease and use data provided by the WHO for validation. Also, we explore the effects of vaccination and quarantine rates using optimal control theory.

- 2210 **Realizing Graphs with Prescribed Connectivity**
Lew Sears, Washington and Lee University

We realize graphs based on parameters of vertex connectivity, edge connectivity, minimum degree, and maximum degree. Based on the relationship of the parameters, we create an algorithm that produces a graph that satisfies the parameters for any size desired.

11:30 - 11:45 Parallel Talks Session II

- 2202 **An Intelligent Combinatorial Game Player**
Laura Hutchinson, Virginia Commonwealth University

The logic behind the construction of an automated conjecture making program will show to be effective in running a combinatorial game player. The results of this is an intelligent game player with strategic moves and many fascinating conjectures about the mathematics of Chomp.

- 2203 **Panel Session on Graduate School**
Rao Chaganty, Old Dominion University
Michael Lam, James Madison University

What is graduate school really like? What makes a good graduate school application? What schools should you consider? How important are the GREs? Get some answers from this panel of faculty members.

- 2204 **Transforming an Alloy Model Into a Petri Net**
Allie Brown, Mary Baldwin College

Petri nets are a graphical method for modeling software systems, but the state explosion problem makes their design complex and time-consuming. The proposed approach to eliminate this problem is to model a system with the declarative language Alloy and automatically transform it into a Petri net.

- 2207 **Elementary Analysis via Extremal Extensions**
Alex McCleary, Virginia Commonwealth University
Extremal extensions are an alternate method of building analysis using order preserving functions. They are analogous to the Yoneda Embedding in category theory and provide a powerful and concise way to do everything from building the reals to defining integrals and derivatives.
- 2208 **Enhancing Groundwater Quality through Computational Modeling**
Akhil Waghmare, Thomas Jefferson High School for Science and Technology
Nanoparticles can remediate polluted groundwater, so it is critical to understand their movement. The study enhances MNM1D model using more realistic assumptions about the groundwater-porous medium system. This work involved a numerical scheme for the model as well as a parameter estimation study.
- 2209 **Soft Contact Lens Hydration Modeling**
Austin Alderete, George Mason University
Excessive dehydration in contact lenses can lead to dry eye and general discomfort for the wearer. In this work, the hydration level in a soft contact lens is modeled using the heat equation. We present a method of predicting the oscillatory steady state to which the solution converges.
- 2210 **The Smith and Critical Groups of the Rook's Graph**
Noah Watson, James Madison University
Jonathan Gerhard, James Madison University
Let R_n denote the graph with vertex set consisting of the squares of an n by n grid, with two squares of the grid adjacent when they lie in the same row or column. This is called the square rook's graph, and on it we can play a chip-firing game that gives us an algebraic invariant of the graph.
- 11:50 - 12:05 Parallel Talks Session III*
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- 2202 **Automated Conjecturing: Chomp and Intelligent Gameplay**
Bryan Kaperick, Virginia Polytechnic Institute and State University
We describe a novel approach to analyzing Chomp, a combinatorial game. Our approach utilizes a conjecture-making program that infers relations between invariants associated with a game board. These conjectures are used to extend theory for distinguishing between winning and losing game positions.

2204 Lower Bound Cluster Algebras and Stanley-Reisner Complexes

Bradley Zykoski, University of Virginia

Lower bound cluster algebras have an important place in the flourishing study of cluster algebras. This talk will showcase new combinatorial results concerning these algebras and certain simplicial complexes associated to them. These results appear in our paper: <http://arxiv.org/abs/1508.02314>.

2207 Conditions for Factoring a Cubic and its Derivative Over \mathbb{Q}

James Board, Radford University

Presented is an exploration of the conditions on coefficients of a reduced cubic equation and its derivative such that both are factorable over rational numbers. Generation of sets of eligible coefficients which satisfy the required conditions are made using MATLAB and highlighted in this talk.

2208 Modeling the Classification of Diabetic Retinopathy

Daniel Ruhnke, The College of William and Mary

Diabetic Retinopathy is a disease which can be prevented by early detection, making accurate classification important. This research involves processing images, extracting features of symptoms, and applying data driven mathematical modeling to accurately classify the different stages of the disease.

2209 Atherosclerosis and Social Influences

Curtis Lamp, Shippensburg University

Dino Garcia, Shippensburg University

Atherosclerosis is the accumulation of plaques, consisting of fats and cholesterol, in arteries. Smoking and obesity can lead to Atherosclerosis. In this presentation, we develop a preliminary mathematical model which views smoking and obesity as epidemics that can be spread through social influence.

2210 Coloring the Plane to Guarantee Rainbow Translates

John Ryan, New York University

We prove that, given any triangle, it is possible to color the plane with 3 colors so that every translate of the triangle has rainbow vertices (all vertices have different colors). Further, we show that 4 colors is sufficient to guarantee that translates of a parallelogram have rainbow vertices.

2202 **Consensus vs. fragmentation in a model of opinion dynamics**

Ratna Khatri, George Mason University

In a model of opinion dynamics, interaction between agents either leads to a consensus, where agents converge to a single opinion as time evolves, or to a fragmented state with multiple opinions. We predict consensus or fragmentation after linearizing the system about a uniform density solution.

2203 **Panel Session on REUs and Summer Programs**

Elizabeth Denne, Washington and Lee University

Eva Strawbridge, James Madison University

Kyle Duke, 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!

2204 **Lorentzian Scalar Products on Lie Algebras**

Sabrina Walker, Longwood University

In this talk we will discuss the extent to which one can use the automorphism group of a Lie algebra to find canonical representatives of equivalent Lorentzian geometric structures on a given Lie algebra. Partial classification results for some low dimensional Lie algebras will be presented.

2207 **Bounding the Root Counts of Trinomials over Finite Fields**

Sean Owen, University of Maryland, Baltimore County

We present a new upper bound on the number of roots of trinomials over finite fields, and prove it to be sharp in the case of even-degree fields with loose constraints on the exponents, refining the recent work of Bi, Cheng, and Rojas (2014) on finding a finite-field analogue of Descartes' Rule.

2208 **Modeling of Two-Dimensional Grain Growth**

Robert Argus, George Mason University

We study the mesoscopic behavior of a grain boundary network and propose a novel two-dimensional model describing the evolution of the distribution of misorientations. The model obtained is able to predict steady-state statistics as well as coarsening rates for normal isotropic grain growth.

2209 SNP-ing Out Obesity

Victoria Kelley, James Madison University

In this study, we build a system of non-linear ordinary differential equations that considers both genetic and environmental effects on populations with three distinct genotypes. The model suggests that environment does not play a significant role on obesity.

2210 Generalized Hyperbolic Fully Augmented Links

John Harnois, James Madison University

We discuss Generalized Hyperbolic Fully Augmented Links and their connection with tessellations of the plane whose duals are graphs with perfectly matched vertices such that if a vertex is matched it is of the same degree.

12:30 - 1:35 Lunch and Poster Session

hallway

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.

Classification of Plankton with Convolutional Neural Nets

Nadia Aly & Chaoran Wei, The College of William and Mary

Can the Flu be predicted?

Carmen Augusto, Smith College and Maria Martinez, Pomona College

Engaging in Action Research to Inform a University-Level Introductory Statistics Course

Deborah Bray, Longwood University

Conditions for Factoring a Cubic and its Derivative Over \mathbb{Q}

James Board, Radford University

Math Modeling Neural Networks under Amyloid Beta Treatment

Haarika Chalasani, Thomas Jefferson High School for Science and Technology

An Analogue of the Median Voter Theorem for Approval Voting

Kyle Duke, James Madison University

Regularization Penalties for Logistic Regression

Ivan Echevarria, College of William & Mary

Analysis of a Metapopulation Model with an Allee Effect

Cassie Hartley, James Madison University

Mathematical Modeling of Syphilis

Kristina Kelly, The College of William and Mary

Mathematical Models and Algorithms to Stop Illegal Poaching

Pradyuta Padmanabhan, Thomas Jefferson High School for Science and Technology

Depth Distribution of Transposable Elements in *M. edax*

Channing Parker and Katie Voss, James Madison University

Stability and Computational Analysis to Optimize Nanofilters

Akhil Waghmare, Thomas Jefferson High School for Science and Technology

Lorentzian Geometries on Finite Dimensional Lie Algebras

Sabrina Walker, Longwood University

1:40 - 1:55 Parallel Talks Session V

2202 Homology and the Ricker Map

Cristin Mayes, Hampton University

The Extreems - QED is a summer program sponsored by the National Science Foundation (NSF) at the College of William and Mary. The following is a detailed presentation on my homological and coupled-patch research.

2203 Panel Session on REUs and Summer Programs

Elizabeth Denne, Washington and Lee University

Rebecca Field, James Madison University

Brad Zykoski, University of Virginia

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!

2204 Probability search problem for UAV's in unknown environments

Kathleen McLane, George Mason University

We consider a unified model for an unmanned aerial vehicle(UAV) that incorporates the dynamics along with a decision-making framework using probabilistic search algorithms. Bayes filters are implemented to detect the presence of targets. These models can be applied to many applications.

2207 Properties of the First Hurwitz Equation

Josiah Banks, Youngstown State University

In this talk we present original research on the Hurwitz Equation and discuss divisibility properties as well as operations to generate an infinite number of solutions. Other aspects looked at include: the solution space forming an infinite group and fixed divisors of the orbits of the group.

2208 A Seasonal Matrix Model for Growth of *Lycium Carolinianum*

Angie Davenport, James Madison University

In this presentation we will discuss a proposed stage-based model that can provide insight into the ecosystem that encompasses the Aransas National Wildlife Refuge and the migrating Whooping Crane, or *Grus americana*.

2210 Conjugacy Classes of $\mathrm{GSp}(2n, p)$

Jonathan Gerhard, James Madison University

The finite matrix group $\mathrm{GSp}(2n, p)$ is the subgroup of $\mathrm{GL}(2n, p)$ consisting of matrices that preserve an antisymmetric bilinear form up to scalar multiple. For $n = 3$ and 4 , we use a parameterization of Shinoda to identify conjugacy classes of $\mathrm{GSp}(2n, p)$ with the goal of finding their sizes.

2:00 - 2:15 Parallel Talks Session VI

2202 Omega-Complexity in Chaotic Systems

Shayna Jackson, Mary Baldwin College

Chaotic systems have been a difficult area of study. Because of the complex nature of the systems there are few single-valued invariants that can be used to describe them. One such notion of dimensions is Omega-Complexity. We will attempt to further analyze this notion of Omega-Complexity.

2204 Detecting Outliers In Regression Trees

Nicholas Granered, James Madison University

Regression trees are an alternative to classical linear regression models that seek to fit a piecewise linear model to data. Here, we adapt an outlier detection algorithm proposed by Hadi & Siminoff (1993) using classical linear regression models into one which utilizes regression trees.

2207 Optimal Control of the Stefan Type Free Boundary Problems

Ryan Stees, James Madison University

We consider the inverse Stefan problem (ISP) for a general second order linear parabolic PDE with a temperature constraint. We reformulate the ISP as an optimal control problem, show existence of the optimal control, discretize and prove convergence of the discrete problems to the continuous one.

2208 Asymmetric Dispersal of Coupled Patches under Allee Effect

Margaret Swift, The College of William and Mary

We extend a previous ODE model on symmetric dispersal to an asymmetric relation between 2 coupled patches (oyster reefs) under the Allee effect. Bifurcations occur as dispersal rates change. Large regions exist where extinction is the only possibility, which is concerning for restoration efforts.

2209 Investigating How Neurons Communicate Through PSM

Jeffrey Kopsick, James Madison University

With guidance from the Mathematics, Computer Science and Neuroscience Departments at JMU, I have developed an algorithm for the study of neural networks. This project entails improving the numerical solutions to the differential equations that describe these networks using the Power Series Method.

2210 Ranks of Permutative Matrices

Xiaonan Hu, College of William and Mary

Permutative matrices, m -by- n matrices with each row being distinct permutations of a set of n different variables are studied with special interest in their ranks. A symbolic permutative matrix is identically singular if a row-grouping, an h, k -partition effect or both occur in the matrix.

2:20 - 2:35 Parallel Talks Session VII

2202 A job-market signaling simulation with uncertainty

Nathaniel Bechhofer, George Mason University

Using an agent-based simulation, we find that wages converge to a predicted Bayesian Nash equilibrium when employees attempt to use education to signal (continuous) ability to potential employers. This result holds even with agent expectations not centered around the predicted outcome.

2203 Career and Industry Panel Session

*Jeff Scroggs, NC State Financial Math
Sylvia Lee, James Madison University
Bryce Weaver, James Madison University*

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 them some questions!

2204 Saving Babies in a Heartbeat!

Evan Dienstman, The College of William and Mary

The goal of this project is to study the breathing patterns of premature babies to see if certain patterns give doctors early warnings of septic events. Additionally, the project involves determining if certain patterns are linked to specific invading organisms, providing doctors with a diagnosis.

2207 Discrete Boundary Problems via Integro-Differential Algebra

Sieu Tran, Virginia Tech

To solve discrete boundary problems, we build a Noetherian and confluent rewrite system (i.e. a Gröebner Basis) from the relations between discrete operators. We found the unique normal form of every discrete operator and condition; we also show that their respective field is a direct composition.

2208 Mathematical Modeling of the James Spiny mussel

Marisa Draper, James Madison University

Maranda Pepe, James Madison University

Dylana Wilhelm, James Madison University

Various biological processes complicate conservation efforts of the endangered James Spiny mussel. Dispersion type, clustering trends, odds of detection based on environmental factors, substrate preferences, and matrix population models were analyzed to inform the recovery of this critical species.

2209 Obstructions to Convexity in Neural Codes

Zev Woodstock, JMU

How does the brain encode spatial structure? One way is through hippocampal neurons called place cells, which become associated to convex regions of space known as their receptive fields. We address the question of which neural firing patterns could arise from place cells, and disprove a conjecture.

- 2210 **Novel Algorithms for Modular Form Basis Construction**
Noah McClelland, James Madison University
Matthew Petty, James Madison University
We developed algorithms to compute bases for spaces of modular forms for a given level (N) and weight (k), building basis elements from Dedekind's eta function. Using a transversal algorithm to incrementally build the basis, we were able to reduce memory usage significantly.

2:40 - 2:55 Parallel Talks Session VIII

- 2202 **Real-Time Bidding Optimization for Online Advertising**
Charlotte Ellison, University of Virginia
In the online advertisement industry, real-time bidding is where a sell-side platform holds an auction to sell an ad space. Our team established two different learning models for choosing revenue-maximizing optimal floor prices.

- 2203 **Career and Industry Panel Session**
Jeff Scroggs, NC State Financial Math
Sylvia Lee, James Madison University
Bryce Weaver, James Madison University

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 them some questions!

- 2204 **Mathematics and 3D Printing**
Emily Jaekle, Washington and Lee University
Certain calculus problems can be difficult for students to visualize. A 3D printer can transform these complicated volumes, curves, and surfaces from equations into tangible solids to serve as teaching aids. There are interesting mathematical and computational challenges in creating the models.

- 2207 **Cardiac electrical response using fractional diffusion**
Mae Markowski, George Mason University
It is well known that cardiac muscle tissue is inhomogeneous, but the accepted model used to describe electrical signal propagation in the tissue does not treat it as such. We propose a fractional space-time diffusion model, which will better account for the spatial complexity of the region.

2208 **Dynamics of Ateles Hybridus in Fragmented Landscapes**
Matthew Buhr, University of South Dakota

Ateles Hybridus have undergone endangerment situations for several years. Our goal is to model the dynamics of Ateles Hybridus given their population structure and lifestyle, first through a single patch, then on multiple patches. We then derive conclusions to the endangerment issue through testing.

2209 **Math Modeling Neural Networks under Amyloid Beta Treatment**

Haarika Chalasani, Thomas Jefferson High School for Science and Technology

The mechanisms of the brain abnormalities underlying Alzheimer's Disease are not yet fully understood. The proposed model will allow us to better observe the changes caused by the Amyloid Beta on the neural membrane potential dynamics.

2210 **Linear Fixed Point Systems Over Rings**

Gregory Taylor, College of William and Mary

Suppose a matrix A satisfies $A^{m+1} = A^m$. For matrices over a field, the necessary and sufficient conditions are known. The case for matrices over a ring is an open problem. This talk explores case for the ring of integers mod n and includes a discussion of challenges, progress, and open problems.

3:00 - 3:15 Afternoon tea

2nd floor hallway

Please join us for tasty treats in the HHS 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

An Introduction to Constructive Mathematics

*Daniel Velleman
Amherst College*



Almost all mathematicians agree about what methods of reasoning are acceptable in mathematics – almost all, but not quite all. A small group of mathematicians practice a kind of mathematics known as constructive mathematics. Constructive mathematicians do not accept all of the laws of logic that most mathematicians use. For example, they do not accept the Law of Excluded Middle, which says that for any statement P , either P or $\neg P$ is true. Since constructive mathematicians do not use the same laws of logic as other mathematicians, the theorems they prove are also different. In this talk, I will discuss the philosophical motivation for constructive mathematics, and then I will give some examples to illustrate the methods and theorems of constructive mathematics.