Schedule

9:00 - 10:00 Registration and Breakfast 2nd floor hallway

If you pre-registered, 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 check in at 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 the conference organizers as we welcome you to the tenth annual SUMS extravaganza.

10:10 - 11:00 Opening Address auditorium 2301

A Combinatorial Gaming Zoo
Dr. Gwyneth Whieldon

Hood College

Combinatorial games, sometimes called *games of no chance* or *games of perfect information*, are two player games in which players take turns making moves to change the initial position of the game. Unlike many games, here both players have perfect information about the positions and moves available in the game, and no chance is involved in a move. Games of this sort appear naturally in the "wilds" of mathematics, in areas ranging from graph theory to knots, tangles, groups and rings. In this talk we'll explore some of this strange zoo of algebraic and combinatorial games, introducing you as explorers to exotic and fun mathematics along the way. Come ready to try your strategic abilities against your fellow mathematics students too!

2203 The Fastest Path between Two Points with an Obstacle
Kathleen Bell, Western Kentucky University
Consider a path between two points on the axes of a coordinate plane, with a rectangular obstacle having one vertex on the origin. If the rate of travel through the obstacle is slower than the rate of travel in the surrounding area, we discuss the optimal path from point A to point B.

2204 The Effect of Prey Dispersal on a Two-Patch Predator-Prey System
Victoria Kelley, James Madison University
Considering the effect of prey dispersal in a two-patch predator-prey model, we assume patch two has a significantly smaller carrying capacity and higher predation rate. We characterize stability conditions of the established coexistence equilibrium in the parameter space, and use numerical simulations to observe conditions for which Hopf bifurcation occurs.

2208 Periodic Matrix Population Model for Monarch Butterflies
Emily Hunt, James Madison University
We use periodic population matrices to model the life cycle of the monarch butterfly and find that this unique migration is not currently at risk. We extend the model to address the three primary obstacles for the long term survival of this migration: deforestation in Mexico, extreme weather patterns, and milkweed deficiency.

2209 $N + K$ Queens
Bethany Alloway, Morehead State University
The $n + k$ Queens Problem requires the placing of n Queens and k Pawns on an $n \times n$ chessboard in such a way that no two Queens attack each other. Recently we have been developing a program that uses the Biswas-Michael Gravity Algorithm to find a solution that has the least total attacks on non-Queen cells.

2210 Panel Session on Graduate School
Dr. N. Rao Chaganty, Old Dominion University
Dr. Elizabeth Denne, Washington and Lee University
Dr. Leah Shaw, College of William and Mary
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.

11:30 - 11:45 Parallel Talks Session II

2203 Periodic Billiard Trajectories in Two Dimensions
Ryan Stees, James Madison University
We discuss periodic billiard trajectories in two dimensions. After introducing some definitions, we provide a few motivational results. Then, for closed, smooth, non-convex curves with two inflection points, we prove the existence of at least one 2-periodic trajectory.

2204 Periods of Linear Recurrences over Finite Rings
Danjoseph Quijada, Washington and Lee University
We investigated the periodicity of infinite sequences of ring elements generated by linear recurrence relations. Specifically, we analyzed sequences over finite fields and cyclic group algebras.

2208 Sonification of Mathematics Using a String Ensemble
Rebecah Storms ♡, Southwest Virginia Governor's School
The goal of this project was to effectively and pleasingly combine math and the arts using equations and a string ensemble. A melody line that strategically resembles a certain function was composed for a part. The equations describe the pitch value in Hertz as a function of the beat number.

2209 Realizations of Secondary Polytopes
Aleyah Dawkins, James Madison University
John Harnois, James Madison University
Polytopes have been investigated since Euclid and have enjoyed a significant renaissance in the last half-century. Triangulations of polytopes generate a plethora of beautiful structures and have many applications within and beyond pure mathematics. One object associated to the triangulations of polytopes is the secondary polytope. Our objective is

to provide some first results and further questions on secondary polytopes.

2210 Panel Session on Graduate School (CONTINUED)
Started at 11:10. Feel free to enter or leave as the discussion continues.

11:50 - 12:05 Parallel Talks Session III

2203 2D Dijkgraaf-Witten Theory with Defects
Hwajin Park, University of Virginia
Aria Dougherty, Mary Baldwin College
A standard construction in 2-dimensional topological quantum field theory is of state-sum invariants. In Dijkgraaf-Witten theory, such constructions involve triangulating surfaces, labeling edges with group elements, and evaluating 2-simplexes using group 2-cocycles. We introduce defects on curves into 2D Dijkgraaf-Witten theory and construct a state-sum invariant for surfaces with curves.

2204 Developing An Online Linear Algebra Course with Mathematica
Sarah House, Radford University
A complete university-level mathematics course can be made accessible through the Mathematica software platform. It includes randomized online quizzes featuring constructive feedback adjusted to each student's progress. We hope to demonstrate the importance of information accessibility and adaptive mastery-based learning as an effective method to develop solid comprehension of concepts.

2208 The Flour Beetle - A Discrete Mathematical Model
Matthew Buhr, University of South Dakota
Some recent experimental studies of flour beetles (Tribolium Castaneum) have indicated a possibility of behavior in the laboratory that appears to be chaotic. We describe and attempt to analyze a model for such behavior, taking note of the properties of the life cycle of the flour beetle. We can then manipulate parameter values to find if the dynamics are very sensitive to any changes in cannibalism rates within the population of beetles, and then determine any possible chaotic behavior.

2209 **Patterns and Combinatorial Statistics on Restricted Growth Functions**
Jonathan Gerhard, James Madison University
A restricted growth function (RGF) is a sequence of positive integers such that the first element is always a 1, and every element afterwards can be no greater than 1 plus the max of all the previous elements. In this talk, we will combine common notions of avoidance and statistics on combinatorial objects through generating functions and study the resulting polynomials.

2210 **Panel Session on REUs and Summer Programs**
Owen Hill, College of William and Mary
Dr. Edwin O'Shea, James Madison University
Dr. Gwyneth Whieldon, Hood College
Want to learn more about Research Experience for Undergraduates programs and other summer oportunities in mathematics? Come ask this panel of students and faculty your questions!

12:10 - 1:30 Lunch and Poster Session hallway

LUNCH: If you have a star on your name tag, you can pick up your boxed lunch near the registration table around 12:30. If you don't have a star, you will need to wait until 1:00 to pick up a box lunch if there are some left.

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.

($\heartsuit$ indicates high school student)

Research Posters

Fluid Structure Interaction Models for Aneurysm Arterial Wall Dynamics Incorporating Geometric and Material Nonlinearity *Haarika Chalasani $\heartsuit$, Thomas Jefferson High School for Science and Technology*

Growing Networks with Positive and Negative Links *Corynne Dech, College of William and Mary*

Use of an Effective Non-Hermitian Hamiltonian in Analyzing Base Components for Quantum Computing *Tanya Hoatson $\heartsuit$, Governor's School for Science and Technology*

Pattern Formation in Intertidal Mussel Populations *Wade Hodson, The College of William and Mary*

Integration By Parts *Parissa Joukar ♡, Mountain Vista Governor's School*

Dynamics of a contracting online network *Greg Kirwin, College of William & Mary*

Trends in the Polar Ice Caps *Brittany Kowalewki, Wesley College*

The Mathematical Modeling and Simulation of Thermal Injury Propagation: Lipid Peroxidation and Inhibition by Vitamin E *Michael Machado ♡, The Governor's School at Innovation Park*

Mathematical Modeling and implementation of a Graphical User Interface for determining optimal locations of missing objects *Sabrina Mazer ♡, The Governor's School at Innovation Park*

Logistic and Linear Multiple Regression Analysis of the Kinematic Determinants of Success in the Fencing Flick *Anya Michaelsen ♡, Lake Braddock Secondary School*

Investigation of Immigration Policies Through Social Dynamics Modeling of Undocumented Immigrant Population *Chelsea Mohindroo, George Mason University*

A Mathematical Analysis of Soccer Games *Daniel Rong ♡, Montgomery Blair High School*

The Queen of Mathematics *Emma Ruby ♡, Mountain Vista Governor's School*

Sonification of Mathematics Using a String Ensemble *Rebecah Storms ♡, Southwest Virginia Governor's School*

Enhancing Groundwater Quality Through Computational Modeling of Nanoparticle Transport and Interaction in Porous Media *Akhil Waghmare ♡, Thomas Jefferson High School for Science and Technology*

Math of Matching *Michael Walton ♡, Harrisonburg High School*

Expository Posters

Pascal's Triangle *Mira Bagous ♡, Mountain Vista Governor's School*

Determining the Significance of a Set of Data *Sophie Gibbs ♡, Mountain Vista Governor's School*

Why e is Irrational *Alex Hicks ♡, Mountain Vista Governor's School*

Linear Algebra *Alwin Hollebrandse ♡, Moutain Vista Governors School*

Standard Deviation *Nicole King ♡, Mountain Vista Governor's School*

Cryptography and Information Security *Tony Lunsford ♡, Mountain Vista Governer's School*

Sine Language *Ryan McKenna ♡, Mountain Vista Governer's School*

The Unit Circle *Jacob Adams ♡, Madelyn Patrick ♡, Mountain Vista Governor's School*

Financial Mathematics *Abigail Re ♡, Mountain Vista Governors school*

Tangency Problem of Apollonius *Michael Shannon, Frostburg State University*

Vitruvius and Da Vinci—Body Proportions *Kelli Showalter ♡, Eddie Mestre ♡, Marissa Lutz ♡, Harrisonburg High School*

Exploring Asymptotes *Abby Wilson ♡, Mountain Vista Governor's School*

Acoustic Oddities *Zev Woodstock, James Madison University*

1:30 - 1:45 Parallel Talks Session IV

2203 **Partial Metric Spaces: Representation and Classification**
Owen Hill, College of William and Mary
Partial metrics generalize the standard notion of distance, a metric, allowing non-zero self-distances. We demonstrate construction of partial metrics from standard metrics and vice versa, which results in a useful representation theorem. We also examine nontrivial partial metric topologies, analyze separation axioms and explore properties of sequences and limits.

2204 Dynamics of Glial Cell Defense Mechanisms in Response to Ischemic Hypoxia in the Brain
Matthew Buhr, University of South Dakota
Three models are introduced that explore the dual role of glial cells in the formation of scar tissue and in the neural repair following hypoxia ischemia in the brain. Scar tissue helps protect the brain during the acute phase of injury by limiting the spread of secondary damage, but limits recovery by inhibiting the repair of damaged neurons. Our results compare how the trade-offs between scar tissue formation and neural repair impacts future brain health.

2208 Bifurcation Scenarios in External Cavity and Delay-Coupled Semiconductor Lasers
Jessica Walker, Mary Baldwin College
The Lang-Kobayashi system of delay differential equations describes the behaviors of the external cavity and delay-coupled semiconductor laser cases. Through research, we find new information regarding the solution behaviors in both cases as well as the prevalence of Hopf bifurcations as their solutions lose stability.

2209 Realizability of Graphs with Prescribed Parameters
Candace Bethea, Washington and Lee University
There are standard techniques for finding vertex connectivity, edge connectivity, minimum degree, and maximum degree for a given graph of size n. We look at the reverse problem: given a prescribed vertex connectivity, edge connectivity, minimum degree, and maximum degree, what are the restrictions on the size of a graph? We examine the case when the sum of vertex connectivity and maximum degree is strictly less than the sum of edge connectivity and minimum degree. We consider the strict inequality case as well as the cases when parameters may be equal.

2210 Panel Session on REUs and Summer Programs
Traymon Beavers, James Madison University
Dr. Edwin O'Shea, James Madison University
Dr. Gwyneth Whieldon, Hood College
Want to learn more about Research Experience for Undergraduates programs and other summer oportunities in mathematics? Come ask this panel of students and faculty your questions!

2203 **Folded ribbon knots in the plane**
Catherine Zhu, Washington and Lee University
Mary Camp, Washington and Lee University
We discuss folded ribbon knots (knots tied in long thin strips of paper and folded, origami style) and ribbonlength. We give examples that show the importance of folding information when finding the ribbonlength.

2204 **Subtractive to Additive Manufacturing**
Lisha White, James Madison University
Michael Caple, James Madison University
By hand-carving, wooden pliers can be made from a solid block of wood with 10 cuts. With a combination of mathematical and engineering methods, we were able to replicate the mathematical description of the pliers and use additive manufacturing for better understanding the hexagonal pliers joint.

2208 **The Hybrid-Bremmer Series Method for an Inverse Scattering Problem: Convergence, Stability, and Error Characterization**
Zev Woodstock, James Madison University
Robert Staniunas, James Madison University
We present a series solution for an inverse scattering problem with applications in seismic imaging. Starting with the equation for an acoustic wave propagating in a spatially varying medium, we formulate a forward series solution for the scattered wave, then an analogous inverse series that recovers the spatially varying medium from measurements on the subsurface boundary. We explain both the forward and and the inverse problems, and prove convergence, stability and error results for both the forward and the inverse series. (Our analysis is for the one dimensional problem.)

2209 The Abelian Sandpile Model on Fractal Graphs
Rafael Setra, University of Maryland, College Park
The Abelian Sandpile Model (ASM) is a process where chips are placed on a graphs vertices. When the number of chips on a vertex exceeds its degree, chips are distributed to each neighboring vertex. We study the resulting patterns from the ASM on fractal graphs and generalize to further graphs.

2210 Panel Session on Career & Industry
Paul Boisen, National Security Agency
Ann Lewis, Pendago
Phil Riley, Two Sigma
John Webb, James Madison University
What can you do with a math degree? What kinds of companies and institutions value mathematical talent? This panel has experience using mathematics outside of academia, so come ask them some questions!

2:10 - 2:25 Parallel Talks Session VI

2203 Properties of Tsirelson space
Noah Duncan, Washington and Lee University
James Quigley, Washington and Lee University
In the early 1970s Boris Tsirelson developed a method for constructing norms on infinite sequences that has proved extremely useful to researchers in Banach space theory. Tsirelson's method involves inductively constructing a sequence of intermediate norms and taking a limit. This past summer, James Quigley and Noah Duncan at Washington and Lee University, working with Prof. Kevin Beanland, investigated some open questions regarding the stabilization of these intermediate norms on certain vectors. In this talk, we will discuss these problems and describe some of our approaches towards solving them.

2204 Geometric Modeling of Wooden Pliers

Traymon Beavers, James Madison University
Ezekiel Mihelcic, James Madison University

Wooden pliers can be constructed from a rectangular block of wood using ten cuts. A two-dimensional model describing the mechanics of the three-dimensional pliers was constructed. This model fully predicts whether pliers constructed with an arbitrary set of cuts can open and, if so, how far those pliers will open.

2208 Mathematically Modeling the Marvelous Kidneys

Katie Sipes, James Madison University

The kidneys are organs that are found distal and dorsal of your body. They are responsible for filtering blood plasma of water, salts, and ions. Kidneys either create a dilute waste product in a large quantity, or a small concentrated amount. We can further understand the semipermeability of the kidneys with mathematically modeling and further analysis.

2209 Affine Permutation Pattern Avoidance

Ryan Stees, James Madison University
Abigal Liskey, James Madison University

We utilize visual definitions of the symmetric groups and their infinite analogs, the affine symmetric groups, to discuss pattern avoidance in affine permutations. Then, we develop a new proof of a fundamental result. Finally, we describe computational methods we have used to improve an algorithm that checks for pattern avoidance.

2210 Panel Session on Career & Industry (CONTINUED)

Started at 1:30. Feel free to enter or leave as the discussion continues.

2:30 - 3:00 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!

3:00 - 3:10 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!

3:10 - 4:00 Closing Address auditorium 2301

Making Mathematics Real
Dr. Laura Taalman

Mathematician in Residence
Museum of Mathematics

For a pure mathematician, mathematics is a set of abstract constructs completely separated from reality, and using technology to explore mathematics can seem like, well, cheating. But with the rise of undergraduate research in mathematics comes a need for elementary unsolved problems that students can pursue. Modern technology can help fill this need and support exploratory, investigative mathematics, even for those of us that are old-school mathematical purists at heart. Going a step further, the recently accessible technology of 3D printing can take abstract mathematical objects and literally make them real.