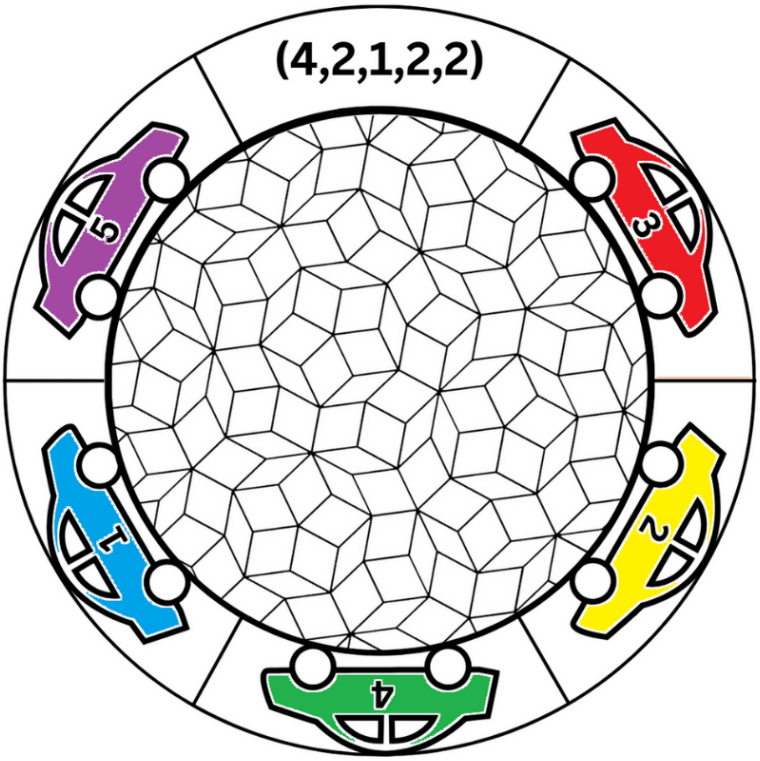
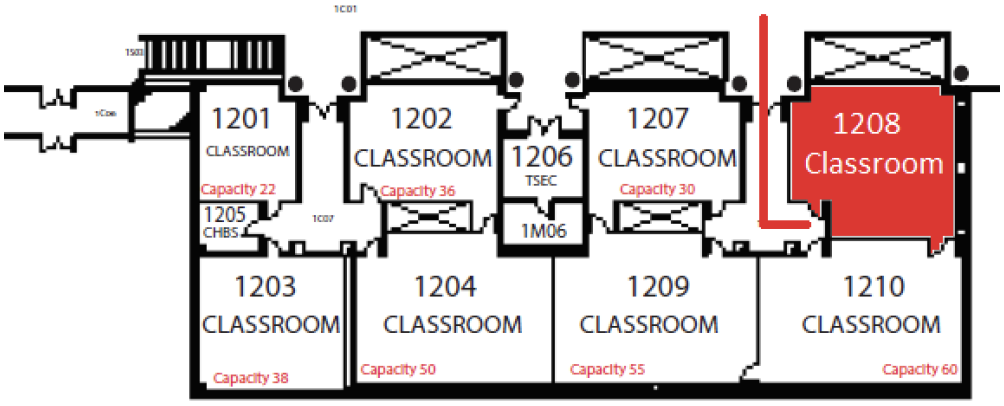
Shenandoah Undergraduate Mathematics and Statistics Conference

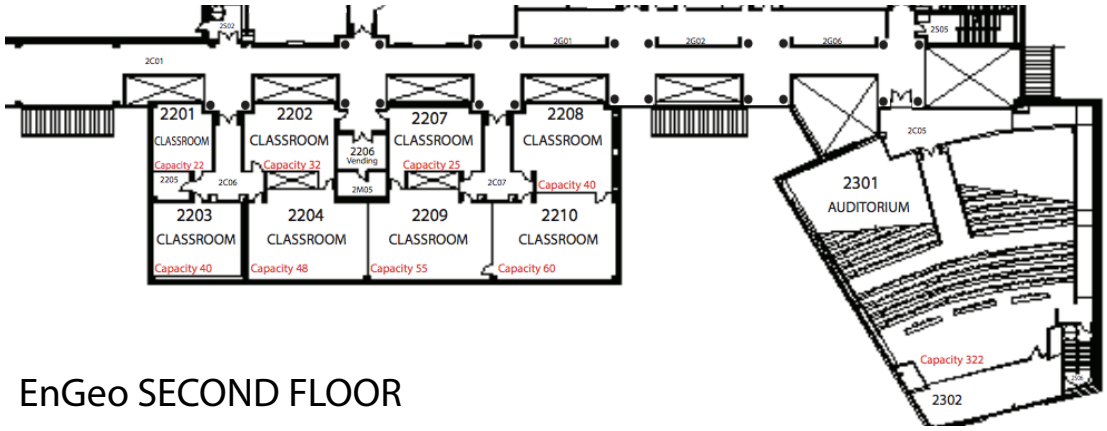


Saturday October 7, 2023
James Madison University

All events are on the first and second floors of the JMU EnGeo building.



EnGeo First Floor



EnGeo SECOND FLOOR

Wireless Network: Log onto "JMU-Visitors"
Username: sums@jmu.edu
Password: 662594
The username and password are case specific.

Notes:

Jellybean Competition

Rules: Each person may enter only once. Your guess must consist of a connected *interval* of real numbers. The winning entry will be the smallest interval containing the actual number of jellybeans, with any ties broken using the distance from the center of your interval to the actual number. The winner will be announced at the prize session at the end of the day.

Thank you to all of the volunteers who make this conference possible. We are grateful for support from the JMU's College of Science and Mathematics, and the General Education Program.

Join us next year for SUMS 2024!
`www.jmu.edu/mathstat/sums`

SUMS 2023 TIMETABLE

When	What & Where				
9:00-10:00	Registration 2nd floor hallway				
10:00 - 10:10	Welcome Dr. Sam Prins (JMU, CSM Dean) 2301				
10:10 - 11:00	Opening Talk Dr. Mark Embree (VT) 2301				
11:15 - 11:30	Parallel Session I				
	Job Panel 2208	K. Athey 1207	L. Harrison 1208	J. Layne 1209	V. Paz Soldan Viscarra 1210
11:35 - 11:50	Parallel Session II				
	Job Panel 2208	E. Lawing 1207	H. Zhang 1208	S. Fiscus 1209	A. Downs 1210
11:55 - 12:10	Parallel Session III				
	Grad Panel 2208	N. Remmers 1207	T. Edwards 1208	J. Plute 1209	N. Msechu 1210
12:15-1:15	Lunch and Poster Session Hallway				
1:45-2:00	Parallel Session IV				
	REU Panel 2208	A. Jeem 1207	B. Worms 1208	S. Lowery 1209	A. Usmanov 1210
2:05-2:20	Parallel Session V				
	REU Panel 2208	E. Doby 1207	T. Schupp 1208	J. Novaes 1209	 1210
2:30-3:00	Afternoon Coffee & Tea Hallway				
3:10 - 4:00	Closing Talk Dr. Pamela Harris (UWM) 2301				
4:10-4:20	Prize session 2301				
4:20	Conference Closing Dr. Ravi Shankar (JMU, Math/Stat Dept. Head) 2301				

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.

Poster presenters should take their posters to room EnGeo 2202 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 auditorium 2301

Join Dr. Samantha Prins, Dean of the College of Science and Mathematics, as we welcome you to SUMS 2023.

10:10 - 11:00 Opening Address auditorium 2301

Mathematical Quasicrystals

Dr. Mark Embree
Virginia Tech

In 2011, Dan Shechtman was awarded the Nobel Prize in Chemistry for his discovery of quasicrystals, novel materials with properties somewhere between the regularity of crystals and the disorder of random structures. In parallel with this scientific breakthrough, mathematicians have developed tools for understanding aperiodic order, such as Fibonacci substitutions and Penrose tilings. We will survey these mathematical models of quasicrystals, relying on linear algebra and graph theory. Eigenvalues play a central role, giving insight into how these exotic materials could behave.

These problems can be subtle and surprising, opening opportunities for a wide range of mathematical contributions. We will describe our collaborative approach, which integrates numerical computation as a key tool in mathematical discovery, providing a bridge between pure and applied mathematics.

11:15 - 11:30 Parallel Talks Session I

2208 **Career Panel**
Paul Boisen, National Security Agency
Will Clewett, Comcast
Cameron Robinson, Booz Allen Hamilton
Ask questions and learn about careers involving mathematics and statistics.

1207 **Methods for Debiasing Boosted Random Forest Predictors**
Kara Athey, James Madison University
Breiman's "Boosted Forest" approach utilizes the variance reduction of Random Forest and the bias correction of the Boosted method but doesn't fully utilize Boosting's fine-tuning technique. In this project, we modify Boosted RF to more closely mirror Boosting's bias correction method to overall improve predictor bias.

1208 **Disjoint Congruence Classes Conjecture**
Luna Harrison, The College of William and Mary
This talk will present the current state of progress on Sun's conjecture on disjoint congruence classes, as well as cover new techniques and progress. It will also discuss the various roadblocks and challenges that are faced.

1209 **A Motivated Proof of the Bressoud-Gollnitz-Gordon Identities**
John Layne, University of Virginia
We give a motivated proof of the Bressoud-Gollnitz-Gordon partition identities. We use ideas from earlier motivated proofs, such as "ghost series" and same-shelf recursions, to accomplish this. This work was part of the 2023 Summer Ursinus College NSF REU grant number 1851948.

1210 **Prediction of Acoustic Loads on Rocket Structure at Launch**
Valentina Paz Soldan Viscarra, James Madison University
Joseph Ungerleider, James Madison University
Rockets require precise acoustic load predictions to avoid damage to their structure. Based on the NASA SP-8072 model, a MatLab code has been implemented that accurately predicts the sound pressure levels on the rocket. This is currently being enhanced with a Directivity Index for refined accuracy.

11:35 - 11:50 Parallel Talks Session II

2208 **Career Panel**
Paul Boisen, National Security Agency
Will Clewett, Comcast
Cameron Robinson, Booz Allen Hamilton
Ask questions and learn about careers involving mathematics and statistics.

1207 **Snowfall Trends across the United States**
Evan Lawing, James Madison University
Due to climate change snowfall patterns have been changing across the United States. Ski towns in the US have built their economy on snow but have seen some down years in the past decades and it could continue to the future as well. In this project we will analyze the snowfall trends of the past 50 years.

1208 **New Bounds on Cyclic Van der Waerden Graphs**
Hongyi Zhang, Haverford College
Ameer Muhialdeen, Brown University
We prove a new upper bound on the independence number of Z/n, for composite n, whose edges are r-term arithmetic progressions, by reducing to a combinatorial problem about finite cartesian products. We prove a new lower bound number theoretically and a new upper bound on its chromatic number with similar techniques.

1209 **Geometric hypergraphs and the Hadwiger-Nelson problem**
Sean Fiscus, Duke University
Hongyi Zhang, Haverford College
The chromatic number of the unit distance graph on R^d is unknown. Using a famous theorem simplifying this problem to finite graphs, we locate a class of geometrically defined hypergraphs of arbitrarily large edge cardinality whose proper colorings coincide with the proper colorings of the unit distance graph on R^d.

1210 **The Mathematics of QR Codes**
Adam Downs, Radford University
QR codes have become a common medium for accessing information. In order to ensure the information is scanned properly, error correction involving Reed-Solomon codes is embedded in the data. We describe the role of mathematics in how QR codes are constructed, and how error correction is provided.

11:55 - 12:10 Parallel Talks Session III

2208 **Graduate Panel**
Andre Mas, NC State University
Rao Chaganty, Old Dominion University
Learn about what life is like as a graduate student in mathematics or statistics.

1207 **Census Population Estimation with Heterogeneous Catchability**
Nathanael Remmers, James Madison University
The size of a population can be estimated by repeatedly taking samples from the same population. In this work, we will explore how to use quasi-symmetric loglinear models to estimate population size when individuals have heterogeneous catchability and furthermore, the heterogeneity pattern varies across samples.

1208 **Discrete Helly Type Theorems for Axis Parallel Boxes**
Timothy Edwards, Gannon University
A recent Helly type result of Halman states that a family of axis parallel boxes contains a point from some discrete set S in its intersection whenever every subfamily of size 2d contains a point of S in its intersection. We prove colorful, quantitative, and fractional variations of this result.

1209 **The Sandpile Group of Subset Intersection Graphs**
Jenna Plute, Texas A&M University
Lauren Engelthaler, University of Dallas
The sandpile group of a graph is a finite abelian group related to the graph's structure. We consider the Laplacian matrix of various subset intersection graphs. Building on work by Wilson and Bier, we conjugate this Laplacian matrix to a diagonalizable upper triangular form revealing the corresponding sandpile group.

1210 **Mathematically modeling the spread of racism**
Nossim Msechu, Battlefield High School
Racial discrimination has continued to play a factor in the many lives of minorities in America. This research project aims to understand the passage of racism through different stages and illustrate how certain factors can minimize the spread of these ideals through mathematical modeling.

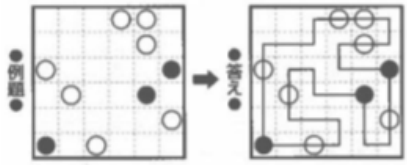
12:15 - 1:15 Lunch hallway

LUNCH: If you are hungry and have a circle on your badge, please pick up a boxed lunch near the registration table at 12:15. (If you do not have a circle, it means that you registered after our catering order deadline. But you still might get a free lunch. Please wait until 12:30 to check for unclaimed lunches).

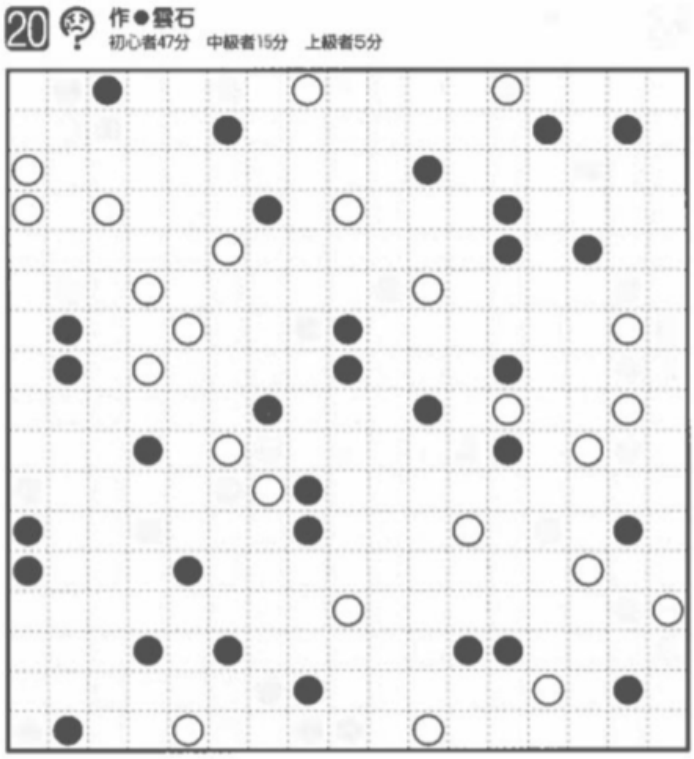
Masyu puzzle from Nikoli

Rules of Masyu:

1. Make a single loop with lines passing through the centers of cells, horizontally or vertically. The loop never crosses itself, branches off, or goes through the same cell twice.
2. Lines must pass through all cells with black and white circles.
3. Lines passing through white circles must pass straight through its cell, and make a right-angled turn in at least one of the cells next to the white circle.
4. Lines passing through black circles must make a right-angled turn in its cell, then it must go straight through the next cell (till the middle of the second cell) on both sides.



Find more Nikoli puzzles at this link:
www.nikoli.co.jp/en/puzzles/



12:30 - 1:15 Poster Session hallway

POSTER SESSION: Students will be near their posters during lunch. Please stop by to see their excellent work! Poster judging will start by 12:30.

Recursive Polynomials: Combinatorics and Analysis
Luke Bridges, Michigan State University & Max Budnick, Georgia Institute of Technology

A Statistical Analysis and Linear Models of Cerebral Stroke
Peter Jin, James M. Bennett High School

On the t-Elasticity of Numerical Semigroups
Brianna Worms, James Madison University

Improved Critical Drift Estimates for the Frog Model on Tree
Aryan Dugar, Johns Hopkins University

Prediction of Acoustic Loading on Rocket Structure at Launch
Valentina Paz Soldan Viscarra, James Madison University & Joseph Ungerleider, James Madison University

Colorful Variation of the Integer Tverberg Problem
Timothy Edwards, Gannon University

Path Cover Number of 4-Regular Graphs
Adam Jutt, William & Mary

A 2D Model of Pollen Tip-Focused Intracellular Ca2+ Gradient
Yinuo Chen, College of William and Mary

Analysis of Coanda Jet Boundaries via Digitization Modeling
Nik Alexander, James Madison University & Macklin Luckinbill, James Madison University & Josiah Walker, James Madison University

Seasonal Population Model of the Chesapeake Bay Blue Crab
Gwendolyn Sargent, College of William & Mary

Shock Associated Noise in Rocketry
Hunter Newman, James Madison University

Iterative Solvers as Discrete Dynamical Systems
Eliza Wapperom, Blacksburg High School

New Bounds on Cyclic Van der Waerden Graphs
Hongyi Zhang, Haverford College & Ameer Mudialdeen, Brown University

Matrix Multiplying If You Can't Share Data or Trust Everyone
Medha Durisheti, Virginia Tech & Clare Hinds,Virginia Tech

Aeroacoustics of Flame Trenches
Matthew Smith, James Madison University

1:45 - 2:00 Parallel Talks Session IV

2208 **REU Panel**
David Duncan, James Madison University
Sat Gupta, UNC-Greensboro
Jenna Plute, Texas A&M University
Learn all about the process of applying for, and participating in, an REU program.

1207 **Numerical modeling of Ground Heat Exchangers**
Abid Jeem, Washington and Lee University
Wonjun Jo, Washington and Lee University
Ground source heat pump systems (GSHP) are efficient for space heating and cooling. Proper GSHP sizing requires accurate knowledge of ground thermal properties. Our 1-D heat equation model, using measured temperature data as initial and boundary conditions, optimizes thermal properties and validates model accuracy.

1208 **On the t-Elasticity of Numerical Semigroups**
Brianna Worms, James Madison University
Let S be a numerical semigroup generated by the vector v and n be a non-unit in S. A factorization of n is a vector whose dot product with v is n, and the length of the factorization is its 1-norm. Allowing ourselves to measure length as an arbitrary t-norm, we analyze "t-elasticity" as a function of t.

1209 **Ribbon numbers for 12-crossing knots**
Samuel Lowery, Slippery Rock University
We explore the ribbon number of 12-crossing knots and enumerate all ribbon codes with at most 4 ribbon intersections, leading us to identify the ribbon number of 56 knots. We also consider a generalization of the ribbon number for knots bounding genus g ribbon surfaces.

1210 **New Approaches to Mouse Colon Modeling**
Adam Usmanov, University of Pittsburgh
Colon motility, the spontaneous self-generated movement and motion of the colon muscle and its cells, is produced by activity in different types of cells such as myenteric neurons of the enteric nervous system (ENS), neurons of the autonomic nervous system (ANS) and interstitial cells of Cajal (ICC).

2:05 - 2:20 Parallel Talks Session V

2208 **REU Panel**
David Duncan, James Madison University
Sat Gupta, UNC-Greensboro
Jenna Plute, Texas A&M University
Learn all about the process of applying for, and participating in, an REU program.

1207 **Effectiveness of Riparian Buffer Systems in Nutrient Removal**
Elke Doby, James Madison University
Effectiveness of riparian buffer systems on stream health was evaluated using six selected farms in the Shenandoah Region, VA. Linear models were used to evaluate the relationship between water quality data and environmental factors. Results revealed riparian buffers have a positive outcome in improving water quality.

1208 **Counting Primitive Characters**
Tommy Schupp, American University
This paper presents a formula to find the number of primitive Dirichlet characters for a given modulus. In particular, we find that the Dirichlet convolution of the Euler totient function with the Möbius function counts the number of primitive Dirichlet characters.

1209 **Extremal Property of the Symmetric Decreasing Rearrangement**
Julia Novaes, Longwood University
It is shown that for a given log concave function, its symmetric decreasing rearrangement is always harder to approximate in the symmetric different metric by log-affine minorants with a fixed number of break points. This extends a classical result of Macbeath (1951) from convex bodies to a functional setting.

2:30 - 3:00 Afternoon tea 2nd floor hallway

Please join us for tea and coffee in the EnGeo foyer. This is your last chance to enter the candy contest!

3:10 - 4:00 Closing Address auditorium 2301

Parking Functions: Choose your own adventure

Dr. Pamela Harris
University of Wisconsin-Milwaukee

Consider a parking lot consisting of n consecutive parking spots along a one-way street labeled 1 to n. Suppose n cars want to park one at a time in the parking lot and each car has a preferred parking spot. Each car coming into the lot initially tries to park in its preferred spot. However, if a car's preferred spot is already occupied, then it will proceed forward in the street parking in the next available spot. Since the parking lot is along a one-way street, it is not guaranteed that every car will be able to park before driving past the parking lot. If we let a_i denote the preference of car i and all of the cars are able to park under these conditions, then the preference list $(a_1, a_2, \ldots, a_n)$ is called a parking function (of length n).
For example, $(4, 2, 1, 2, 2)$ is a parking function, but $(5, 1, 2, 5, 2)$ is not (you should convince yourself of this!). In this talk, we provide an answer to the question of how many parking functions of length n there are and we consider many new avenues for research stemming from this enumerative question.

4:10 - 4:20 Prize Session auditorium 2301

Please join us for the prize session in the auditorium. Speaker awards, poster competition winners, and the candy contest winner will be announced!

4:20 Conference Closing auditorium 2301

Send off by Dr. Ravi Shankar, Head of JMU's Department of Mathematics and Statistics.

"19" Puzzles for SUMS 19

Jason Rosenhouse

October 7, 2023

This is the nineteenth edition of the SUMS conference. That's our last prime number for a while! So how about we honor that fact by considering some puzzles that involve the number 19?

1. 19 ants are dropped at the same time on a stick. Each ant lands on an arbitrary part of the stick and randomly chooses whether to move left or right. When two ants bump into each other, they immediately bounce off each other and start crawling in the opposite direction. The stick is 1 m long and the ants crawl at a rate of 1 m/min. When an ant arrives at an end of the stick, it falls off. What's the longest amount of time it could possibly take for all the ants to fall off the stick?

2. A doctor prescribes a regimen of medication for his patient. The patient has 19 "A" pills and 19 "B" pills, and he is to take exactly one of each every day until he runs out. On the fourth day, he accidentally puts one A pill and two B pills in his hand. The pills are visually identical, so he has no idea which is the A pill and which is the B pill. The pills are irreplaceable, so he cannot simply discard the pills. What can the patient do to keep to his schedule without losing any of the pills?

3. 19 soldiers are stationed in a field in such a way that the distances between any two are pairwise distinct. Each is ordered to watch the soldier nearest to him. Prove that there is at least one soldier who is not watched by anyone.

4. Is it possible to arrange 19 small squares (possibly of different sizes) into one large square? (To clarify: We are talking about aligning squares along their edges. No fair stacking them! Plainly you cannot arrange two or three squares into a larger square, but just as plainly you *can* arrange four squares into a larger square. So what's the verdict for 19?)

All of these puzzles are adapted from the recent book *The Price of Cake and* 99 *Other Classic Mathematical Riddles* by Clément Deslandes and Guillaume Deslandes, published by MIT Press. For solutions, feel free to contact Jason Rosenhouse at rosenhjd@jmu.edu.

In Memory of our Colleague and Friend
Dr. Edwin O'Shea

Please consider making a donation to the

Edwin O'Shea Memorial Scholarship
for Undergraduate Mathematics Research

https://gofund.me/18182530.