SUMS 2024 TIMETABLE

When	What & Where			
9:00-10:00	Registration & Breakfast 2nd floor hallway			
10:00 - 10:10	Welcome Dr. Sam Prins (JMU, CSM Dean) 2301			
10:10 - 11:00	Opening Talk Dr. Gretchen Matthews (VT) 2301			
11:15 - 11:30	Talk Session I			
	T. Tarter 1207	J. Noel 1208	S. Zanetti 1209	M. Moretti 1210
11:35 - 11:50	Talk Session II			
	C. Phillips 1207	V. Bate-Poxon 1208	H. Zhang 1209	D. Funk 1210
12:00 - 12:15	Panel Session I			
	Career/Industry 1207	Graduate School 1208	REU 1209	
12:15-1:45	Lunch and Poster Session Hallway			
1:50-2:05	Panel Session II			
	Career/Industry 1207	Graduate School 1208	REU 1209	
2:10-2:25	Talk Session III			
	Y. Bidav 1207	R. Bascom 1208	A. Gorman 1209	A. Chada 1210
2:30-2:45	Talk Session IV			
	N. Calhoun 1207	J. Arulandu 1208	T. Ross 1209	
2:45-3:00	Afternoon Coffee & Tea Hallway			
3:10 - 4:00	Closing Talk Dr. Vic Reiner (UMN) 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 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 2024.

10:10 - 11:00 Opening Address auditorium 2301

Serving Up Data with Polynomials

Dr. Gretchen Matthews
Virginia Tech

Polynomials over finite fields have been employed to protect and transmit information in a variety of ways, starting with Reed-Solomon codes in the 1960s. Reed-Solomon codes are based on polynomials in a single variable and are responsible for the error-correction that powers CDs, DVDs, and QR codes, among many other behind-the-scenes uses. Generalizations included the famous Reed-Muller codes (which inspired polar codes behind 5G) and algebraic geometry codes. The data deluge of the past decade has prompted a new application. In this talk, we consider the use of polynomials and curves over finite fields to share data with multiple groups simultaneously.

1207 **Applications of Benford's Law for UAS Threat Classification from Variational Pathfinding Models**

Timothy Tarter, James Madison University

In this work, we examine applications of Benford's Law beyond financial fraud detection; namely, we establish 'Benford Models' which can be applied to time-series data of variational pathfinding models for drones, ballistic missiles, and other spatial phenomena. These Benford Models provide both a generalization of Benford measure to sigma-algebras beyond the significand algebra and a new tool for threat modeling in national security.

1208 **The Effect of Natural Motion on Retinal Ganglion Cell Output**

Jared Noel, University of Arkansas

The retina displays a remarkable capacity for anticipating object motion in the visual scene. In this work, we recorded the spike trains elicited by a mouse retinal ganglion cell when presented with a naturally moving stimulus, and we used mechanistic modeling to elucidate the primary mechanism driving this response.

1209 **An Interpolation Problem for Discrete Analytic Polynomials**

Steven Zanetti, University of Michigan - Ann Arbor

A basic interpolation problem for discrete analytic polynomials on the integer lattice in the complex plane can be solved using an expedient polynomial basis and associated shift operators. A complete description of solutions can be obtained under certain conditions, formulated in terms of Vandermonde determinants.

1210 **Stochastic Gradient Methods for PDE-Constrained Optimization**

Niccolo Moretti, Dominican University New York

The goal is to find a stochastic alternative to the Riemannian conjugate gradient (RCG) method for solving a PDE-constrained optimization problem. By defining Riemannian Stochastic Weighted (RSW) gradient methods, numerical studies suggest that an RSW variant is a suitable alternative to the RCG method.

11:35 - 11:50 Parallel Talks Session II

1207 **A New Generalization of the Line Graph and its Spectral Characteristics**

Connor Phillips, James Madison University
Robert Petro, James Madison University

Given a graph, we introduce a generalization of its line graph called the ω-clique graph (taking $\omega = 2$ recovers its line graph). We explore properties of this construction including its spectrum and its relation to the line graph. Finally, we apply these theorems to discover novel information about Conway's 99 graph.

1208 **An Analysis of Biofilm Visual Complexities**

Veronica Bate-Poxon, College of William & Mary

Biofilms are diverse communities of microorganisms. Currently, labs don't have set rules on scoring a biofilm's visual complexity. My work aims to create a systematic process for classifying biofilms robust to image noise, centered around biofilm circularity, local binary patterns, and other image analysis techniques.

1209 **Topological Approaches to Convex and Intersection Problems**

Hongyi Zhang, Haverford College

We explore several generalizations of the Erdős-Szekeres using tools from equivariant topology. By applying methods such as the Borsuk–Ulam theorem and nerve lemmas, we establish conditions on set families that ensure the existence of convex sets. Besides, we investigate other non-embeddability results using topology.

1210 **Solving the Wave Equation on Discrete Time Scales**

Davis Funk, West Virginia University

We present a solution to an IVP for the 1D wave equation on time scales through the application of a Fourier transform and its inverse via contour integrals. The time scale of the spatial dimension is the integers and a broader class of discrete time scales, while the time dimension is the positive reals.

12:00 - 12:15 Panel Session I

1207 **Career Panel**
Will Clewett, Geico
Minh Huynh, KPMG LLP
Ask questions and learn about careers involving mathematics and statistics.

1208 **Graduate Panel**
Rao Chaganty, Old Dominion University
Zev Woodstock, James Madison University
Learn about what life is like as a graduate student in mathematics or statistics.

1209 **REU Panel**
Alex Capaldi, James Madison University
Josh Makela, James Madison University
Learn all about the process of applying for, and participating in, an REU program.

12:15 - 12:45 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).

12:45 - 1:45 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 12:45.

Chip Firing on Signed Graphs
Mateo Torres, University of Delaware; Zach Benton, Stanford University; Jane Kwak, UCLA; Mckinley Xie, Texas A&M

An Interpolation Problem for Discrete Analytic Polynomials
Steven Zanetti, University of Michigan - Ann Arbor

Key Hubs and Connectivity Patterns in the Human Brain
Ryan Bascom, Van Nguyen & Dias Shymbay, Washington and Lee University

Modeling Shock Associated Noise in Rocketry
Lydia Pelham & Hunter Newman, James Madison University

Stokes Flow Around Swimming Microorganisms
Mckenna Witt, James Madison University

Cops and Robbers on Oriented Graphs
Noah Calhoun, Centre College

Asymptotic Dynamics Via GPR Surrogates
Aya Yu, Virginia Commonwealth University

Invertibility of Operators Associated to Polyhyperbolic Splines
Luke Paris, Longwood University

Stochastic Gradient Methods for PDE-Constrained Optimization
Niccolo Moretti, Dominican University New York

Research of Machine Learning in Modern Urban Functionality
Xiaoming Wang, Arizona State University

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

Applying the PSM to Shock Associated Noise
Trevor Schonbrun & Arushi Chauhan, James Madison University

Seasonal Population Model of the Chesapeake Bay Blue Crab
Xiaoyu Lin, College of William and Mary

Target Pebbling in Trees
Yunus Bidav, Virginia Commonwealth University

Testing the Boundaries of a Coanda Jet
Josiah Walker & Gregory Granaham, James Madison University

1:50 - 2:05 Panel Session II

1207 **Career Panel**
Will Clewett, Geico
Minh Huynh, KPMG LLP
Ask questions and learn about careers involving mathematics and statistics.

1208 **Graduate Panel**
Rao Chaganty, Old Dominion University
Zev Woodstock, James Madison University
Learn about what life is like as a graduate student in mathematics or statistics.

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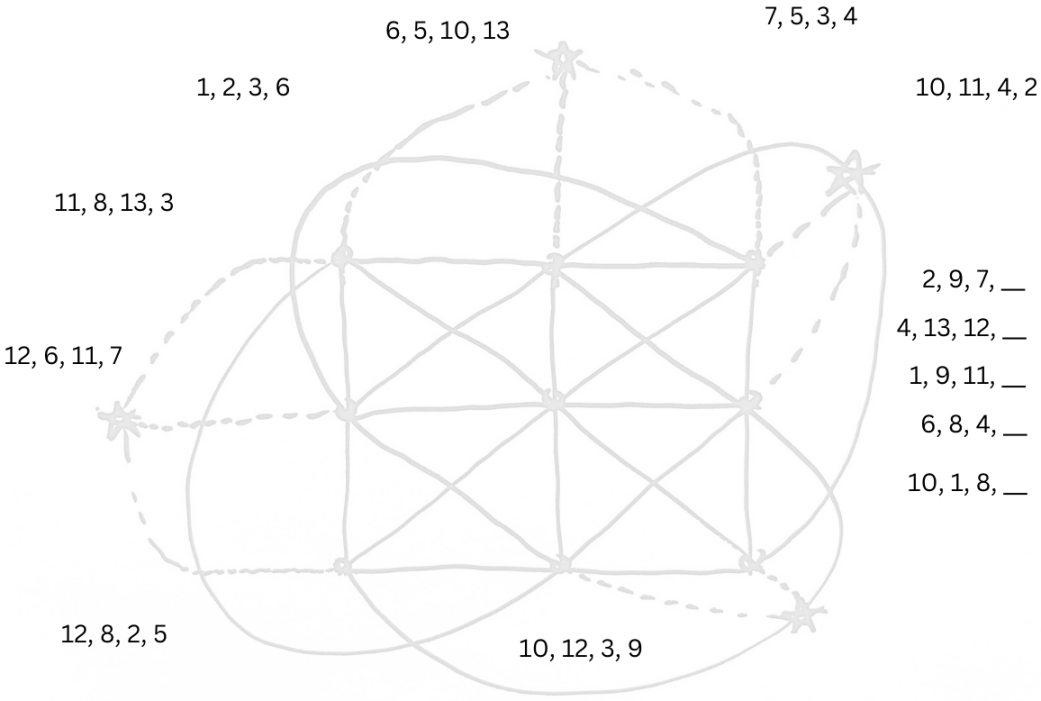
Alex Capaldi, James Madison University
Josh Makela, James Madison University

Learn all about the process of applying for, and participating in, an REU program.

Find the Design

Below are subsets of size four of the set $\{1, 2, \ldots, 13\}$, but they are not all complete.



Use each of the numbers $1, 5, 7, 9, 13$ exactly once to fill the blanks above and satisfy the condition: *any two subsets have exactly one number in common.*

Note: Each subset represents the points on a line in the projective plane of order 3 (sketched); therefore the subsets are like the cards of a smaller version of the game "Spot It!"

Some Puzzles for SUMS 20

Jason Rosenhouse

November 2, 2024

With this conference, SUMS enters its third decade. Quite an achievement! In fact, thinking about twenty straight SUMS conferences gets me thinking about other interesting sequences. So have a go at the following "Continue the sequence" puzzles. In each case, creative thinking is more important than mathematical skill, and all are "obvious, once you see it." Good luck!

1. We start with an old classic. What is the next number in this sequence?

   $$3,\ 3,\ 5,\ 4,\ 4,\ 3,\ 5,\ 5,\ 4,\ ???$$

2. And here's one that deserves to be a classic! What is the next number in this sequence?

   $$\underbrace{1,\ 1,\ 1, \ldots, 1}_{22 \text{ ones}},\ 3,\ 1,\ 1,\ ???$$

3. Those of us who teach math for a living know that whenever we give an exam, we can expect to get some strange answers. For example, during a lesson on exponents, a student summoned forth the following expression:

   $$A^{BCD}EF^{G}HI^{J}KLMN^{OPQRS}T^{U}VWXY$$

   Work out the rule the student was following, and place the Z accordingly.

4. That reminds me of another letter sequence puzzle. Careful though! This one could drive you crazy for a full week. What is the next letter in this sequence?

   $$O,\ U,\ E,\ H,\ R,\ A,\ ???$$

5. Since alphabetical order is an especially interesting sequence, here is a little puzzle I've always liked: There is only one number that has all of its letters in alphabetical order when written in standard English. Find that number.

6. And we really should end with one of the all-time, slam dunk classics of this genre. Find the next number in this sequence:

   $$1,\ 11,\ 21,\ 1211,\ 111221,\ 312211,\ ???$$

   Actually, since I have never met the person who could solve this without having seen it before, I will give you a hint: Read off each number simply as a sequence of digits, and look at the immediately preceding number as you do so.

For hints or solutions, feel free to contact Jason Rosenhouse at rosenhjd@jmu.edu.

1207 **Graph Edge Colorings and the Uniqueness Spectrum**
Yunus Bidav, Virginia Commonwealth University
The uniqueness spectrum of a graph is the set of all k for which G can be k-uniquely colored; denoted $Spec(G)$. Notice that values in $Spec(G)$ must be between zero and the number of edges of G. We call G full spectrum if $Spec(G) = \{0, \ldots, ||G|| - 2, ||G||\}$. We give a complete classification of graphs which have full spectrum.

1208 **Key Hubs and Connectivity Patterns in the Human Brain**
Ryan Bascom, Washington and Lee University
Van Nguyen, Washington and Lee University
Dias Shymbay, Washington and Lee University
This study investigates the human brain's structural connectome by analyzing 90 x 90 structural connectivity matrices from 88 healthy subjects. Using linear algebra and graph theory, we identify key hubs in the healthy brain, providing a benchmark for future research on brain connectivity and disease-related changes.

1209 **Recursive Sequences Generated by Divisibility**
Anthony Gorman, Liberty University
This presentation discusses a proof that the number of integers divisible by three in the interval $\left(2^n, 2^{n+1}\right)$ can be represented by a recurrence relation. It also explores similar patterns with other prime numbers, and alternative methods for finding explicit formulas.

1210 **Parameter Estimation of ODEs Using Neural Nets**
Aidan Chadha, Virginia Tech
We develop computational techniques for inverse problems based on deep learning, where we train artificial neural networks to estimate parameters of physical systems, such as those governed by ordinary differential equations or stochastic processes.

2:30 - 2:45 Parallel Talks Session IV

1207 **Cops and Robbers on Oriented Graphs**
Noah Calhoun, Centre College
Cassidy Kao, Barnard College
Ashleigh Clark, University of Tennessee
Elizabeth Howard, Xavier University

Cops and Robbers is a two-player vertex-to-vertex pursuit game played on a reflexive graph. In this presentation, we define a relational characterization of the class of cop-win oriented graphs in a manner analogous to the characterization provided by Clarke and McGillivray (2012) for undirected graphs.

1208 **Secure CNN Inference for Brain Tumor Classification**
Jovina Arulandu, Oakton High School

The classification of brain tumors is vital for treatment plans yet often delayed by surgery. Our design integrates machine learning, cryptography, and neural networks to classify tumors in MRI images while preserving patient privacy. This approach employs FHE techniques to compute encrypted data without decryption.

1209 **Periods of Recurrence Sequences in Finite Groups**
Teddy Ross, Washington and Lee University
Saad Ahmed Khan Ghori, Washington and Lee University

In this talk, we'll consider recurrence sequences in an arbitrary finite group where the recurrence is defined by a word in terms of some fixed number of the preceding terms. We'll present an upper bound for the maximum period of such sequences and look at some examples where this bound is tight.

2:45 - 3:00 Afternoon Coffee and 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

Counting and Cyclic Symmetry

Dr. Vic Reiner
University of Minnesota

Part of combinatorics looks for nice formulas to count various objects. Sometimes these formulas hide an added surprise: when we introduce a variable to turn them into a polynomial, they count the objects with cyclic symmetry, after plugging in a complex root-of-unity for the variable! We will illustrate this with some of our favorite examples, including some that we still find mysterious.

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 Department of Mathematics and Statistics.

Notes: