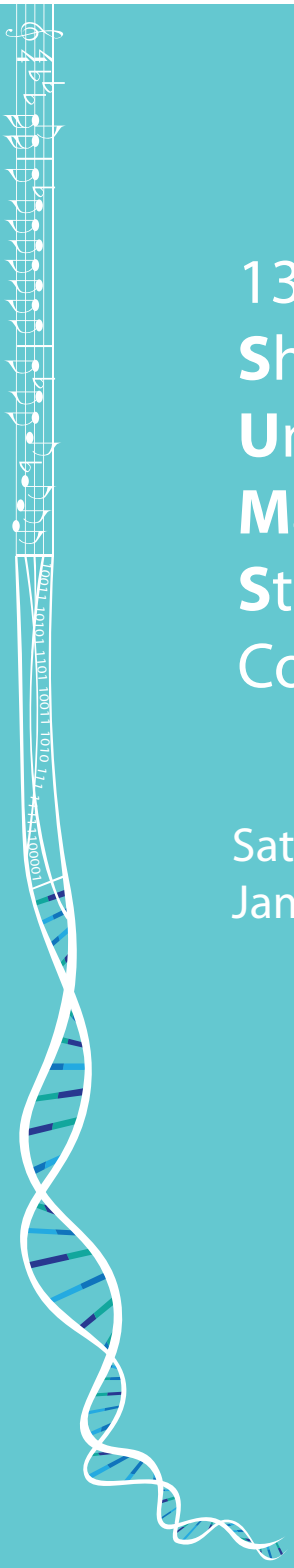
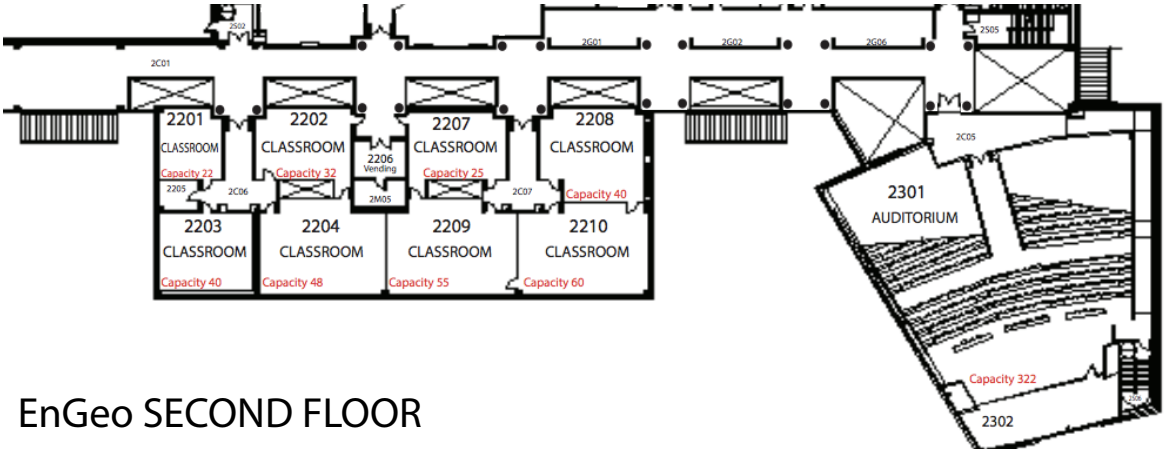


13th Annual Shenandoah Undergraduate Mathematics and Statistics Conference

Saturday, October 7, 2017
James Madison University

All events are on the second floor of the JMU EnGeo (formerly HHS) building.



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: 853838
The username and password are case specific.

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 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 auditorium 2301

Join Dr. Heather Coltman, Provost and Senior Vice President of Academic Affairs for James Madison University, and the conference organizers as we welcome you to the SUMS 2017 extravaganza.

10:10 - 11:00 Opening Address auditorium 2301

Mathematical Modeling in Cancer Research

Suzanne Weekes
Worcester Polytechnic Institute

Cancer research is no longer solely the domain of biologists, oncologists, and other physicians and bench scientists. Mathematicians use modeling and computer simulation to further the understanding of these diseases by developing quantitative descriptions to biological theories at various scales. The analytical and numerical results of these models can be compared to clinical and laboratory data to gain further insights. Results from these models can also be used to drive the design of in vitro or in vivo experiments and are used to develop new paradigms or to challenge existing theories. In this talk, the speaker will give a taste of some mathematical and computational models used by quantitative scientists working to understand the biology and dynamics of cancer.

SUMS 2017 TIMETABLE

When	What & Where				
9:00-10:00	Registration 2nd floor hallway				
10:00 - 10:10	Welcome Dr. Heather Coltman (JMU) 2301				
10:10 - 11:00	Opening Talk Dr. Suzanne Weekes (WPI) 2301				
11:10 - 11:25	Parallel Session I				
	S. Mancini 2203	J. Britton 2204	S. Davis 2208	D. Allen 2209	Grad Panel 2210
11:30 - 11:45	Parallel Session II				
	J. Foster 2203	A. Rahman 2204	D. King 2208	G. Fuselier 2209	Grad Panel 2210
11:50 - 12:05	Parallel Session III				
	H. Switzer 2203	H. Kim 2204	R. Koch 2208	G. Malcom 2209	REU Panel 2210
12:10-12:25	Parallel Session IV				
	C. Brown 2203	A. Diehl 2204	J. Guan 2208	M. Dyer 2209	REU Panel 2210
12:30-1:55	Lunch and Poster Session Hallway				
2:00-2:15	Parallel Session V				
	C. Hambric 2203	E. Zell 2204	J. Adams 2208	O. Babb 2209	Career Panel 2210
2:20-2:35	Parallel Session VI				
	I. Hill 2203	S. Sparks 2204	S. Guerra Abril 2208	C. Lamp 2209	Career Panel 2210
2:40-2:55	Parallel Session VII				
	N. Marzolf 2203	M. Rowland 2204	M. Agrios 2208	C. King 2209	C. Kindley 2210
3:00-3:15	Afternoon tea Hallway				
3:20-3:30	Prize session 2301				
3:30 - 4:20	Closing Talk Dr. Dave Kung (SMCM) 2301				

2203 **Anti-Games on Steiner Triple Systems**

Sophie Mancini, James Madison University

Steiner Triple Systems (STSs) are a category of combinatorial objects with features that have proven useful in determining winning strategies for various games. In this talk, I use geometric properties of these systems to describe a winning strategy for anti-games, variations of conventional games, played on STSs.

2204 **Rheology of nematic liquid crystals and magnetic fields**

Jacob Britton, Radford University

We explore how the linear response of a nematic liquid crystal to small amplitude oscillatory shear is affected by the presence of a static magnetic field. The magnetic field forces an equilibrium alignment of the liquid crystal of our choosing, and the flow causes the orientation to oscillate around this equilibrium.

2208 **Model Theory & Geometry Without the SAS Axiom**

Stephen Davis, University of Virginia

We survey non-SAS geometries and axiom equivalences in the context of Hilbert's modern axiomatization of Euclidean geometry. Our perspective is informed by mathematical logic. Our main result is a novel proof that Euclid's parallel postulate is not equivalent to Playfair's axiom in the non-SAS context.

2209 **Discrete Moment Problems and the News Vendor Application**

David Allen, The College of William and Mary

Solving discrete moment problems can give sharp bounds for functions of discrete random variables. Bounds come from optimizing the linear programs, using estimated moments of functions of discrete random variables as constraints. We structure the bases used to solve the programs and apply it to inventory management.

2210 **Panel Session on Graduate School in Math, Stats and Math Ed**

Mike Lam, James Madison University
Zev Woodstock, NC State University
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 faculty members and grad students!

2203 **Eulerian Numbers in Cryptography**
Jenna Foster, Radford University
In our research, we have given a new proof through combinatorial methods that the number of increasing pairs is equal to Eulerian numbers for a permutation. We have used methods similar to Bellaso to encode messages into binary strings and discovered that this process is producing balanced, pseudorandom binary sequence

2204 **Observing the Behavior of Quasiperiodic Orbits**
Arsah Rahman, George Mason University
Quasiperiodicity is a dynamical behavior often seen in planetary motion. Referencing Das et al's, and Levnajic's and Mezic's work, we observed the standard map's dynamics for an understanding of the quasiperiodic orbits behavior and are extending it for the Froeschle map, and viewing new parameters for other equations.

2208 **Families of Laplacians on Fractals**
Dylan King, Wake Forest University
Using a modified construction of the Sierpinski Gasket we were able to construct and analyze non-standard Laplacians that maintain symmetry and self-similarity. Our chief subject of analysis is the spectrum of the Laplacian, culminating in the formulation of spectral decimation for spectra of modified Laplacians.

2209 **Machine Learning Approach for selecting a Signature Gene Set**
Garrett Fuselier, James Madison University
MacLean Koslowski, James Madison University
Parkinson's disease (PD) is a degenerative disorder of the central nervous system that affects motor function. Our goal is to develop a diagnostic criteria for early detection of PD based on a subject's genetic makeup. We use supervised learning methods to identify a set of genes linked to the development of PD.

2210 **Panel Session on Graduate School in Math, Stats and Math Ed**
Mike Lam, James Madison University
Zev Woodstock, NC State University
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 faculty members and grad students!

2203 **Finding Periods of Linear Recurrence Relations**
Heather Switzer, Longwood University
The goal for this research is to find an efficient algorithm to determine period lengths of the Fibonacci Sequence under modular arithmetic. These periods also known as the Pisano Period. We developed an algorithm for improving efficiency and empirically compared it to a traditional linear search.

2204 **Dynamics of red coral populations**
Hye Kim, George Mason University
Coral is an animal that plays an important role in the marine ecosystem. We analyze a discrete time model for red coral populations, which exhibits fixed points and a Hopf bifurcation, as a function of the basic reproductive number. The numerical results have been verified through computer assisted proofs.

2208 **Metrics of Gerrymandering**
Rachel Koch, James Madison University
A metric for determining the extent of gerrymandering, the Efficiency Gap (EG), is facing the Supreme Court. We analyze EG's strengths, weaknesses, and challenges to become court doctrine. We examine past court rulings and the metrics which these have spurred. Finally, we present some initial findings for a new metric.

2209 **Geometric Distribution of order r and the Stock Market**
Grace Malcom, Salisbury University
The market estimates that the daily return change of the stock market is followed by the normal distribution. After deriving the geometric distribution of order r, we used simulated and theoretical data from both distributions to prove that the normal distribution is not an accurate model for the stock market.

2210 **Panel Session on REUs and Summer Programs**
Brant Jones, James Madison University
Channing Parker , University of Pittsburgh
John Harnois, The 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!

2203 **The Sortability of Permutations under Context Directed Swaps**

Colby Brown, University of Arizona

Context Directed Swaps (CDS) is a sorting operation utilized by ciliates, single celled organisms. CDS is the most efficient of sorting operations utilizing swaps; however, not all permutations are sortable under CDS. We utilize linear algebra and graph theory concepts to determine sortability criterion.

2204 **A Differentiable Exact Approximation to Brownian Motion**

Adam Diehl, James Madison University

Brownian motion is a continuous, nowhere-differentiable random process that drives many stochastic differential equations. The Karhunen-Loeve theorem provides a differentiable approximation to this process. We present a modification of the KL transform that corrects for the error introduced by the approximation.

2208 **Variational Data Assimilation for Neuronal Network Models**

Jiajing Guan, George Mason University

Understanding neuronal networks is a great challenge. We use Fitzhugh-Nagumo model to simulate a chaotic neuronal network. Through Levenberg-Marquardt method, we assimilate the behavior given the data of a few neurons in the network and assign each neuron a condition number describing the difficulty to reconstruct.

2209 **Distributed Algorithms for Constrained NMF**

Matthew Dyer, Longwood University

Three new distributed computing algorithms were developed for constrained non-negative matrix factorization (NMF). All three algorithms were tested on a set of gene expression data. The developed algorithms were able to accurately reconstruct the original matrices with less error than standard NMF algorithms

2210 **Panel Session on REUs and Summer Programs**

Brant Jones, James Madison University
Channing Parker , University of Pittsburgh
John Harnois, The 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!

12:30 - 1:55 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.

Posters

Sortability of Permutations under Context Directed Swaps
Colby Brown, University of Arizona

Eulerian Numbers In Cryptography
Jenna Foster, Radford University

Effects of Spring Damping in a Mother Machine (♢)
Austin Fullmer, University of Houston

Using Big Data to Save Premature Babies
Joel Goddot, Virginia State University

Oncogenic pathways and iron phenotypes in breast cancer
Sergio Guerra Abril, Viktor Belay, Jacqueline Adams. and Linoy Kotler American University

Enigma: What Made The Cipher So Difficult to Break (♢)
Rebecca Journigan, Radford University

Lorentzian Geometry on Finite Dimensional Lie Algebras
Nicole Marzolf, Longwood University

Secret Sum Numbers
Max Misterka, Homeschool

OLD-sets and ID-codes of the Snub Trihexagonal Grid
Jeffrey Shi, Jamestown High School

Predicting Biofilm Dynamics with a Spatial Simulation
Aparajita Sur, William and Mary

Stability Switches of a Square Matrix
Gabrielle Tauscheck, College of William and Mary

The 3-Dimensional Heisenberg Lie Algebra
Sarah Williams, Virginia Commonwealth University

Numerical Analysis on Peakon Collisions
Zachary Zhao, Gilman School

2203 **Potential Stability of Matrix Sign Patterns**
Christopher Hambric, College of William and Mary
The study of stable matrices has several applications for understanding the long term behavior of a system. In our research, we examine irreducible matrix sign patterns, and we expand on prior results regarding the minimum number of non-zero entries necessary for such a matrix to be potentially stable.

2204 **Generalizing the Symmetric Groups as Weyl Groups**
Ethan Zell, The University of Virginia
Motivated by an investigation into cases of the Lusztig Character Formula, one can generalize the Symmetric Groups to their relatives, the Weyl Groups, in order to gain a deeper understanding of their symmetries. By the end of the talk, undergrads will have access to further resources for these questions.

2208 **Oncogenic pathways and iron phenotypes in breast cancer I**
Jacqueline Adams, American University
Viktor Belay, American University
Iron plays a major role in DNA synthesis and cell proliferation; however, it is also positively correlated with breast cancer. By expanding Dr. Chifman's time- and state-discrete mathematical model, we integrated additional biochemical pathways to understand iron regulation and its relationship to breast cancer.

2209 **Predicting Housing Prices in King County, Washington**
Orton Babb, George Mason University
We consider the prediction of housing prices using nonparametric methods centered on support vector machines (SVMs), which can generalize from training data using kernel methods, regularization and empirical risk minimization. The obtained numerical results demonstrate the accuracy and potential of the SVM paradigm.

2210 **Career and Industry Panel**
Jenny Gibson, James Madison University
Paul Boisen, Dept of Defense
Chris Campbell, 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!

2203 **The Critical Group of KG(n,2)**

Ian Hill, James Madison University

Let $KG(n, 2)$ be the Kneser graph on the 2-subsets of an n element set. We use methods stemming from the representation theory of the symmetric group and algebraic graph theory to find a cyclic decomposition of the critical group for this family of graphs.

2204 **Noise Induced Stabilization of Hamiltonian Systems**

Sarah Sparks, Frostburg State University

Noise-induced stabilization is the phenomenon in which the addition of randomness to an unstable deterministic system of ordinary differential equations results in a stable system of stochastic differential equations. We studied ways to perturb Hamiltonian systems such that noise-induced stabilization can occur.

2208 **Oncogenic pathways and iron phenotypes in breast cancer II**

Sergio Guerra Abril, American University
Linoy Kotler, American University

Continuing from part I, we encoded each node in the network using logical update rules, which translated into a polynomial dynamical system. By then simulating this system, we predicted the long-term behavior of our model under different initial conditions, which we then interpreted in the context of iron phenotypes.

2209 **Avoiding Overfitting Evolutionary Models on Time Series Data**

Curtis Lamp, Shippensburg University of Pennsylvania

We consider two evolutionary algorithms, a GA and PSO, and apply them to the Storage Location Assignment Problem (SLAP). The focus of this talk is not on the algorithms themselves but on preventing them from overfitting. We present preliminary results on quantifying the generalizability of these models to future data.

2210 **Career and Industry Panel**

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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!

2203 **Lorentzian Geometry of Lie algebras**
Nicole Marzolf, Longwood University
In this talk, we will present results related to the classification of Lorentzian scalar products on Lie Algebras. Specifically, we classify Lorentzian scalar products on a Lie algebra up to the notion of equivalence determined by changes of basis corresponding to an automorphism of the Lie algebra.

2204 **KMC Dynamics: The Evolution of Crystal Structures**
Molly Rowland, James Madison University
Michael Boyle, James Madison University
We consider a solid-on-solid atomistic model for homoepitaxial growth. Atoms evaporate from, condensate on, and diffuse (hop) across the crystal surface. Facets reflect a long-range order of the atoms on the surface. To explore the facet formation, we numerically simulate a 1-D and 2-D silicon on silicon model.

2208 **Simplicial Homology and Neural Networks**
Mark Agrios, College William and Mary
Concepts from algebraic topology applied to neural networks in understanding their function and behavior. We will look at how simplicial homology can give insight to a network's topological features and how they can dictate the dynamics of the network.

2209 **Analysis of Bank Telemarketing Data Set Using R**
Christina King, Virginia State University
Christopher Triplett, Virginia State University
In this project, we use RStudio to analyze the bank telemarketing data set and build a model to predict the success of bank telemarketing by sorting the attributes according to their impact on a client's decision of subscription to the term deposit or not.

2210 **JMU Math Connections Theatre - Integrating Math to Theatre**
Connor Kindley, James Madison University
Ellen Orie, James Madison University
Tanner Clark, James Madison University
A primary goal of the Connections Theater is to make headway in "connecting" students who might have traditionally had a negative experience, and now perception, of mathematics once again with this powerful field. We will explain our history, reflect on our previous large scale performance, and share tips for others.

3:00 - 3:15 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

Photo courtesy of St. Marys College of Maryland

Theory and Practice: Mathematics and Music

Dave Kung
St. Mary's College of Maryland

The two subjects of math and music are connected in myriad ways, from the rhythm of notes to the frequencies of the pitches. At the advanced level, both mathematical theories and music theories help us understand the other subject. In this talk, we first explore what mathematics tells us about musical instruments, the basic tools of musical practice. In the second half, we flip sides, looking at music theory and how the structure of chords gives us another way to understand topological structures (circles, Möbius strips and higher dimensional tori), some of the basic tools of mathematical practice. Thus the first half connects mathematical theory to musical practice, and the second connects musical theory to mathematical practice. Throughout, examples played on the violin will illustrate all of these beautiful and surprising connections.

All in the Family: Some Brainteasers for SUMS

Jason Rosenhouse

Here at SUMS, we like to think of ourselves as part of one big, happy, math family. So how about some puzzles about families?

1. We start with a classic: A man is looking at a painting of a second man. Gesturing to the man in the painting, he says, "Brothers and sisters I have none, but this man's father is my father's son." Who is the man in the painting? Also try Raymond Smullyan's variation, in which the man looking at the painting says, "Brothers and sisters I have none, but this man's son is my father's son." Now who is he looking at?

2. Suppose I have 1 brother and 2 sisters. My mother's parents have 10 grandchildren, while my father's parents have 11 grandchildren. If no divorces or remarriages occurred, and if none of my father's brothers or sisters married any of my mother's sisters or brothers how many first cousins do I have?

3. If each of two men marries the other's mother, then how are their sons related?

4. Jill wrote the following note to Jack: "Remember that book you lent me? Well, I lent it to my mother, and she lent it to her sister, who gave it to her son-in law, who thought his wife's maternal grandfather would like it. He did, and lent it to his wife, who gave it to her son John. Last night John dropped in and asked me to return it to his son. So here it is." How are Jack and Jill related?

5. Finally, heere's a clever one from Lewis Carroll: The governor of Whatchamacallit is hosting an exclusive dinner party. The guests include his father's brother-in-law, his brother's father-in-law, his father-in-law's brother, and his brother-in-law's father. What is the smallest possible number of guests at the party?

A Candy Puzzler

courtesy of Steve Lucas

(no relation to Edouard Lucas)

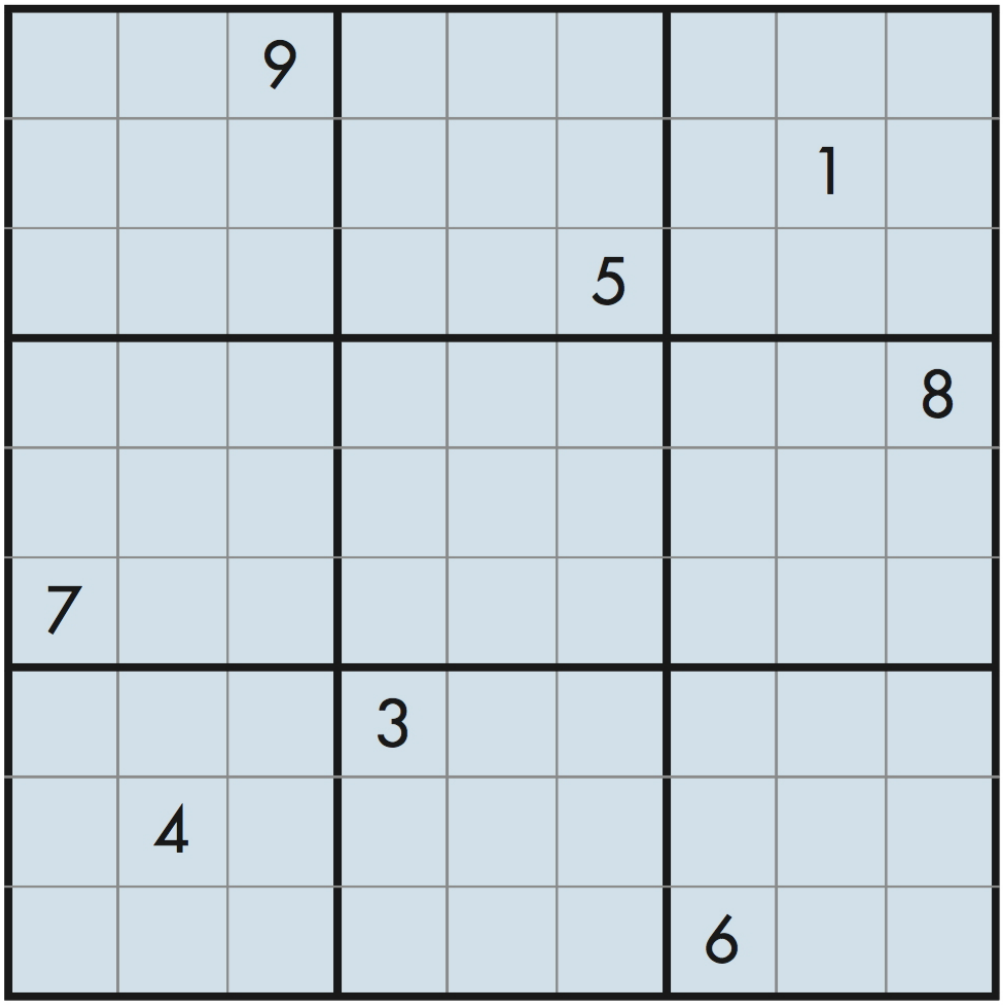
One of the most famous sequences in popular mathematics is the Fibonacci sequence, where you start with zero and one, then every number in the sequence is the sum of the previous two. The sequence was popularized by Leonardo of Pisa's text Liber Abaci (he was only known as Fibonacci, son of Bonacci, much later) of 1202, although this was only a trivial side example to his main aim of introducing positional notation to Europe in a practical way. And there is evidence that the sequence was known in India beforehand.

In any event, Fibonacci's sequence was particularly popularized by Edouard Lucas, a French mathematician who in the late 19th century generalized Fibonaccis sequence, came up with a closed form solution, and developed the underlying theory. You could develop an entire course building on the Fibonacci sequence. But today we are interested in what is today called the Lucas sequence, where you start with two and one, then every number in the sequence is the sum of the previous two.
The number of jelly beans in our bottle is the sum of two (not necessarily consecutive) numbers from the Lucas sequence.Can you find it?

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 jelly beans, with any ties broken using the distance from the center of your interval to the actual number of jelly beans. The winner will be announced in the prize session at the end of the day.

All-Magic Sudoku.

Fill in the grid so that every row, column, and block contains 1–9 exactly once. In addition, all nine of the blocks must be semimagic squares whose rows and columns add to the same number. Watch out; this puzzle is challenging and requires its own preliminary detective work about possible semimagic squares.



Taken from the book *Taking Sudoku Seriously* by Jason Rosenhouse and Laura Taalman, Oxford University Press 2012

Join us next year for SUMS 2018!
`www.jmu.edu/mathstat/sums`
Peter Kohn and Roger Thelwell