*All events are on the second floor of the JMU HHS Building*


Support for the Shenandoah Undergraduate Mathematics and Statistics Conference is provided by:

National Science Foundation grant DMS-0846477, Mathematical Association of America, Regional Undergraduate Mathematics Conferences program

James Madison University Department of Mathematics and Statistics, College of Science and Mathematics, General Education Program, Office of the Special Assistant to the President for Diversity, Office of Admissions, Pi Mu Epsilon, and Mathematics and Statistics Club

Contributions of books, puzzles, games, and other prizes came from the following generous sponsors of SUMS:

# Schedule

## 9:00-10:00 Registration and Breakfast

*2nd floor hallway*

If you have not registered online, please visit the registration table in the foyer and sign in. If you pre-registered then you can find a printed nametag at the registration table.

Poster presenters should check in to room 2201 now.

Be sure to stick around for the Prize Session at the end of the day; all talk and poster presenters will be awarded prizes at the session.

## 10:00-11:00 Opening Address

*auditorium 2301*

### *Elliptic curves: What are they and why should we care?*

Dr. Ravi Ramakrishna
Cornell University

Elliptic curves can be thought of from many points of view. Geometrically, they look like the surfaces of donuts, which are relatively straightforward objects. Arithmetically, they are extremely complex. Both the solution to Fermat's Last Theorem in the '90s and the Conjecture of Birch and Swinnerton-Dyer (one of the Clay Math Institute's million dollar problems) involve elliptic curves.

In this talk Dr. Ramakrishna will explain what it means "to look at a donut arithmetically", why other sorts of surfaces are better understood and explain relations to classical Diophantine questions going back to ... Diophantus.

Dr. Ramakrishna earned a B.A. from Cornell in 1988 and a Ph.D. from Princeton in 1992. He held postdocs at the University of Chicago and Yale University before joining Cornell. He received the Centennial Fellowship from the American Mathematical Society and has held visiting positions at UC Berkeley, Princeton University, the University of Utah and the Kigali Institute of Science and Technology. His research is in algebraic number theory. In particular he focuses on on Galois Representations, Modular Forms and the topic of his talk, Elliptic Curves.

## 11:10-11:25 Student Talks Session 1 *(choose one of five talks)*

*2203* ***Diffusion of a Chemical Pollutant Modeled By a Fourier Series***
Teresa Yao, University of Mary Washington

A presentation of Fourier series that model the diffusion of a chemical pollutant in both one-dimensional and two-dimensional regions. Original computer code was developed to calculate the concentration at any time and position and produce animated graphs modeling the diffusion of the pollutant.

*2204* ***A Combinatorial Proof of a Partition Recursive Relation***
Oleg Lazarev, Princeton University

Many identities and relations for the partition function have traditionally been proven using generating functions. We will provide an alternative combinatorial proof of a classical recursive relation for the partition function and present generalizations to the multipartition function.

*2208* ***A Stability Study of an Equilibrium Solution in an Asset-Price Model***
Arjun Sanghvi, George Mason University

A previously developed agent-based model is used to simulate the price of a financial asset. Geometric Brownian Motion is an equilibrium solution under assumptions of perfect rationality and efficiency. We numerically investigate how this solution loses stability as these assumptions are weakened.

*2209* ***Modeling the Evaporation of a Tear Film over a Contact Lens***
Kevin Talbott, George Mason University

We examine a tear film model that allows for fluid transfer through a contact lens and includes the effects of evaporation. Of interest are the effects of parameters on depletion rates of the outer and inner tear films, steady-state values, and opening rates of possible rupture.

*2210* ***Asymptotic Connectivity of Hyperbolic Planar Tilings***
Robin Neumayer, University of South Carolina

Asymptotic connectivity is a measure of overall connectivity of infinite graphs. We will study infinite graphs comprising half-planes of varying hyperbolic planar tilings and show that asymptotic connectivity is independent of the chosen basepoint for the measure. We will then characterize the behavior of such graphs in order to compute the asymptotic connectivity.

## 11:30-11:45 Student Talks Session 2 *(choose one of five talks)*

*2203* ***Using Power Series to Develop Taylor Series Coefficients and Solve Basic IVP ODEs***
Anthony Chieco, James Madison University

We will present a method to find Taylor Series coefficients by using substitutions and Cauchy products. The Taylor coefficients will be generated rapidly because the program only uses basic mathematical functions and does not take derivatives. Using these coefficients we will then see how they can solve basic initial value ODEs.

*2204* ***Characterizing B(P) for Rational Perfect Set Forcing***
Alex Srisuwan and Brad Miller, James Madison University

Since its invention by Paul Cohen, the method of forcing has revolutionized the foundations of mathematics. Among its many applications, forcing allows the study of relative consistency results related to existence of Boolean algebras. In this talk, we characterize the Boolean algebra associated with rational perfect set forcing.

*2208* ***The S&P 500, Reality vs. the Black Scholes Model***
Andrew Snyder-Beattie, University of Mary Washington

Models for pricing financial derivatives hinge upon an assumption that the price of an underlying asset follows Geometric Brownian Motion (GBM). Our statistical analysis of historical data shows that this may be a problematic assumption. We will discuss ways to reconcile the GBM model with the market in addition to offering possible alternatives to GBM.

*2209* ***The Transformation of Electrocardiogram (ECG) into Sound by Mathematical Stimulation***
Heming Zhao, Southwest Virginia Governor's School

The electrocardiogram (ECG) is an essential tool to diagnose cardiovascular diseases. The objective of this study is to transform ECG into musical sound using Mathematica. A parameterized-mathematical model is introduced to build various ECG patterns, which then are transformed into different sounds. Advantages and applications of this idea are presented.

*2210* ***Vertex Identifying Codes***
Ari Cukierman, College of William and Mary School

For a graph, $G$, a subset $D$ of the vertex set of $G$ is a vertex identifying code if for each vertex $v$ in $G$, the intersection of $D$ and the closed neighborhood of $v$ is unique and non-empty. We study codes of minimal density for the infinite hexagonal grid.

## 11:50-12:05 Student Talks Session 3 *(choose one of five talks)*

*2203* ***Numerical Power Series Solutions to Initial Value Ordinary Differential Equations***
Reginald Ford, James Madison University

We will present a powerful, adaptive Power Series (PS) method for solving differential equations. The Matlab implementation of the PS method solves a large class of differential equations and easily outperforms the best known algorithms like adaptive Runge-Kutta-Fehlberg.

*2204* ***Abelian Repetitions in Partial Words***
Dimin Xu, Bard College

We investigate that for a given $p$, what is the smallest alphabet such that there exists an infinite word with finitely or infinitely many holes and avoids abelian $p$th-powers. We also ask if we insert arbitrarily many holes into an infinite abelian $p$-free full word, whether it will remain abelian $p$-free.

*2208* ***Investigation of Technical Analysis using Agent Based Financial Model***
William Brayer, George Mason University

Standard financial models use geometric Brownian motion to simulate the evolution of an asset price. We present an alternate model. We test technical analysis and show that it produces excess returns and that herding may account for this phenomenon.

*2209* ***Modeling Molecular Docking using Optimization Techniques***
Robert Hill, George Mason University

The study of docking a molecular wire to a bacterial photosynthetic reaction center is critical in assembling photovoltaic devices. Molecular docking is driven by energy-minimization principle, so we analyze this phenomenon by building an AMPL optimization model and solving it using interior-point method and sequential quadratic optimization technique.

*2210* ***Coalitions and the Banzhaf Index***
Amanda Ketner, Elon University

The Banzhaf power index is used to measure power quantitatively among voters in politics. A modification of this index is studied using graph theory, and an application to the United States Supreme Court is discussed.

## 12:10-12:25 Student Talks Session 4 *(choose one of five talks)*

*2203* ***Backwards Ricci Flow on Some Locally Homogeneous 4-Manifolds***
Demetre Kazaras, St. Mary's College of Maryland

In this talk we examine the backward Ricci flow on some locally homogeneous 4-manifolds. In some cases, the flow can be written as a system of first order ordinary differential equations and we can describe the long time behavior. Possibly, there is convergence to a sub-Riemannian geometry.

*2204* ***Cantor Minimal systems***
Juan Carlos Ortega, James Madison University

Cantor spaces have unique properties: the purpose of our study is to investigate minimal dynamical systems on cantor spaces. We examine Kakutani equivalence and flow equivalence of the systems, and prove that they imply each other. In addition, we discuss topological conjugacy between two specific types of Cantor minimal systems, namely Denjoy systems and Sturmian subshifts.

*2208* ***Multiplicative Decremental Tag Sysems and Random Trees***
Chris Kirkland, Mercer University

In this talk, we discuss techniques which we use to analyze statistical properties of labeled, randomly generated trees produced by the Use-It-or-Lose-It algorithm. In particular, we take a graph theoretic approach to analyzing a generalization of the Decremental Tag System.

*2209* ***Computational Docking of Molecular Wires***
Byong Kwon, George Mason University

To build efficient photovoltaic devices using bacterial photosynthetic reaction centers, molecular wires (MWs) that serve as good conductors to transport electrons from and to the reaction centers are needed. We explore computational models of docking MWs to the reaction centers. Such models can help propose suitable MWs for photovoltaic devices.

*2210* ***Refinements to Traditional Electrostatic MEMS Models***
Robert Deaton and Eric Sabo, University of Delaware

Microelectromechanical systems (MEMS) suffer from a so-called "pull-in" instability which severely limits device design and operation. Here, key theoretical results concerning this instability are surveyed and compared to a new experimental study of electrostatic deflections. Gaps between theory and experiment are uncovered and various corrections to the theory are presented.

## 12:30-2:00 Lunch and Poster Session

*2nd floor hallway and foyer*

**Lunch:** Those who registered for lunches can pick them up near the registration area at 12:30. You may eat in any of our talk rooms or in the nTelos room at the end of the hall past the poster displays. At 1:00, those who did not reserve a lunch may take a box lunch if any remain.

**Poster Session:** Students will be near their posters during lunch. Stop by and see their excellent work! Poster judging will start at 1:00.

***Model development for lignocellulosic biofuels***
Amir Ahmadi, Morehead State University and Helen Vo, UC Berkeley

***Relationships between Las Vergnas, Krushkal, and Bollobas-Riordan polynomials***
Ross Askanazi, Ohio State University

***Cryptology with Mathematica***
Thawda Aung, Randolph College

***Collaborative filtering in recommender systems***
Michael Curtis, University of Maryland, Baltimore County

***Arbelos and Pappus chain***
Deepak De, Mountain Vista Governor's School

***Refinements to traditional electrostatic MEMS models***
Robert Deaton and Eric Sabo, University of Delaware

***Variation in the three-body problem***
Xuyi Guo, Harrisonburg High School

***Theory and applications of Benford's law***
Allie Lewis, University of Portland

***Forecasting***
Shonalika Mondal, Freedom High

***Lie groups via matrix groups***
Crystal Peoples, Longwood University

***Binary time series***
Arleen Rodriguez, University of California, San Diego

***On numerical models of chemical pollutant diffusion***
Erin Strange, University of Mary Washington

***The critical exponent for conventional powers of DN matrices***
Olivia Walch, College of William and Mary

***Singular value decompostion, a new approach for determining 3-D grain sizes***
Brittany A. Wilhelm, James Madison University

***The transformation of electrocardiogram into sound by mathematical stimulation***
Heming Zhao, Southwest Virginia Governor's School

***AMC Workshop****: From 2:00-3:40 a workshop on preparing for high school AMC mathematics competitions runs concurrently with the SUMS program, in room 2207, for interested high school students, parents, and faculty.*

## 2:00-2:15 Student Talks Session 5

*(choose one of six talks)*

*2203* ***Eigenvalues and Eigenvectors to Symmetric Circular Graphs***
Zhen Wei, University of Virginia

Resistor networks are analyzed using their response matrices, response matrices of several resistor networks, such as square and radial patterns have been studied. This research presents a new type of radial resistor network, and the derivation of its eigenvectors.

*2204* ***Gaussian Soap Bubbles***
Brian Tennyson and Demetre Kazaras, St. Mary's College of Maryland

This talk contains preliminary results on (and plenty of pictures concerning) the study of minimal surfaces (i.e. "soap films") in Gaussian 3-space. We will discuss generalizations of results from classical minimal surface theory, including periodic examples and surfaces of revolution.

*2208* ***Using Variations of Beta-Binomial Distributions to Investigate Robust Scoring Methods***
Christopher Kinson, Albany State University; Karen Nielsen, University of Oklahoma; and Malin Rapp-Olsson, University of Arizona

During judged competitions, how do we know that the best contestant won? Using variations of beta-binomial distributions, we model the contestants' abilities and the judges' scoring tendencies. We use Monte Carlo simulations to investigate seven scoring methods and determine which method, if any, works best for various judge panels.

*2209* ***Mechanistic Interpretation of Conventional Michelis-Menten Parameters***
Immanuel Williams, University of Maryland Baltimore County

Motivation for this work is that the Michelis-Menten model is frequently employed to interpret drug uptake data. The objective was to simulate drug uptake via a mechanistic model of a drug transporter and interprets the results in the context of the Michelis-Menten model.

*2210* ***Help! My Random Oracle is Broken!***
Gene S. Kopp and John D. Wiltshire-Gordon, University of Chicago

Alice has several finitary random oracles, but some may be miscalibrated! She knows only that a majority are functioning properly; she doesn't know which ones. Can Alice use the oracles to simulate a biased coin flip? We prove the answer: Precisely if the bias is an algebraic number!

*2202* ***Panel Session on Careers and Industry in Mathematics***
*Steve Garren, James Madison University*
*Gertrud Kraut, Southern Virginia University*
*Heather Watson, James Madison University School of Engineering*

What can you do with a math degree? What kinds of companies and institutions value mathematical talent? Find out from this panel of people with experience using mathematics outside of academia.

## 2:20-2:35 Student Talks Session 6 *(choose one of six talks)*

*2203* ***The Critical Exponent for Conventional Powers of DN Matrices***
Olivia Walch, College of William and Mary

The critical exponent for Hadamard powers of DN matrices is known to be $n$ - 2, but what about conventional powers? Verification of $n$ - 2 as the critical exponent for conventional powering is provided for $n <= 5$, and an upper limit is given for any $n$.

*2204* ***Polygons Inscribed in Conics in the Projective Plane***
Adeel Ahmad Khan, University of Maryland
and Monica Nastasescu, Princeton University

In 2009 Tabachnikov and Schwartz found by computer experimentation several interesting theorems in classical projective geometry which were similar in spirit to Pascal's theorem. We discovered algebraic geometric proofs by clever application of Max Noether's AF+BG theorem.

*2208* ***Theory and Applications of Benford's Law***
Allie Lewis, University of Portland

Benford's Law helps analyze real-life data sets, providing methods to detect abnormalities resulting from data collection errors or fraud. We apply new and old Benford tests to controversial data sets, including the 2009 Iranian election and Climategate. We also explore theoretical implications, analyzing the Weibull distribution's conformity to expected probabilities.

*2209* ***Continuation Analysis of the Diblock Copolymer Equation in One Dimension***
Ian Johnson, George Mason University

Diblock copolymers are materials formed by the reaction of two linear polymers. The diblock copolymer equation governs the formation of these polymers. We discuss continuation analysis of the equilibria of the diblock copolymer equation in one dimension, and secondary bifurcations, including apparent bifurcations from infinity.

*2210* ***Counting Radius N Hextile Knot Mosaics***
Michael Blankenship, Morehead State University

Hextile knot mosaics on square tile knot mosaics, are tessellations of hexagons containing zero to three strands that form knots and links. The focus of the presentation is on the development and implementation of a computer-based approach to determining the number of possible mosaics in any given radius.

*2202* ***Panel Session on Graduate School in Mathematics and Statistics***
*Pam Arroway, North Carolina State University*
*Ezra Brown, Virginia Tech*
*John Johnson, James Madison University and Howard University*
*Brandt Kronholm, St. Mary's College of Maryland*
*Nagaraj Neerchal, University of Maryland, Baltimore County*

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 from schools with graduate programs.

## 2:40-2:55 Panel and Student Talks Session 7 *(choose one of six talks)*

*2203* ***Multilinear Algebra and Tensors***
Will Henderson and Jeff Wyman, James Madison University

Using a novel method of order preserving tensor multiplication, we have defined several operators for this definition of tensor multiplication. We have extended several matrix decompositions to tensors, and explored their applications in video compression and facial recognition. We will discuss the implementation and construction of the operators and decompositions.

*2204* ***Solution Theory for Bilinear Systems of Equations***
Dian Yang, College of William and Mary

A system of equations is called bilinear if each of its equations has a bilinear form on the left hand side and a constant on the right hand side. Our research gives a general solution theory for bilinear systems of equations by relating them to linear systems.

*2208* ***Biologically-Based Lumping of a Quaternary Fuel Mixture***
Jamahl Stokes, University of Maryland Baltimore County

Although models predict the behavior of inhaled chemicals, the application of these models to large mixtures is often infeasible. Biologically-based lumping (BBL) provides an effective way reduce the order of a model while maintaining accurate results.

*2209* ***Mathematical Modeling of Interface-Dominated Materials Properties***
Russell Mahoney, George Mason University

Many useful materials are polycrystalline. In this talk, we show how a combination of macro- and mesoscopic tools such as the finite element microstructure analysis package OOF2 and grain growth models can be used to study the effects of grain coarsening on materials properties.

*2210* ***Investigations in Linear Algebra and Combinatorics related to Biclique Decompositions of Graphs***
Shadiyah Mangru, George Mason University

We formulate five new propositions related to the Graham-Pollak Theorem. The first four illuminate properties of biclique edge covers and matrix representations of such covers. These four propositions motivate the fifth, on the recursively-defined sparse null space basis for a particular subset of matrices of interest in Algebraic Graph Theory.

*2202* ***Panel Session on REUs and Summer Programs***
*Cory Colbert, VCU*
*Michael Curtis, UMBC*
*Allen Gehret, Univ. of MD*
*Demetre Kazaras, St. Mary's MD*
*Amanda Ketner, Elon University*
*Gene Kopp, University of Chicago*
*Crystal Peoples, Longwood University*

Want to learn more about Research Experience for Undergraduates programs and other summer opportunities in mathematics? Find out from this panel of students.

## 3:00-3:15 Student Talks Session 8 *(choose one of five talks)*

2203 ***Perfect Partitioning of Block Permutation Matrices***
Jeffrey Soosiah, College of William and Mary

Given block permutation matrices of fixed dimensions, we conjecture that the set of all such matrices can be perfectly partitioned, for any choice of dimensions and block size. We demonstrate that the conjecture holds for specific choices of the dimension with block size 2 x 2.

2204 ***Progress on the Lonely Runner Conjecture***
Christopher Horvat, University of Pittsburgh

Recently, we have demonstrated that the famous Lonely Runner Conjecture is proved for all but a set of measure zero. In this talk, we discuss these results, as well as our current progress towards a full solution, drawing influence from the field of dynamical systems

2208 ***Model Development for Lignocellulosic Biofuels***
Amir Ahmadi, Morehead State University and Helen Vo, UC Berkeley

Controversy surrounding biofuels derived from food sources has lead to the exploration of second generation biofuels. In light of current models' need of verification and further optimization, our REU group has verified and recreated past research with our own model. Our model aligns with experimental data provided by the NC State Forestry and Renewable Energy Program.

2209 ***How to Stop the Loosening Zone***
Logan Smith and Jose Aguilera, Gainesville State College

In the process of pumping viscous fluid down a borehole, one observed phenomena is the loosening of the surrounding rock, and this action makes the borehole's radius expand. The fracturing of rocks is considered to be on the base of the kinetic mechanism. In this paper we derived a formula that calculates the radius, $R$, of the loosening zone based on time, $t$.

2210 ***Relationships Between Las Vergnas, Krushkal, and Bollobas-Riordan Polynomials***
Ross Askanazi, Ohio State University

We compare polynomial invariants of graphs embedded into a surface. The Las Vergnas polynomial compares different matroids of the dual graph with the original. The Bollobas-Riordan polynomial generalizes the Tutte polynomial. The Krushkal polynomial examines the symplectic structure of the graph's embedding. We report various relationships between the three invariants.

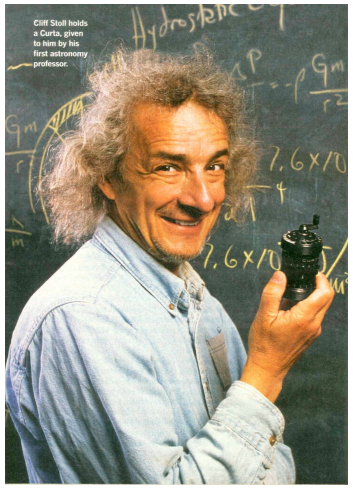
## 3:15-3:45 Afternoon Tea *2nd floor hallway*

Please join us for tea, coffee, and tasty treats in the HHS foyer. This is your last chance to enter the candy corn contest!

## 3:45-4:00 Prize Session *auditorium 2301*

After tea please join us in congratulating all of our student presenters and the winners of the poster competition and the candy corn contest.

## 4:00-5:00 Closing Address *auditorium 2301*




### *Low Dimensional Topology for Fun and Profit - or how to extract money from the 4th dimension...*

Cliff Stoll
Acme Klein bottle company

For over ten years, Acme Klein Bottle has provided nonorientable manifolds to math folk. Like much of mathematics, it's marginally profitable, but endlessly entertaining.

While thousands of computer models of the Klein Bottle grace the Internet, physical models are rarely built. Using Pyrex glass and a torch, we supply the finite but unbounded demand for one-sided, R3 immersed, zero-volume, borosilicate Riemannian manifolds.

So how do you make a Klein Bottle? Come to Cliff's talk and find out!

Although he started out as an astronomer, Cliff Stoll is best known for catching a ring of computer hackers during the early days of the Internet -- he told this story in his book, "The Cuckoo's Egg". Cliff now designs and makes Klein Bottles for math folk, along with other topological shapes.