Mathematical Association of America
MD-DC-VA Section, April 13 & 14, 2018
Washington & Lee University and Virginia Military Institute
Abstracts

Abstracts for the workshop and invited addresses are listed first, in chronological order, followed by faculty and graduate student abstracts, alphabetized by submitting presenter's last name. Student presentation abstracts follow, with student poster abstracts at the end (also alphabetized by submitting presenter's last name).

Invited Addresses

FRIDAY WORKSHOP

Michael Starbird, University of Texas at Austin

Inquiry Based Learning: Math and Beyond

4:00 PM, Room 327, W&L Huntley Hall

When students prove theorems or solve problems on their own and present their results to their peers, interesting things happen. Expected outcomes include students' developing problem-solving and theorem-proving skills and the ability to tell whether reasoning is correct or flawed. But beyond those mathematical skills, this type of experience frequently involves important consequences on students' self-reliance, independent thinking, and willingness to make mistakes.

BANQUET ADDRESS

Jason Rosenhouse, James Madison University

Why Mathematicians Can't Write

8:00 PM, Hall of Valor, VMI Marshall Hall

As mathematicians, we frequently tout the beauty of our subject. We then expect students to learn from textbooks that seem specifically designed to be dull and confusing. We are in danger of thinking that textbook authors must truly hate their subjects, to write about them with so little passion and voice. We will soberly consider, and occasionally rant angrily about, some of the problems with modern mathematical writing. Along the way we will balance the proceedings with various examples of good writing, both by and about mathematicians.

SATURDAY INVITED ADDRESSES

Michael Starbird, University of Texas at Austin

Effective Thinking Through Mathematics

9:55 AM, Gillis Theater, VMI Marshall Hall

A wondrously romantic belief is that brilliant thinkers magically produce brilliant ideas: an apple knocks out Newton and calculus appears in a fevered dream. We can enjoy fanciful fables of leaps of genius, but we should not be fooled into believing that those fables are fact. Straightforward practices of effective thinking inevitably lead to better lives for us all and occasional works called genius. No magic and no leaps are involved. Techniques of effective thinking and creativity can be taught, learned, and mastered; and mathematics provides a wonderful vehicle to convey life-changing habits of mind.

Jennifer Quinn, University of Washington Tacoma

Epic Math Battles: Counting vs. Matching

3:45PM, Gillis Theater, VMI Marshall Hall

Which technique is mathematically superior? The audience will judge of this tongue-in-cheek combinatorial competition between the mathematical techniques of counting and matching. Be prepared to explore positive and alternating sums involving binomial coefficients, Fibonacci numbers, and other beautiful combinatorial quantities. How are the terms in each sum concretely interpreted? What is being counted? What is being matched? Which is superior? You decide.

Contributed Faculty Papers by Author

Emad Abdurasul, James Madison University
Small Sample confidence bands for the survival function ACL (Abduskhurov, Cheng, and Lin) Estimators
2:50PM Mallory 211
We developed a saddle point- based method for generating small sample confidence bands for the population survival function from the ACL estimators, under the proportional hazards model. In the process, we derived the exact distribution of this estimator and developed mid-population tolerance bands for saddle-point estimators. Our method depends upon the Mellin transform of the zero-truncated survival estimator. This transform is inverted via saddle point approximation to yield a highly accurate approximation to the cumulative distribution function of the respective cumulative hazard function. This distribution function is then inverted to produce our saddle point confidence bands. Then we compared our saddle point confidence bands with those obtained from competing large sample methods as well as with those obtained from the exact distribution. In our simulation study, we found that the saddle point confidence bands are very close to the confidence bands derived from the exact distribution. In addition to being close, it is easier to compute, and it outperforms the large sample methods in terms probability convergence.
Content Area: Non-parametric
Recommended for Students: Yes

Abdinur Ali, Norfolk State University
Chung-Chu (George) Hsieh, Norfolk State University
Mushtaq Khan, Norfolk State University
Machine Learning algorithms for Malware Detections
9:00AM Mallory 414
It is becoming almost impossible to detect new polymorphic computer viruses using the traditional detection techniques. These viruses keep changing their signatures from one execution instance to the next one. Therefore, it is paramount to use machine learning algorithms which can learn from experience. In this simulation, we applied machine learning algorithms to malware data sets. Then, we assessed the precision of those learning algorithms. In this paper, we will cover estimation techniques and probabilistic learning. This material is based on research sponsored by the Office of the Assistant Secretary of Defense for Research and Engineering (OASD(R&E)) under agreement number FAB750-15-2-0120.
Content Area: Applied Mathematics
Recommended for Students: Yes

Joseph Anderson, Salisbury University
Convex Geometry in Algorithms for Heavy-Tailed Statistics
8:10AM Mallory 414
Traditional algorithmic approaches to statistical learning problems rely on mean, covariance, and higher-order statistical properties to study the structure of data. However, many modern applications of machine learning encounter data that exhibits heavy-tailed behavior, where one may no longer be able estimate a mean or covariance. We demonstrate new techniques to overcome this barrier by borrowing tools from classical convex geometry and apply them in the context of signal processing and basis recovery. The result is provably-efficient algorithms at the intersection of geometry, optimization, and statistical machine learning.
Content Area: Geometry, optimization, machine learning
Recommended for Students: Yes

Moa Apagodu, Virginia Commonwealth University
Elementary Proof of Congruences Involving Sum of Binomial Coefficients
3:15PM Mallory 211
We provide elementary proof of several congruences involving single sum and multisums of binomial coefficients.
Content Area: Combinatorics/Number Theory
Recommended for Students: Yes

Abstracts

Frank Barnet, Frostburg State University
The Construction and Use of Stereo Anaglyphs in the Teaching of Multivariable Calculus
8:10AM Mallory 212
Many topics in multivariable calculus can be better illustrated and enlivened with the use of stereo anaglyphs. In this session I introduce a Mathematica package that constructs anaglyphs from Mathematica 3D graphics, and show how I have used those stereo images in explaining topics such as Lagrange multipliers and the curl of a vector field to my calculus students. Participants in this talk will be provided with anaglyph glasses so that they can enjoy the stereo images and animations that will be shown.
Content Area: Mathematica graphics, multivariable calculus, anaglyphs
Recommended for Students: Yes

Neal Bushaw, Virginia Commonwealth University
Daniel W. Cranston, Virginia Commonwealth University
Bootstrap Percolation on Polygon Tilings of the Plane
8:10AM Mallory 412
We consider bootstrap percolation in tilings of the plane by regular polygons. First, we determine the percolation threshold for each of the infinite Archimedean lattices. More generally, let T denote the set of plane tilings t by regular polygons such that if t contains one instance of a vertex type, then t contains infinitely many instances of that type. We show that no tiling in T has threshold 4 or more. This material is self-contained, and requires no particular background. We'll share many open problems, as well as the intuition behind these results.
Content Area: Combinatorics, Graph Theory
Recommended for Students: Yes

Melanie Butler, Mount St. Mary's University
A heuristic for student-led mathematical discussion on an assigned reading
2:25PM Mallory 212
This talk will give details on a heuristic that students can use to engage in a student-led discussion of a mathematics reading. The goal of the heuristic is to help students learn to generate their own discussion on a mathematics reading by supplying templates for statements and responses as well as a structure for the discussion itself.
Content Area: Teaching
Recommended for Students: Yes

David Carothers, James Madison University
Mathematics Teacher Preparation in the new CUPM Curriculum Guide
8:10AM Mallory 213
The 2015 Curriculum Guide from the MAA Committee on the Undergraduate Program in Mathematics (CUPM) includes recommendations for the preparation of high school mathematics teachers. There are a number of changes from previous CUPM reports that if implemented would have significant implications for mathematics major programs. We will review portions of the CUPM report regarding coursework for future teachers and discuss possible paths forward for both large and small institutions. We hope to save some time for discussion among any who are interested in cooperation across the section in revising content and approaches in existing courses as well as the need for developing new courses.
Content Area: mathematics education
Recommended for Students: Yes

David Clark, Randolph-Macon College
Why I love teaching Intro Stats (now)
8:35AM Mallory 212
Despite its objective curricular and societal importance, Intro Stats was the first class I hated to teach. The emphases on building histograms and computing correlation by hand, and finding p-values using back-of-the-book tables seemed all wrong. And why delay p-values and hypothesis testing — the fundamental concepts of basic inferential statistics — until the end of the course? The list of complaints goes on. Thankfully, Nathan Tintle and his team offer an appealing and user-

friendly alternative in their new textbook, which approaches inference using simulation-based techniques rather than theory. Their non-traditional take on Intro Stats has changed my world; I have drunk the Kool Aid, and want to at least offer you a cup.
Content Area: Statistics Education
Recommended for Students: Yes

John David, Virginia Military Institute
New MAA SPORTS SIGMAA
9:25AM Mallory 119
This year a new SPORTS SIGMAA was approved by the MAA board of directors. One of the early goals of this SIGMAA is to foster connection in the mathematical community in this subfield on both the research and pedagogical sides. Projects in this area are generally accessible to undergraduates and make great tools in the classroom, outreach and in capstone situations. In addition the analytical skills learned in this area translate well to workforce or graduate studies. This SIGMAA wants to offer resources and support to mentors and students pursuing work in this area including project creation, completion, presentation and publication. In addition to describing the SIGMAA's work and goals, I will describe personal work in support of this goal.
Content Area: Sports, Mentoring, Pedagogy
Recommended for Students: Yes

Ming Fang, Norfolk State University
A Modified Fixed Point Problem
8:35AM Mallory 414
In this talk we will first derive a modified fixed point problem E[x]=E[f(x)], where E is an expectation operator and f is a nonlinear operator, x is a random variable. The fixed point iteration schemes will be presented through Monte Carlo method and Gauss–Hermite quadrature.
Content Area: Numerical Analysis, Probability
Recommended for Students: Yes

Greg Hartman, Virginia Military Institute
Open Source Textbooks & an APEX Calculus Update
2:50PM Mallory 213
The open source textbook movement has grown rapidly over the past few years. In this talk, an overview will be given on the motivation behind using open texts, where to find them, new innovations available and how/why to create your own. Additionally, an update on the status of the open source APEX Calculus project will be given, about which several talks have been given at our Section meetings in the past.
Content Area: Math Education
Recommended for Students: Yes

Steven Hetzler, Salisbury University
Products of Series: What Can We Know?
2:50PM Mallory 413
While the evaluating the product of two convergent infinite series is generally an intractable problem, certain special cases are interesting. The purpose of this talk is to present properties of some of these products, and to suggest associated problem sets for use in Calculus 2, Discrete Math, or Real Analysis courses.
Content Area: Calculus, Infinite Series, Discrete Math, Real Analysis
Recommended for Students: Yes

Dan Kalman, American University
Generalized Fibonacci Numbers Revisited
9:00AM Mallory 413
A lovely result about difference equations, derived by linear algebra methods, gives the kth term of the solution to a

constant coefficient difference equation under two assumptions: (1) the roots of the characteristic polynomial are distinct, and (2) the initial terms are 0, 0, ... , 0, 1. In this talk I will show how this result can be extended to arbitrary initial terms.
Content Area: Linear Algebra, Difference Equations
Recommended for Students: Yes

Kelli Karcher, Virginia Tech
Proofreading in Discrete Math: Common Misconceptions vs Serious Logical Fallacies
9:25AM Mallory 212
How do we engage our students in writing clear, concise, and well-structured proofs? Is it enough to provide careful definitions and well-constructed examples in class? We will discuss ways of providing careful analysis and feedback for student solutions during class via proofreading and how such critiques lead to productive theoretical discussion and faster mastery of the subject matter.
Content Area: Math Education
Recommended for Students: Yes

Mitchel T. Keller, Washington and Lee University
PreTeXt: One Input, Many Beautiful Outputs
3:15PM Mallory 213
In this talk, we will take a look at some of the features of PreTeXt (formerly MathBook XML), which is a language designed for authors to be able to use a master source file to produce a variety of output formats. A PreTeXt source file marks up the structure of the document (theorems, proofs, exercises, examples, figures, etc.) using an XML syntax that may remind users of HTML, but with a total focus on structure and not presentation. Mathematical expressions in the source are marked up using LaTeX notation. Support for including a variety of interactive elements in the document is available, with additional interactive features planned. While most existing PreTeXt projects are book-length, the system is now mature and stable enough that interested individuals are encouraged to use it for developing materials for their courses, regardless of whether they might eventually develop into a larger project.
PreTeXt source files are easily converted to HTML that looks good on both desktops and mobile devices and LaTeX for producing print versions. A conversion from PreTeXt to the EPUB format used by Apple's iBooks is almost ready for release, and a PreTeXt to Kindle conversion will follow shortly. The speaker is the author of one open-source text written in PreTeXt (Applied Combinatorics with W.T. Trotter) and co-editor of the PreTeXt edition of Bogart's Combinatorics through Guided Discovery (with Oscar Levin and Kent E. Morrison) and is a core member of the group guiding further development of PreTeXt.
Content Area: Mathematical writing/publishing
Recommended for Students: No

Robb Koether, Hampden-Sydney College
Iterating the Locker Problem
3:15PM Mallory 119
In the well known Locker Problem, 1000 lockers are numbered 1 to 1000 and 1000 students are numbered 1 to 1000. For each k, student k is instructed to reverse the state of every locker door that is a multiple of k. If all 1000 students do this, which lockers will be left open? We will consider iterating this process. At each iteration, we send exactly those students whose lockers were left open on the previous iteration. We will develop a formula involving bitwise operations that will tell whether door d will be left open on iteration n. An immediate consequence is that the sequence repeats itself fairly quickly, after the number of iterations is a relatively low power of 2.
Content Area: Number Theory
Recommended for Students: Yes

M. Leigh Lunsford, Longwood University
Transitioning from the Finite to the Infinite in the Hilbert Space l^2
8:10AM Mallory 413

Compactness in finite dimensional Euclidean space (i.e. R^n) guarantees that one can pack at most a finite number of closed balls of radius r, 0<r<1, into the closed unit ball. This is true no matter how small the value of r. In the Hilbert space l^2 ("little L 2") this does not apply. Interestingly, it is not hard to show that you can pack at most two balls of radius ½ into the closed unit ball of l^2 but if the radius is small enough, for instance ¼, then you can pack infinitely many balls into the unit ball. Thus, as you decrease from a radius of ½ to a radius of ¼ you will reach a value where packings radically change. This value is a boundary for an abrupt transition from the finite to the infinite in l^2. What is this number and can we prove it has this property? Attend this talk to find out!
Content Area: Analysis
Recommended for Students: Yes

Nicholas Martin, Shepherd University
A new way to solve linear homogeneous ODE's with constant coefficients
2:25PM Mallory 414
The paper presents a new, elementary, and self-contained method to solve linear homogeneous ODE's with constant coefficients. The method is very elementary, a simple algebraic device that finds all solutions without guessing them first. Knowledge of single variable calculus is sufficient to understand the method, some familiarity with linear systems of equations helps.
Content Area: Differential Equations
Recommended for Students: Yes

Caroline Melles, US Naval Academy
p-ary bent functions and strongly regular Latin square type graphs
8:35AM Mallory 412
Bent functions over a finite field can be thought of as maximally non-linear functions. They can be defined using Fourier transforms, but can also be described by the combinatorics of their level sets, by the parameters of certain associated Cayley graphs, and by the algebra of the adjacency matrices of these graphs. For the Boolean (p = 2) case, Dillon discovered a simple combinatorial condition for a function to be bent. In graph-theoretic terms, a Boolean function is bent if and only if its Cayley graph is strongly regular with feasible Latin square or negative Latin square type parameters. Dillon's theorem does not generalize in an obvious way to primes p > 2. The Cayley graphs associated with a bent p-ary function are not necessarily strongly regular. We prove a generalized Dillon-type theorem in the other direction, giving graph-theoretic conditions which guarantee that a p-ary function is bent. We also show how to construct such bent functions from orthogonal arrays. These results are joint work with David Joyner.
Content Area: Combinatorics, graph theory
Recommended for Students: Yes

Roland Minton, Roanoke College
The Sausage Catastrophe and Other Fun Facts
8:35AM Mallory 119
What can be done with important or wonderfully bizarre but not so important mathematical tidbits that do not fit into standard undergraduate mathematics courses? One answer is a "fun fact" given as a break partway through each class period. The benefits of this technique and some of my favorite fun facts and puzzles will be discussed.
Content Area: Mathematics Education
Recommended for Students: Yes

Galamo Monkam, Morgan State University and Bowie State University
On Composition of Power Series
3:15PM Mallory 413
A formal power series is actually the sequence of its coefficients. The composition of formal power series is eventually, or can only be, determined by their coefficients. We first investigate the coefficients of $f^n(x)$ if $f(x)$ is a formal power series. Of course, mathematical induction or the multinomial coefficients can be used to initiate the investigation of the coefficients of $f^n(x)$. We are going to show that the k-th coefficient of $f^n(x)$ mainly depends on a_0. The discovery of a

new recurrence relation will lead to the new proof of the composition of formal power series which were first introduced in 2001 by Dr. Xiao-Xiong Gan.
Content Area: Analysis
Recommended for Students: Yes

Edwin O'Shea, James Madison University
Which came first: Abraham Lincoln's chicken or Euclid's egg?
2:25PM Mallory 119
Abraham Lincoln "studied and nearly mastered" Euclid's Elements "since he was a member of Congress." We wish to pinpoint one part of geometry's influence on Lincoln by studying a fragmentary document on tariffs dating from his time as a representative-elect. We claim this document on tariffs is good evidence of one of two positions: Either geometry influenced Lincoln's political thought (the egg came first) or, young Lincoln's rhetoric style primed his path to Euclid as a tool to perfect his arguments (the chicken came first). Either way, the chicken and egg have a substantive relationship.
Content Area: Geometry, History
Recommended for Students: Yes

Marcus Pendergrass, Hampden-Sydney College
A Math And Music PechaKucha
9:00AM Mallory 119
I will present a short PechaKucha on mathematics and music, accompanied by a soundtrack of mathematically-generated original music, followed by open discussion. What is a PechaKucha? What is mathematics? What is music? Let's discuss!
Content Area: Mathematics and Music
Recommended for Students: Yes

Adrian Rice, Randolph-Macon College
Partnership, Partition, and Proof: The Path to the Hardy-Ramanujan Partition Formula
2:50PM Mallory 412
This year marks one hundred years since the publication of one of the most startling results in the history of mathematics: Hardy and Ramanujan's asymptotic formula for the partition function. To celebrate the centenary, this paper looks at the creation of their remarkable theorem: where it came from, how it was proved, and how the assistance of a third contributor helped to influence its ultimate form.
Content Area: History of mathematics
Recommended for Students: Yes

Robert Sachs, George Mason University
The i road to higher mathematics -- results from the current first implementation
9:25AM Mallory 213
A new variant of a transitions / proofs course is being taught this semester for the first time. The central theme is the complex extensions of familiar objects, mostly polynomials and basic transcendental functions. I will describe some of the results thus far in terms of student learning and attitude.
Content Area: Teaching
Recommended for Students: Yes

Charles Samuels, Christopher Newport University
Metric Mahler measures over number fields
2:25PM Mallory 412
For an algebraic number α, the metric Mahler measure $m_1(\alpha)$ was first studied by Dubickas and Smyth in 2001and was later generalized to the t-metric Mahler measure $m_t(\alpha)$ by the author in 2010. Later results of Jankauskas and the author ensure that $m_t(\alpha)$ is fairly well-understood when $\alpha \in \mathbb{Q}$. We present an analog of those results when α belongs to a number field K, taking a particular interest in the case where K has class number equal to 1.
Content Area: Number Theory

Recommended for Students: No

Bonita Saunders, NIST
NIST's Digital Library of Mathematical Functions and the Digital Age
3:15PM Mallory 212
One of the most cited mathematical references is the National Bureau of Standards Handbook of Mathematical Functions first published in 1964. The NBS Handbook, also called Abramowitz and Stegun, for the editors, contained informative formulas, graphs and tables to assist mathematicians and physical scientists who needed special mathematical functions for their everyday work. In 2010 an updated and expanded version of the handbook was released as a web-based compendium called the Digital Library of Mathematical Functions (DLMF). This talk looks at the digital features outlined in a recent Physics Today paper that show how the DLMF uses the power of the web to offer much more support to researchers. Work on new chapters and expansions of current chapters will also be discussed.
Content Area: Special Functions
Recommended for Students: Yes

Joseph Slagel, Virginia Tech
Linear Algebra Done Lazily
8:35AM Mallory 413
Solving linear systems can be such arduous work! What if instead of inverting the whole coefficient matrix to solve a linear system, we looked at one constraint (one row) at a time? What a delightfully lazy approach! Of course, there can be a price to such a lazy scheme...
Content Area: Linear Algebra
Recommended for Students: Yes

Mohammed Talukder, Elizabeth City State University
Risk Factors for Having Obesity
8:35AM Mallory 211
The purpose of this study is to analyze the risk factors for having obesity. Obesity is a condition in which the natural energy reserve, stored in the fatty tissue of humans and other mammals, exceeds healthy limits, and also can be defined as high proportion of body fat. It has become a growing issue in the United States, which is the highest rated nation of obesity in the world, having one hundred twenty-seven million overweight people. About sixty million adults, or thirty percent of the adult population, are now obese, which represents a doubling of the rate since 1980. During the past decade, the sharpest increase of seventy percent in rates of overweight and obesity occurred among the ages eighteen through twenty-nine. The rate of obesity continues to grow year by year. I used the program SPSS, Statistical Package for the Social Sciences, to analyze the data. The response obese or non-obese, is a binary or dichotomous. In this study logistic regression model was developed to estimate the odds ratio (with confidence interval) of the risk factors, such as gender, age, and cholesterol. Also, the likelihood ratio test was performed to test the significance of the risk factors.
Content Area: Statistics, Logistic Regression
Recommended for Students: Yes

Student Abstracts by Author

Hanna DeMeester, Shenandoah University
The Statistical Difference in Coach and Athlete Perceptions of Physical and Mental Demand During a Collegiate Season
9:25AM Mallory 211
The research conducted during this study was performed as an interdisciplinary collaboration between the Exercise Sciences and Mathematical Sciences Departments at Shenandoah University. The purpose of this research was to assess the difference between a Field Hockey coach and her athletes perception of physical and mental demand of practice and training, while also examining the difference of the coach's pre-practice intention and their post-practice perception of

the difficulty of practice. This study was conducted as an applied statistics course where knowledge acquired in previous Introduction to Statistics and Advanced Statistics courses was used to determine the proper tests to perform. The data was collected using a sliding scale model from both the coach and players on the Field Hockey team. To determine the tests to be used, we had to gauge what kind of data was desired by those within the Exercise Science Department and what exactly they wanted their data to determine. The data was carefully cleaned and organized in order to be analyzed and was analyzed using multiple Paired Samples T-Tests and the General Linear Model for Repeated Samples. The analyzed data allowed for conclusions to be drawn about whether or not the systematic planning of athletic or physical training was successfully being implemented and understood between the coach and athletes.

Jennifer Erbach, Shenandoah University
Is the Relative Use Factor Adaptable As Well As Useful?
2:50PM Mallory 212
Collection and circulation analysis is a process librarians use to evaluate their collections and make decisions, regarding those collections, in response to those evaluations. The goal of this research is to determine if the Relative Use Factor (RUF) technique is applicable in settings other than middle school libraries, as it was designed. Understanding the limits of the RUF allows librarians to understand when it is appropriate to apply it. Research by K. Gavigan, is the basis for the research project and first introduces the RUF technique as an analysis tool for Graphic Novel Collections in Middle School Libraries. This research project studies the Relative Use Factor to decide if it is a viable analysis method of an entire library, instead of just 1 topic area, and if it applicable across all secondary libraries, not just middle school libraries. Data was collected from a number of schools in the Winchester, Virginia area and analyzed using the RUF. For comparison purposes, the RUF was used to evaluate the Smith Library at Shenandoah University, as an example situation where the technique is obsolete, due to the academic focus of the library. Initial results indicate that the RUF is a viable tool but has limitations, such as distinguishing between a popular subject area in a library or a particular book that is popular among the students.Results and methods from this project could be expanded to include analyzing its effectiveness in non-academic libraries such as the Public Library system or Private Corporate Libraries.

Shannon Haley, University of Mary Washington
Non-commutative Massey-Omura Encryption with Symmetric Groups
2:25PM Mallory 413
We introduce two non-commutative variations on the original Massey-Omura encryption system using conjugations in the symmetric group S_n. Patented in 1986, the original system was based on the cyclic group $F^*$of units in a finite field F. In place of the abelian group F^*, we will work in the non-abelian group S_n using disjoint permutations as well as maximal abelian subgroups in order to potentially create a more secure system. Introducing the non-abelian group S_n presents the need to create a keyspace of commuting permutations and abelian subgroups of sufficient size. We analyze the security of our modified systems by examining the bit-level security of each ad susceptibility to standard message attacks. Additionally, we find that the keycount for the first system grows factorially with *n*. We show that the keycount for the second variation grows exponentially with *n* while improving on the first modification by allowing any number of users to participate in communication.

Jamee Hood, Muhlenberg College
Food Waste at Muhlenberg College
9:00AM Mallory 211
This research addresses food waste in Muhlenberg College's dining hall from a statistical perspective. Food waste is a growing issue in the United States, in which 30% to 40% of food supply gets discarded, according to the USDA. Colleges' and universities' dining halls are a unique place to explore this topic in that they have the capacity to feed thousands of students for every meal. This study utilizes quantitative and qualitative data collected through observational studies to investigate how much food is wasted, where it is wasted (pre-consumer versus post-consumer), and why. Ultimately we are able to calculate the environmental and economic costs of this waste and make recommendations to Muhlenberg on how to reduce food waste in the dining hall.

Abstracts

Spirit Karcher, Christopher Newport University
Prime Factors and Divisibility of Sums of Powers of Fibonacci Numbers
3:15PM Mallory 412
The Fibonacci sequence, which is generated using the recursive formula $\mathrm{F_{n+2}} = \mathrm{F}_{n+1} + \mathrm{F_n}$ with $\mathrm{F}_1 = \mathrm{F}_2 = 1$ is one of the most famous integer sequences because of its fascinating mathematical properties and connections with other fields such as biology, art, and music. In this paper, we will examine patterns in the prime factors of sums of powers of Fibonacci numbers. For example, $\mathrm{F}_{3n+4}^2 + F_{3n+2}^2$ is even for all $\mathrm{n} \in \mathbf{N_0}$. To do this, we will use techniques from modular arithmetic and facts about the divisibility of Fibonacci numbers. These techniques can then be applied to predict patterns for other powers and prime factors of sums of Fibonacci numbers.

John Kent, Shenandoah University
Using the Coupon Collector's Problem to Analyze Randomized Bundling in Magic: the Gathering
8:10AM Mallory 119
For over 20 years, Magic: the Gathering has dominated the collectible card game world, and millions have experienced the thrill of tearing open a pack of cards to see what is inside. This style of purchasing through randomized bundles has endured for trading cards and is now prevalent in other mediums such as video games. Examples include Overwatch and Dota 2, where in-game cosmetic items like weapon models or character outfits can be purchased in "treasures" or "loot boxes" with unknown, randomized contents. In these virtual worlds where resale or trading may be limited, how can a consumer have a firm idea of values for items that can't be directly bought or sold? This research project builds upon Robert A. Bosch's Optimal Card-Collecting Strategies for Magic: The Gathering examining Magic: the Gathering using the "Coupon Collector's Problem" framework, via a simulation of opening packs of these cards to complete a collection. Bosch's work focused on purchasing strategies for obtaining one copy of each card, where this program incorporates mixed probabilities, treats subsets of cards as complete collections, and varies the number of copies desired to examine the purchases required to obtain different types of collections. In cases where repeated purchasing of bundled items is the only way to obtain them, the expected value of bundles purchased multiplied by the price per bundle can be thought of as the price of a collection. In this way these results are essentially "prices" for collections of cards ,and this framework could be applied to any such bundle with well-defined probabilities with adjustments to appropriate parameters. Analysis in this manner could further understanding of the real cost of a collection for an individual or a population.

Rachel Koch, James Madison University
Metrics of Gerrymandering: Quantifying Intent
2:50PM Mallory 119
A metric for determining the extent of political gerrymandering, called the Efficiency Gap (EG), has faced the Supreme Court of the United States (SCOTUS) this year. We will analyze EG's strengths, weaknesses, and the challenges it may face when it is scrutinized by the Court. We will also examine past SCOTUS rulings pertaining to partisan gerrymandering and the suggestions made the Court for future plaintiffs. Finally, we present some initial findings for a new metric, the power of a vote, which focuses on the political power of the individual instead of the political power of the party. The power of a vote works to quantify intent in redistricting decisions, and capitalize on Justice Kennedy's assertion that gerrymandering is a violation of the First Amendment.

Ian Miller, St. Mary's College of Maryland
A Combinatorial Argument in a Packing Problem
9:00AM Mallory 412
How many regular tetrahedra can share a vertex without overlapping? It is known that 20 can and 23 cannot but it is unknown whether 21 or 22 can. Intuition tells us that any packing of 21 or 22 tetrahedra would be asymmetric. We introduce a combinatorial argument which formalizes this asymmetry to make a statement about local behavior.

Ben Rhodes, James Madison University
Solving Numerical PDEs: Finite Element Methods and deal.ii
3:15PM Mallory 414
The Poisson Equation is a staple in the world of partial differential equations and a perfect building block to discover how

finite element methods are used to solve partial differential equations. We will first go over a basic one-dimensional abstract finite element method problem to get an intuitive sense of how it works, before moving on to the more complex higher-dimensional cases, where we get a glimpse of the deal.ii finite element method software. We will demonstrate the power this software has to offer in regards to solving the Poisson Equation as well as many other partial differential equations, and show examples/applications in the real world.

Bailey Stewart, University of Mary Washington
The Disadvantages of Implementing Symmetric Groups in Zero-Knowledge Protocols
9:25AM Mallory 413
After summarizing the standard zero-knowledge proof over Z_n, we examine how to adapt the protocol to an arbitrary symmetric group S_n. We then show that there is an efficient attack on this new zero-knowledge protocol in which an attacker may always successfully impersonate an honest prover. Finally we discuss how removing the requirement that all elements be invertible leads to a monoid version of our protocol that is not susceptible to the same attack.

Cameron Stopak, James Madison University
Divisibility Tests Beyond the Integers
9:25AM Mallory 412
Divisibility tests in the Integers are an ancient method of testing whether one Integer divides another. We will summarize the results of others on what are called Summing and Trimming divisibility tests. These results are extended to general Euclidean Domains with special attention to the Gaussian Integers.

Andrew Tomassone, James Madison University
Brendan Armani, James Madison University
Andrew Levy, James Madison University
An Implementation & Analysis of the Singular Value Decomposition Applied to Image Compression
2:50PM Mallory 414
This talk will cover an analysis of the Singular Value Decomposition (SVD) applied to image compression. We developed a Java applet, using the Java swing package and JAMA (Java matrix library) to produce a GUI that can load in an image and use the SVD algorithm decompose the image and produce all possible rank-deficient approximations, allowing the user to save any approximation that they desire. We used a set of (reasonably) random images obtained from the web to analyze the proportion of singular values needed for any given image to produce a seemingly indistinguishable rank-deficient approximation.

Vasily Vasilyev, Shenandoah University
Facility Location Problem: Research for Placing an IKEA Warehouse
9:25AM Mallory 414
The facility location problem is a technique used by business to optimally place facilities to minimize transportation costs. The facility location problem was defined and studied in the 17th century offering a geometric solution by Fermat-Weber. Studying facility location problem has many applications in mathematics, economics, physics, and engineering; it covers different aspects that vary in complexity from single-stage, single-linear, single- product, uncapacitated, deterministic and non-linear probabilistic models. This research reviews the brief history of the facility location problem, factors included in the problem, and a model for solving a specific example of the FLP, placing an IKEA warehouse in an optimal location. The goal is to minimize the cost, as determined by the availability and the price of the land, of placing warehouse in one of the locations that would serve five IKEA stores. Using Excel, this research optimizes the cost of the facility location based on variables like distance from warehouse to the stores and the fixed cost of the location placement. A correct solution would benefit IKEA by cutting down costs of facility maintenance and supply ordering. This research offers a single optimal solution with the shortest optimal distance from all of the store locations and minimal cost based on the price of the land. To obtain optimal solution, this model can adapt other factors in the form of constraints like the interstate roads access, population of the city, human capital availability, capital limits, etc.

Isaac Woods, Christopher Newport University

Stochastic Modeling of the IR Spectra of Nitrate Ions in Atmospheric Particles

2:25PM Mallory 211

We attempt to model the IR spectra of nitrate ions in water using continuous time markov chains and Monte-Carlo simulations. The model considers nitrate in a bound and unbound state resulting in a two state model. These two states describe the kinetics within a reverse micelle, which atmospheric chemists use to study atmospheric particles. Simulations are then compared to experimental data resulting in extensions of our model to include other factors such as pH.

Special Discussion Sessions Sponsored by the MD-DC-VA IBL Consortium

These special discussion sessions will be lead by Mitch Keller (Washington and Lee University), Amy Ksir (US Naval Academy), and Cassie Williams (James Madison University).

IBL Chat (for current users of Inquiry-Based Learning and related pedagogies)

8:35AM Mallory 213

How are things going in your classes? What issues are coming up? What successes would you like to share? This session is intended as a chance for us to connect with each other and share ideas.

IBL Activity Swap

9:00AM Mallory 213

One of the biggest hurdles instructors face when thinking of adopting Inquiry-Based Learning is finding good materials. Many instructors end up writing their own. If you've written an activity that you like and are willing to share, we encourage you to bring copies! We will share some of our own favorites, and suggestions for where to find more.

Inquiry-Based Learning Q&A (for those new to IBL, or just curious about it)

2:25PM Mallory 213

How does it work? How do you assign grades? What do you do if...? Bring your questions, and we will have a panel of experienced IBL instructors share their answers.