# Mathematical Association of America
# MD-DC-VA Section, November 17 & 18, 2017
# Christopher Newport University
# 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. Undergraduate Student presentation abstracts follow also alphabetized by submitting presenter's last name.

## Invited Addresses

### FRIDAY WORKSHOP

**Elizabeth Burroughs, Montana State University**

***The MAA's Instructional Practices Guide: Making Use of a New Resource***

**4:00 PM Luter 372**

The MAA Instructional Practices Guide is a companion guide to the 2015 CUPM Guide to Undergraduate Programs in the Mathematical Sciences. The IP Guide focuses on three core practices: Classroom Practices, Assessment Practices, and Course Design Practices. The guide is in draft form, preparing for release in 2018. This workshop will provide an overview of the contents of the guide and an opportunity to examine some of its recommendations in depth.

### BANQUET ADDRESS

**David Kung, St. Mary's College of Maryland**

***The Power of Mathematics Teaching in an Age of Alternative Facts***

**8:00PM DSU Ballroom**

Most citizens spend years in our mathematics classes before they ever cast a vote. Are we preparing them to be responsible, informed participants in a thriving democracy? What mathematics is required to understand current events, critically examine issues of social and economic justice, and properly evaluate public policy proposals? What can educators who teach mathematics do to fight back against the rise of alternative facts? We will discuss example problems, student projects, and pedagogical choices that push us in the direction of a more just world.

### SATURDAY INVITED ADDRESSES

**Francis Su, Harvey Mudd College**

***The Geometry of Cubes***

**9:45AM McMurran Hall 101**

Cubes are one of the simplest geometric objects. Or are they? I will ask some basic questions that show how cubes are connected to many other mathematical ideas. Some are recent discoveries by undergraduates.

**James Sellers, Penn State University**

***Revisiting What Euler and the Bernoullis Knew About Convergent Infinite Series***

**2:05pm McMurran Hall 101**

All too often in first-year calculus classes, conversations about infinite series stop with discussions about convergence or divergence. Such interactions are, unfortunately, not often illuminating or intriguing. Interestingly enough, Jacob and Johann Bernoulli and Leonhard Euler (and their contemporaries in the early 18th century) knew quite a bit about how to find the *exact* values of numerous families of convergent infinite series. In this talk, I will show you two sets of *exact* results in this vein. The talk will be accessible to anyone interested in mathematics, so bring a friend!

## Contributed Faculty Papers by Author

**Abdinur Ali, Norfolk State University**
**Chung-Chu(George)Hsieh, Norfolk State University**
**Mushtaq Khan, Norfolk State University**
***Malware Analysis with Finite Ordered Trees***
**11:05AM Luter 242**
Today, cost and severity of computer security breaches are on the rise. The detection models are continuously updated in order to keep up with these new cyber-attacks. Virtual Machines provide a powerful approach to scrutinize security weaknesses of computer systems. In our framework, we will illustrate the benefits of using virtual simulations in order to understand the corresponding real world domain. In this paper, we simulated compromised machines in a virtual environment. Compromised computers can be linked as a collection of botnets and can be utilized to attack other computers. In particular, these models solve the problem of finding efficiently the intricate behaviors and presence of malicious Codes. 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

**Emad Abdurasul, James Madison University**
***Small Sample Confidence Intervals for the Kaplan-Meier Estimators under the Proportional Hazards Model***
***3:40PM Luter 170***
We develop a saddlepoint- based method for generating small sample confidence bands for the population survival function from the Kaplan-Meier (KM) estimators, under the proportional hazards model. In the process, we derive the exact distribution of this estimator and develop mid-population tolerance bands for saddlepoint estimators. Our method depends upon the Mellin transform of the zero-truncated survival estimator. This transform is inverted via saddlepoint 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 saddlepoint confidence bands. Then we compare our saddlepoint 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 saddlepoint confidence bands are very close to the confidence bands derived from the exact distribution. In addition being close, it is easier to compute, and it outperforms the large sample methods in terms probability convergence.

**Brian Bradie, Christopher Newport University**
***On a weighted sum of Fibonacci numbers***
**4:05PM Luter 137**
Benjamin, Neer, Otero and Sellers (Fibonacci Quarterly, August 2003) investigated the sequence

$$a_n = \sum_{k\geq 1} \frac{k^n F_k}{2^{k+1}}$$

each of whose terms is defined as an infinite series comprised of weighted Fibonacci numbers $F_k$. They provided a probabilistic interpretation for $a_n$ developed an exponential generating function for the sequence, and outlined a procedure for obtaining a closed form expression for $a_n$. Here, the closed form of Benjamin, et. al., is simplified, producing a finite length sum of weighted Fibonacci numbers. Next, a different closed form expression for $a_n$ is developed, again in the form of a finite length sum of weighted Fibonacci numbers. Several generalizations of the original sequence are considered.
Content Area: Integer sequences
Recommended for Students: Yes

**Maila Brucal-Hallare, Norfolk State University**
***Wave-like entire solutions to lattice differential systems with a single defect***
**11:30AM Luter 242**
We explore the traveling wave problem of one-dimensional lattice differential systems in case the medium over which the

solution propagates has a single defect. Consider

$$(1)\ \dot{u}_j = d_{j+1}(u_{j+1}-u_j)+d_j(u_{j-1}-u_j)+f(u_j),\ j\in Z,\ t\in R$$

where f is a bistable nonlinearity. If the coupling coefficients $d_j$ satisfy $d_j = d$, then we obtain the one-dimensional lattice Nagumo

$$(2)\ \dot{u}_j = d(u_{j+1}-2u_j+u_{j-1})+f(u_j),\ j\in Z,\ t\in R.$$

It is known that for a sufficiently large diffusion $d > 0$, there is a traveling wave solution to (2). Here, we would like to extend the result when we have a single defect in the diffusion coefficients, namely $d_j = d$ for all $j \neq 0$ and $d_j = d_0$. Using a super-solution and a sub-solution, we will show that there is a wave-like time-global solution to (1) that is close to the traveling wave solution to (2).

Content Area: Differential Equations
Recommended for Students: No

**Hongwei Chen, Christopher Newport University**
***On a New Integer Sequence***
**11:30AM Luter 137**
The derangement sequence defined by the recurrence relation $d(n) = (n-1)\big(d(n-1) + d(n-2)\big)$ has been studied extensively. In this talk, we introduce a sequence satisfying $a(n) = (n-2)a(n-1)a(n-2)$, and find the closed form and asymptotic expression. We also discuss some open questions related to this sequence.
Content Area: Discrete Math
Recommended for Students: Yes

**Ashlee Edwards, Old Dominion University**
***Traveling Salesman Problem: Around the Globe***
**4:05PM Luter 242**
The Traveling Salesman Problem is a difficult and well-known optimization problem in which the salesman starts at a Home city and visits a number of other cities before returning home, while trying to minimize distance/cost. We explore the TSP on a sphere with three fixed cities and a variable Home point, and characterize optimal circuits in the case where the tree cities are vertices of an equilateral triangle.
Content Area: Math Modeling, TSP, Optimization
Recommended for Students: Yes

**Ming Fang, Norfolk State University**
***Efficient Frontiers with Personal Preference***
**8:50AM Luter 242**
In this talk we will first review the celebrated Markowitz Mean-Variance Optimization. Then we will use two different ways to demonstrate how to take personal preference (risk aversion or tolerance) into the consideration of portfolio construction.
Content Area: Financial Mathematics
Recommended for Students: Yes

**Susan Goldstine, St. Mary's College of Maryland**
***Knitting Symmetries: Preliminary Needling***
**8:50AM Luter 170**
In the past year or so, I've been taking a deep dive into the symmetry structure of different types of knitting. Here, we will take a look at my current understanding of what symmetry types are represented in different traditional forms of knitting to different levels of approximation.

There will be lots of pretty pictures and real live knitting, and prior knowledge of knitting or group theory is NOT required to enjoy and learn from this talk.
Content Area: Symmetry groups, mathematical art, knitting
Recommended for Students: Yes

**Marshall Gordon**
***Revisiting "The Problem of Learning to Teach"***
**8:50AM Luter 264**
This paper revisits "The Problem of Learning to Teach" that appeared in the Monthly around 40 years ago offering a perspective in response to that foundational concern. In particular, the recent focus on how to promote students' mathematical thinking is making great strides. In so doing, in addition to presenting problem-solving techniques students can learn problem-clarifying strategies to help them proceed when no clear path is obvious.
Content Area: Mathematical thinking; mathematics education
Recommended for Students: No

**Spencer Hamblen, McDaniel College**
***Mastery-Based Grading in Intro to Proofs***
**3:15PM Luter 170**
The day before the beginning of the Spring 2017 semester, I decided to rewrite the syllabus and completely change my Introduction to Proofs course to incorporate mastery-based grading. This talk will discuss the process of using mastery-based grading for the first time, and ponder whether it was a good idea.
Content Area: Pedagogy
Recommended for Students: No

**Brian Heinold, Mount St. Mary's University**
***Exercises for a Numerical Methods Course***
**11:05AM Luter 264**
I have taught Numerical Methods several times now, and each time I have mostly created my own exercises. This talk will contain a large sampling of those exercises, which are different from what is typically found in textbooks. Some of them test conceptual understanding in interesting ways, some are reviews of forgotten calculus material, and many involve technology like spreadsheets and Python.
Content Area: Teaching, Numerical Methods, General
Recommended for Students: Yes

**Alathea Jensen, George Mason University**
***Self-Polar Polytopes***
**3:40PM Luter 137**
A self-polar polytope is a self-dual polytope that is equal to a reflection or rotation of its own polar set. These polytopes were introduced by Lovasz (1983) as a means to address the chromatic number of distance graphs on the sphere. They can also be used to generate graphs with large chromatic number which are triangle-free. This talk focuses on basic questions regarding these polytopes, such as when a self-dual polytope can be realized as self-polar, how these polytopes can be constructed, their facial
structure, and algebraic properties of their indicator functions.
Content Area: Combinatorics
Recommended for Students: Yes

**Brant Jones, James Madison University**
***An easy proof of quadratic reciprocity for an undergraduate number theory course***
**8:50AM Luter 137**
There are many proofs of quadratic reciprocity. In this talk, we present one which we believe deserves to be better known. It relies on a simple counting argument and reinforces the use of the Chinese Remainder Theorem.
Content Area: number theory

Recommended for Students: Yes

**Chris Lee, Roanoke College**
***Mastery Based Testing – An Introduction and Observations from Implementation in a Variety of Levels of Mathematics Courses***
**11:30AM Luter 264**
For the last two years at Roanoke College a handful of faculty in mathematics have been successfully experimenting with the implementation of Mastery Based Testing (MBT) in classes. In this presentation I will provide an introduction to MBT and present observations and data from this current semester during which I'm using MBT in four different courses with student cohorts ranging from general education statistics students to upper-level mathematics majors. Special attention will given not just to the mechanics of Mastery Based Testing, but more importantly to the importance of how the idea is described and presented to students. Additionally, current research plans comparing effectiveness and acceptance among different student groups will be discussed.
Content Area: Scholarship of Teaching and Learning in Mathematics
Recommended for Students: Yes

**Jack Love, George Mason University**
***Stable Limits of Polygon Spaces***
**3:15PM Luter 137**
We study moduli spaces of polygons, taking as our starting point the work of Millson on polygons in $\mathbf{R}^2$ and $\mathbf{R}^3$, and the work of Farber and Fromm on polygons in higher dimensions. We define the stable limit of polygons spaces and the diagonals map on this limit.
Content Area: Topology, Geometry, Combinatorics
Recommended for Students: Yes

**Sara Malec, Hood College**
***Continued Fractions and Semigroup Generators***
**11:05AM Luter 142**
Special kinds of polyhedral cones in $\mathbf{R}^d$ have a Hilbert basis, which is a minimal generating set for the semigroup of the lattice points within that cone. In $\mathbf{R}^2$, these Hilbert bases can be computed using a specific continued fraction decomposition related to the bounding rays of the cone. We investigate certain cases of these cones and their related Hilbert bases, and relate them to the generating sets of algebraic structures known as intersection algebras, which capture information about how the intersections of powers of ideals grow.
Content Area: Commutative Algebra
Recommended for Students: Yes

**Alex Meadows, St. Mary's College of Maryland**
***Vennim!***
**3:40PM Luter 142**
Vennim is a variant of the game Nim in which players may take from more than one pile, based on a Venn diagram. It can also be visualized as playing on a simplicial complex. We discuss some basic ideas of games and strategies and some basics that we know about Vennim.
Content Area: Combinatorics, Game Theory
Recommended for Students: Yes

**Matthew A Morena, Christopher Newport University**
***Signature Functions for Predicting Resonant and Attenuant Population Cycles***
**3:40PM Luter 242**
Periodic environments are commonly observed in nature and are known to enhance or suppress populations. We study the responses of two competing, discretely-reproducing populations to periodic fluctuations in four parameters. We take a special interest in the case where the two species are very similar, as might happen after a mutation occurs in a species. We prove that small, 2-periodic forcing in the parameters support 2-cyclic oscillations of the populations. We

then develop signature functions for predicting the responses of the populations to these periodic environmental fluctuations. Periodic environments are favorable for the total biomass, and for each individual species, if the corresponding signature function is positive, but are deleterious when a corresponding signature function is negative. As a demonstration, we apply our results to several two species population models that include the Logistic, Ricker, and Beverton-Holt models.
Content Area: Population biology
Recommended for Students: Yes

**Stephen Morse, George Mason University**
***In-place Excel Macros for Gauss Elimination***
**3:15PM Luter 264**
In-place Excel Macros are presented that enable interactive row-by-row and column-by-column pivot selection and reduction to REF and RREF. Students select pivots, interact by selecting matrix arrays, and rapidly proceed step-by-step to the desired form. Macros are also presented that enable construction of particular solutions and of a set of basis vectors for the null space.
Content Area: Introductory Course in Linear Algebra (teaching)
Recommended for Students: Yes

**Minah Oh, James Madison University**
***Grad, Curl, and Div on Axisymmetric Domains***
***4:05PM Luter 269***
A three-dimensional problem defined on an axisymmetric domain, a cylinder or a coke bottle for example, can be reduced to a sequence of two-dimensional problems. In this talk, we will see how the grad, curl, and div operators arising from such dimension reduction continue to be closely related by constructing a sequence of exact sequences. We will also discuss applications of axisymmetric problems as well.
Content Area: Calculus, Functional Analysis, Numerical Analysis
Recommended for Students: Yes

**Christina Osborne, University of Virginia**
***Old and new chain rules***
**11:30AM Luter 142**
One of the first tools we learn in a calculus class is the chain rule, which tells us how to compute the derivative of a composition of functions. In the 1800s Faa di Bruno proved a formula for taking the nth derivative of a composition of functions. More recently, in 2005 Huang, Marcantognini, and Young provided a new formula for the derivative of a composition of functions by defining a new tool: the nth directional derivative. The nth directional derivative is inspired by the directional derivative that one encounters in multivariable calculus. Furthermore, the nth directional derivative has a chain rule of its own. Throughout this talk we will explore the construction and connections of these chain rules.
Content Area: Calculus
Recommended for Students: Yes

**Cherng-tiao Perng, Norfolk State University**
***Gordan, Ville, and von Neumann's Minimax Theorem***
**8:50AM Luter 142**
This talk aims to give a simple but self-contained introduction to von Neumann's minimax theorem.
Content Area: Linear algebra, optimization theory, game theory
Recommended for Students: Yes

**Alice Petillo, Marymount University**
***Just-in-time remediation for Liberal Arts classes***
**3:40PM Luter 264**
Background and Rationale: Remedial education has been the focus of renewed interest. California policymakers have advocated eliminating high-stakes placement tests and non-credit remedial classes. The IES National Center for Education

Statistics report for Remedial Coursetaking at U.S. Public and 4 Year Institutions found that the remedial math students compared unfavorably in terms of completion of college math credits with non-remedial students.

There are different models for math remediation at the university level. The presenter has developed a model of including remediation in an existing college-level class at Marymount University (MU). Using data from previous cohorts of students from 2007-2011 the presenter investigated whether there are differences in the 6-year graduation rate based on whether or not students took remedial math classes at MU and what type of remedial math class was taken.
Content Area: Mathematics Undergraduate Education
Recommended for Students: No

**Heather Rollins, University of West Florida**
***A Walk through the Garden: Open Problems***
**3:40PM Luter 269**
Looking for a research topic? Want a fresh problem to play with? The Open Problem Garden website has a collection of mathematical conjectures of varying difficulty and importance.

In this session, we'll walk through OpenProblemGarden.org, check out all the options for finding conjectures open and closed, and even select a problem to explore on our own. Maybe you'll find inspiration for yourself or one of your students!
Content Area: General, Research
Recommended for Students: Yes

**Jason Rosenhouse, James Madison University**
***Lewis Carroll on Solving Sorites***
**11:05AM Luter 170**
Given two categorical propositions, it is rarely difficult to determine what, if anything, follows from them. For example, from, "All cats are mammals," and "All mammals are animals," you quickly conclude that, "All cats are animals." But what if you wish to determine what follows from more than two categorical propositions? With four or more propositions, this is too difficult for most people to do in their heads. Problems involving numerous categorical propositions are often referred to as ``sorites puzzles,'' which is the Greek word for ``heap.'' In the late 1800s, Lewis Carroll (better known as the author of the Alice books) devoted considerable attention to such puzzles, and devised several methods for solving them. We shall consider these methods, and we will relate them to other concerns of 19th century British logic. We will also discuss Carroll's considerable merits as a mathematical expositor.
Content Area: Logic, Recreational Mathematics
Recommended for Students: Yes

**Bob Sachs, George Mason University**
***The i road to higher mathematics -- promoting inquiry as part of mathematical maturity***
**8:50AM Luter 269**
This coming spring I will pilot an alternative version of our Transitions/Proofs course centered on complex numbers and functions. There is a lot of beautiful and significant mathematics, some of which is hard to find elsewhere in the undergraduate curriculum. Moments where student inquiry is natural will be highlighted.
Content Area: undergraduate education and curriculum
Recommended for Students: Yes

**Ryan Shifler, Salisbury University**
***Curve Neighborhoods of the Odd Symplectic Grassmannian***
**11:05AM Luter 137**
The odd symplectic Grassmannian IG:=IG(k, 2n+1) parametrizes k dimensional subspaces of $\mathbb{C}^{2n+1}$ which are isotropic with respect to a general (necessarily degenerate) symplectic form. The odd symplectic group acts on IG with two orbits, and IG is itself a smooth Schubert variety in the submaximal isotropic Grassmannian IG(k, 2n+2). A curve neighborhood is the closure of the union of all rational curves of degree d in IG that meet a given subvariety X in IG. There are only a small number of explicit curve neighborhoods calculated combinatorially in IG. Even with limited calculations, curve neighborhoods were used to prove a Chevalley formula in the equivariant quantum cohomology of IG. I will discuss the

known calculations of curve neighborhoods in IG.
Content Area: Combinatorial Algebraic Geometry
Recommended for Students: Yes

**Daniel Showalter, Eastern Mennonite University**
***Improving retention of underrepresented STEM majors through embedded tutoring***
**3:15PM Luter 269**
Retention among STEM majors is low nationwide, but particularly among underrepresented students of color and first generation college students. EMU is in the second year of a project designed to train faculty and employ embedded tutoring with the goal of better supporting STEM majors. I will overview the project and share some of the preliminary findings and challenges, especially with regards to the tutoring component.
Content Area: Mathematics Education
Recommended for Students: Yes

**Laura Taalman, James Madison University**
***Math as Design Engine: Leveraging mathematics to create 3D printed art***
**11:30AM Luter 170**
Mathematicians have a powerful secret universe to draw from when creating 3D-printable designs. In this talk we'll discuss how software like Grasshopper, OpenSCAD, Structure Synth, and TopMod can be used to turn mathematical knots, curves, polyhedral wireframes, and procedurally generated forms into 3D printed jewelry, housewares, and art. We will also display printed pieces from the collection at mathgrrl.com/hacktastic/designs.
Content Area: Mathematical Art and Design
Recommended for Students: Yes

**David Taylor, Roanoke College**
***Classroom Stats: Spice Up Your Classroom with Fun, Live, Data Collection and Analysis***
**9:15AM Luter 269**
Studies show that students are more engaged in a statistics class when the data being used is personal, either because the data supports a cause they care about or because it is about them. In this talk, we demonstrate a new, free, mobile application and website for teaching statistics that allows instructors to collect data (via fun, small, games), run experiments, and instantly analyze the results in front of the class. Instructors and students can also download the raw data to use in other statistics software such as MINITAB, R, and SPSS. The benefits of using the Classroom Stats system is that it eliminates the tedious process of manually collecting and recording data from students, and it allows the instructor to design and run meaningful experiments to teach statistical inference. We demonstrate how to use this application for both descriptive and inferential statistics along with our experience using it in the classroom.
Content Area: Statistics Education
Recommended for Students: No

**Zheng Tong, Christopher Newport University**
***Equilibrants of Matrices***
**3:15PM Luter 142**
In 1975, Hoffman introduced the concept of equilibrant in his paper "Linear G-Function". Hoffman showed a formula to calculate the equilibrant.In 1976, Johnson in his paper "An Inequality for Doubly Stochastic Matrices", stated and proved one of his theorems.In 1982 and 1991, Johnson discussed the relationship between M-matrices and nonnegative matrices in his paper " Inverse M-matrices" and his book "Topics in Matrix Analysis". Hoffman gave the definition and formula of equilibrants of matrices, till today, no any numerical techniques to be shown. How to find the equilibrants by numerical methods is a new research field. In 2011, Dr. Johnson and I proved some theorems in our paper "Equilibrants, semipositive matrices, Calculation and Scaling", and we also find the numerical method for compute the equilibrants.
Content Area: linear algebra
Recommended for Students: No

**Bruce Torrence, Randolph-Macon College**
***Finding Fibonacci with Engel's Stochastic Abacus***
**11:30AM Luter 269**
In the early 1970s Arthur Engel developed what he later called the "stochastic abacus," a conceptual tool which allows grade school children to calculate probabilities in an absorbing Markov chain with rational transition probabilities, simply by moving chips along the edges of a directed graph. His paradigm has been widely studied since the mid-1980s, and is now called a "chip-firing" algorithm, or an "abelian sandpile" method. Using techniques of elementary discrete mathematics, we will explore how Engel's algorithm can be employed to study a variety of "pass-the-buck" games, where the players' winning probabilities are known to be closely connected to the Fibonacci and Lucas numbers. We will also demonstrate an interactive Mathematica interface, allowing students to explore and make discoveries with the stochastic abacus.
Content Area: Probability and Combinatorics
Recommended for Students: Yes

**Eve Torrence, Randolph-Macon College**
***Platonic Hypar Zonohedra***
**11:05AM Luter 269**
A pleated hypar is made by folding paper to form an origami model that approximates a hyperbolic paraboloid. The term hyparhedra was coined by Erik Demaine, Martin Demaine, and Anna Lubiw in their 1999 Bridges Conference paper in which they give an algorithm for making paper sculptures based on the Platonic solids from hypars folded from square paper. By experimenting with rhombic paper I have created more symmetric versions of some of the Demaine et al models. Several of these sculptures have been exhibited in Bridges Conference Art Exhibitions.
In this talk I will explore the possibility of building more complex hypar zonohedra by using different shapes of rhombic paper to model a variety of polyhedra with rhombic faces.
Content Area: Geometry, Math and Art, Origami
Recommended for Students: Yes

**Ana Vivas-Barber, Norfolk State University**
***Implications of Media Coverage on the Dynamics of Influenza Transmission***
**4:05PM Luter 142**
The spread of the transmission of human infectious diseases has not only been associated with biological aspects, but also with social variables. In this work the role of media coverage on the dynamics of the influenza spread is analyzed. An epidemiological model with seven compartments is presented—assuming that media coverage can be modeled by a function which has direct implications with the transmission rate of influenza. The basic reproduction number was evaluated, as well as multiple stability results for the free disease equilibrium point. Furthermore, numerical simulations were performed with the hope that the results can be used as a control method in order to avoid the influenza outbreak.
Content Area: Epidemiology, Dynamical Systems, ODEs
Recommended for Students: Yes

## Undergraduate Student Abstracts by Author

**Nathan R Carrington, Virginia State University**
**Advisor: Bourama Toni**
***Game-Theoretical Analysis for Networked Systems***
**9:15AM Luter 137**
This article will introduce fundamental concepts of game theory, its applications, and tools used in solving networked engineering games. The goal is to use game-theoretical analysis to solve problems encountered in networked systems. We first present classical examples of matrix and strategic games to get familiar with the core concepts of game theory. Matrix and strategic games are both considered static and have certain limitations when attempting to model certain network issues. Later, we expand and go into more depth with game theory by shifting focus to dynamic (i.e. bio-

inspired) games. These bio-inspired games more closely resemble problems that arise in networks in real-time. Using this approach allows entities within a game to observe outcomes of previous games and respond accordingly, which is not possible in static games. In the future, this method of analysis can be used to model the inter-relationships within a network that is functioning in real time.

**Jessica Dixon, Washington College**
**Advisor: Gabriel Feinberg**
***Coxeter Groups, Dyck Paths and the Catalan Numbers***
**9:15AM Luter 142**
The Catalan numbers are a sequence of numbers counting many types of mathematical objects. Among these objects are Dyck paths and the fully commutative elements in the Coxeter group A_n which is isomorphic to the Symmetric group. It turns out that the number of fully commutative elements in the Coxeter group A_n with Coxeter length k is the same as the number of Dyck paths with semilength n and the speak statistic, the sum of the peak heights minus the number of peaks equal to k. We explored a bijection between the Dyck paths, and the fully communitive elements of Coxeter groups in which certain statistics were preserved. This led us to a recurrence relation counting the number of Dyck paths with speak statistic k and semilength n after devising a method to combine two smaller Dyck paths to create a larger one in a predictable and useful way.

We also looked at another Coxeter group, D_n in hopes to find a similar bijection between the fully commutative elements and some combinatorial object. Although we found no such bijection, we learned more about the structure and organization of the fully communitive elements. We followed previous work that categorized an important subset of the Coxeter group D_n, and connected them to Catalan's triangle. By carefully studying the underlying structure of these symmetries, we were able to refine the organization and the combinatorics.

**Brae Fletcher, Virginia State University**
**Advisor: Bourama Toni**
***Game Theory***
**9:15AM Luter 170**
Game theory is the mathematical study of interactions between multiple "players". A game is an interactive situation with at least one player, where each player has a set of actions, known as their strategy, and a utility or payoff that is not only dependent on their own action, but also on the actions of the other players. An important aspect of game theory is the concept of the existence of a Nash Equilibrium (NE). Nash Equilibrium is a point, or strategy, for every player that will give that player the best payoff, given that the actions of the other players remain the same. The topic of game theory covers a wide spectrum of branches and applications. The most common branch of game theory is strategic form games. Strategic form games provide a way to analyze the strategic interactions in multi-agent environments. In this presentation, I will give an example of a newer branch of game theory, evolutionary game theory. In evolutionary game theory, players and their matrix games are used to explain and predict the evolution of species, to see which traits have the potential to continue on and which traits will die off.

**Michael Wallace, U.S. Naval Academy**
**Advisor: David Ruth**
***Innovations to increase the power of state-of-the-art graph-theoretic two-sample statistical tests***
**9:15AM Luter 242**
One of the classic problems in statistics is to determine whether a group of observations can be characterized as statistically different from some other group. In the case of the well-known two-sample t-test case, observations are univariate and underlying probability distributions are normal (or in practice, approximately normal). However, in real-world problems the number of covariates may be very large and there may be little known about underlying distributions. Finding powerful tests for group differences in this general multivariate case presents challenges. Recent developments in the area of nonparametric statistics and graph-theoretic tests offer novel solutions to these types of problems. In this research, we aim to improve upon existing methods by exploring the tradeoffs between graph density, test power, and computational costs in a variety of scenarios and recommending guidelines for edge-counting criteria.

# Abstracts

**Isaac Woods, Christopher Newport University**
**Advisor: James Kelly**
***Chaotic Dynamics in a Family of Set-Valued Functions***
**9:15AM Luter 264**
We explore the topological dynamics of a family of set-valued functions introduced by W. T. Ingram in 2015. We focus on two particular properties associated with chaotic behavior: Devaney chaos and the specification property. We show that for certain parameters, the function exhibits both forms of chaos. We also discuss interesting patterns that arise in the periodic points.

**Matvey Yutin, George Mason University**
**Advisor: Matt Holzer**
***Spectral Analysis of the Graph Laplacian on Homogeneous Trees***
**4:05PM Luter 264**
The Graph Laplacian is a fundamental operator of graphs, and its eigenvalues or spectrum are useful in many fields. Eigenvalues are computationally intensive to find for large graphs, but the spectrum is well-known for certain classes of infinite graphs. We truncate infinite graphs using the Dirichlet boundary condition. We prove that the eigenvalues of the Graph Laplacian for finite homogeneous trees under the Dirichlet condition are within the $\ell^2$ spectrum for their infinite counterparts.