# MAA Student Chapters

The MAA Student Chapters program was launched in January 1989 to encourage students to continue study in the mathematical sciences, provide opportunities to meet with other students interested in mathematics at national meetings, and provide career information in the mathematical sciences. The primary criterion for membership in an MAA Student Chapter is "interest in the mathematical sciences." Currently there are approximately 550 Student Chapters on college and university campuses nationwide.

# Pi Mu Epsilon

Pi Mu Epsilon is a national mathematics honor society with 338 chapters throughout the nation. Established in 1914, Pi Mu Epsilon is a non-secret organization whose purpose is the promotion of scholarly activity in mathematics among students in academic institutions. It seeks to do this by electing members on an honorary basis according to their proficiency in mathematics and by engaging in activities designed to provide for the mathematical and scholarly development of its members. Pi Mu Epsilon regularly engages students in scholarly activity through its *Journal* which has published student and faculty articles since 1949. Pi Mu Epsilon encourages scholarly activity in its chapters with grants to support mathematics contests and regional meetings established by the chapters and through its Lectureship program that funds Councillors to visit chapters. Since 1952, Pi Mu Epsilon has been holding its annual National Meeting with sessions for student papers in conjunction with the summer meetings of the Mathematical Association of America (MAA).

# Schedule of Student Activities

### All events are at the Portland Marriott Downtown Waterfront

**Wednesday, August 5**

| | | |
|---|---|---|
| 2:00 pm - 4:00 pm | CUSAC Meeting | Douglas Fir |
| 4:30 pm - 5:30 pm | MAA/PME Student Reception | Columbia (Lobby L) |
| 6:00 pm - 7:15 pm | Math Jeopardy | Salon I |

**Thursday, August 6**

| | | |
|---|---|---|
| 8:30 am - 11:30 am | PME Council Meeting | Salmon Room |
| 8:30 am - 10:25 am | MAA Session #1 | Portland Room |
| 8:30 am - 10:25 am | MAA Session #2 | Eugene Room |
| 8:30 am - 10:25 am | MAA Session #3 | Medford Room |
| 8:30 am - 10:25 am | MAA Session #4 | Salem Room |
| 8:30 am - 10:25 am | MAA Session #5 | Salon B |
| 9:00 am - 5:00 pm | Student Hospitality Center | Exhibit Hall |
| 1:00 pm - 1:50 pm | MAA Lecture for Students | Salon E |
| 2:00 pm - 3:55 pm | PME Session #1 | Medford Room |
| 2:00 pm - 3:55 pm | PME Session #2 | Salem Room |
| 2:00 pm - 3:55 pm | MAA Session #6 | Portland Room |
| 2:00 pm - 3:55 pm | MAA Session #7 | Salon B |
| 4:20 pm - 6:15 pm | PME Session #3 | Medford Room |
| 4:20 pm - 6:15 pm | PME Session #4 | Salem Room |
| 4:20 pm - 6:15 pm | MAA Session #8 | Portland Room |

**Friday, August 7**

| | | |
|---|---|---|
| 8:30 am - 10:25 am | MAA Session #9 | Eugene Room |
| 8:30 am - 10:25 am | MAA Session #10 | Salon B |
| 8:30 am - 10:25 am | PME Session #5 | Medford Room |
| 8:30 am - 10:25 am | PME Session #6 | Salem Room |
| 8:30 am - 10:25 am | PME Session #7 | Portland Room |
| 9:00 am - 5:00 pm | Student Hospitality Center | Exhibit Hall |
| 1:00 pm - 1:50 pm | MAA Student Activities Session: A Look at Dissection Puzzles | Mount Hood |
| 1:00 pm - 1:50 pm | MAA Student Activities Session: Secrets of Mental Math | Salon E |
| 2:00 pm - 4:55 pm | MAA Session #11 | Salon B |
| 2:00 pm - 4:55 pm | PME Session #8 | Medford Room |
| 2:00 pm - 4:55 pm | PME Session #9 | Salem Room |
| 6:30 pm - 8:00 pm | PME Banquet and Awards Ceremony | Mount Hood |
| 8:00 pm - 8:50 pm | J. Sutherland Frame Lecture | Oregon Ballroom Salons E & F |
| 9:00 pm - 10:00 pm | MAA Ice Cream Social and Awards | Salon I |

**Saturday, August 8**

| | | |
|---|---|---|
| 9:00 am - 2:00 pm | Student Hospitality Center | Exhibit Hall |
| 9:30 am - 10:00 am | MAA Modeling (MCM) Winners | Mount Hood |
| 1:00 pm - 2:15 pm | Student Problem Solving Competition | Mount Hood |

# J. Sutherland Frame Lecture

## The Mathematics of Perfect Shuffles

**Persi Diaconis**
Stanford University

Magicians and gamblers can shuffle cards perfectly (demonstrations provided). Understanding what can (and cannot) be done with shuffles leads to math problems, some beyond modern mathematics. The math is also useful for describing all sorts of computer algorithms.

*The J. Sutherland Frame Lecture is named in honor of the ninth President of Pi Mu Epsilon, who served from 1957 to 1966 and passed away on February 27, 1997. In 1952, Sud Frame initiated the student paper sessions at the annual Pi Mu Epsilon meeting, which is held at the Summer MathFests. He continually offered insight and inspiration to student mathematicians at these summer meetings.*

# MAA Lecture for Students

## MATHEMAGIC WITH A DECK OF CARDS ON THE INTERVAL BETWEEN 5.700439718 AND 80658175170943878571660636856403766975289505440883277824000000000000

**Colm Mulcahy**
Spelman College

Some unavoidable coincidences  as well as some truly surprising ones  will be explored as we survey $21^{st}$ century mathemagical creations/entertainments with a deck of cards, touching on topics in combinatorics, algebra, and probability.

# MAA Undergraduate Student Activities Sessions

## Chop-chop! A Look at Dissection Puzzles

**Travis Kowalski**
South Dakota School of Mines and Technology

*Mount Hood*

An activity that investigates the mathematics of popular dissection puzzles, the Tangram and the Stomachion being the chief pair that come to mind. There are a number of interesting mathematical problems that arise from these puzzles - what Tangram constructions are convex? What is the solution to Archimedes' Stomachion puzzle? - that students can investigate while working - even building their own - with tangrams/stomachion games.

## Secrets of Mental Math

**Arthur Benjamin**
Harvey Mudd College

*Salon E*

Dr. Arthur Benjamin is a mathematician and a magician. In his entertaining and fast-paced performance, he will demonstrate and explain how to mentally add and multiply numbers faster than a calculator, how to memorize 100 digits of $\pi$, how to figure out the day of the week of any date in history, and other amazing feats of mind. He has presented his mixture of math and magic to audiences all over the world.

## MAA Student Speakers

| Name | School | MAA Session |
|---|---|---|
| Jairo Aguayo | California State University-Fullerton | 9 |
| Darren Allen | Southwestern University | 2 |
| Rene Ardila | The City College of New York | 1 |
| Christianna Hazel Brown | Metropolitan State College of Denver | 10 |
| Greg Burnham | Princeton University | 5 |
| Elena Caffarelli | Canisius College | 11 |
| Robert Castellano | SUNY Stony Brook | 7 |
| Jacqueline Chalmers | Augustana College | 10 |
| Ming Wei Chang | Augustana College | 11 |
| Rachel Cranfill | Harvey Mudd College | 5 |
| Samantha Dahlberg | Grand Valley State University | 3 |
| Isaak Daniels | Augustana College | 10 |
| Shubham Debnath | University of Minnesota-Twin Cities | 7 |
| Derek DeSantis | California State University Channel Islands | 2 |
| Dallas Duckett | Pepperdine University | 5 |
| John Ensley | Shippensburg High School | 5 |
| Dillon Ethier | Clarkson University | 6 |
| Timothy Ferdinands | Calvin College | 3 |
| Marek Fikejz | Gainesville State College | 2 |
| Stephen Foster | Southwestern University | 2 |
| Kyle Golenbiewski | Grand Valley State University | 8 |
| Alma Rosa Gonzalez | Sonoma State University | 3 |
| Laura Graham | Brigham Young University | 6 |
| Kevin Greimel | Winona State University | 2 |
| William Nathan Hack | Armstrong Atlantic State University | 6 |
| Kaitlyn Hellenbrand | University of Wisconsin - Eau Claire | 1 |
| Aniya Henry | Pepperdine University | 5 |
| Jason Holloway | Clarkson University | 7 |
| Ruya Huang | Linfield College | 4 |
| Jamie Jenson | California State University-Fullerton | 10 |
| Camille Jepsen | Brigham Young University | 11 |
| Andrew Johnson | Mount Union College | 11 |
| Alycia Kolat | Youngstown State University | 1 |
| Ariel Kramer | Goucher College | 7 |
| Cortney Lager | Winona State University | 9 |
| Robert Lang | Florida Atlantic University | 4 |
| Cynthia Lester | Linfield College | 4 |
| Tova Lindberg | Bethany Lutheran College | 1 |
| Lorena Lopez | California State University-Northridge | 3 |
| Cory Lowe | Winona State University | 1 |
| David Macfadden | Augustana College | 4 |

## MAA Student Speakers (Continued)

| Name | School | MAA Session |
|---|---|---|
| Andrew Magyar | Ohio Northern University | 3 |
| Christine R. Martin | California State University-Fullerton | 10 |
| Kyle Marx | California State University-Fullerton | 9 |
| Bryan Michael McCauley | Winona State University | 4 |
| Alex David McCullough | Winona State University | 8 |
| Emily McHenry | Xavier University | 11 |
| Lisa Moats | Concordia College | 8 |
| Kyra Moon | Brigham Young University | 11 |
| Lalla Mouatadid | Vancouver Island University | 1 |
| Amelia Musselman | Harvey Mudd College | 4 |
| Curtis Nelson | Brigham Young University | 4 |
| My Viet Nguyen | California State University-Fullerton | 9 |
| Eddie Niedermeyer | Gonzaga University | 6 |
| Oumarou Njoya | Michigan State University | 10 |
| Derek Olson | Drake University | 7 |
| Michael Parker | University of Utah | 8 |
| Rachel Pepich | Illinois State University | 11 |
| Mitch Phillipson | University of Wisconsin-Eau Claire | 5 |
| Dylan Richard Poulsen | University of Puget Sound | 2 |
| Miklos Zoltan Racz | Budapest University of Technology and Economics | 4 |
| Rebecca Rasweiler-Richter | United States Air Force Academy | 7 |
| David Brandon Roberts | California State University-Northridge | 3 |
| Robert Peter Schneider | University of Kentucky | 9 |
| Gino Shero | Clarion University | 11 |
| Lynnette Snyder | Simpson College | 11 |
| Ashley Toth | Rollins College | 11 |
| Tate Twinam | New College of Florida | 4 |
| Katherine Varga | Kent State University | 5 |
| Robert George Vary | Penn State University | 9 |
| Patrick Walker | Youngstown State University | 6 |
| Jonathan Weisbrod | Rowan University | 9 |
| Victoria L. Widowski | California State University-Monterey Bay | 8 |

# Pi Mu Epsilon Delegates

## Speakers

| Name | School | Chapter | PME Session |
|---|---|---|---|
| Matt Alexander | Youngstown State University | OH Xi | 9 |
| Elizabeth Bernat | University of Mary Washington | VA Zeta | 4 |
| Neil Biegalle | Grand Valley State University | MI Iota | 9 |
| Adam Boseman | University of North Carolina at Greensboro | NC Epsilon | 7 |
| Wyatt Brege | Grand Valley State University | MI Iota | 7 |
| Alexander Byers Brummer | Oregon State University | OR Beta | 4 |
| Cameron Byrum | University of Mississippi | MS Alpha | 3 |
| Kathryn Christian | University of Mary Washington | VA Zeta | 4 |
| Amanda Coughlin | Roanoke College | VA Delta | 3 |
| Lisa Curll | Youngstown State University | OH Xi | 8 |
| Scott Eddy | Youngstown State University | OH Xi | 3 |
| Geoffrey Ehrman | The University of Akron | OH Nu | 1 |
| Thomas Eliot | Willamette University | OR Zeta | 6 |
| Terra Fox | Hope College | MI Delta | 6 |
| Daniel Franz | Kenyon College | OH Pi | 2 |
| Jennifer Garbett | Kenyon College | OH Pi | 8 |
| Harold L. Gomes | City University of New York - Queens College | NY Alpha-Alpha | 8 |
| Yasmeen Hussain | University of Utah | UT Alpha | 7 |
| Masaki Ikeda | Western Oregon University | OR Delta | 7 |
| Tarah Jensen | Grand Valley State University | MI Iota | 9 |
| Jennifer Jordan | Goucher College | MD Theta | 7 |
| Lindsey Kingsland | Concordia University, Irvine | CA Pi | 7 |
| Josh Koslosky | Duquesne University | PA Upsilon | 6 |
| Nicholas Krzywonos | Grand Valley State University | MI Iota | 1 |
| Justin Laufman | Youngstown State University | OH Xi | 9 |
| Michael Lind | Rensselaer Polytechnic Institute | NY Kappa | 5 |
| Mark C. Lucas | Roanoke College | VA Delta | 2 |
| Jason Lutz | St. John's University | MN Delta | 4 |
| Jim Manning | University of South Carolina | SC Alpha | 5 |
| Kaylin McCue | Mount Union College | OH Omicron | 3 |
| Brandon McMillen | Mount Union College | OH Omicron | 9 |
| Killian Meehan | SUNY Potsdam | NY Phi | 1 |
| Leanne Merrill | SUNY Potsdam | NY Phi | 1 |
| Josh Mike | Youngstown State University | OH Xi | 8 |
| Kathleen Miller | St. Norbert College | WI Delta | 8 |
| Dania Morales | Western Oregon University | OR Delta | 9 |
| Kristi Mraz | Youngstown State University | OH Xi | 8 |
| Michael O'Connor | United States Air Force Academy | CO Gamma | 6 |
| Bette Catherine Putnam | University of Mississippi | MS Alpha | 2 |
| Jon Rogers | Southwestern University | TX Pi | 5 |
| Stephanie Schauer | St. Norbert College | WI Delta | 9 |
| Henry Schreiner | Angelo State University | TX Zeta | 5 |

## Pi Mu Epsilon Delegates (Continued)

| Name | School | Chapter | PME Session |
|---|---|---|---|
| William Seck | Youngstown State University | OH Xi | 2 |
| Kian Shenfield | Rhode Island College | RI Beta | 2 |
| Ilan Shomorony | Worcester Polytechnic Institute | MA Alpha | 6 |
| Carson Sievert | St. John's University | MN Delta | 6 |
| Mario Sracic | Youngstown State University | OH Xi | 2 |
| Sarah Stern | Southwestern University | TX Pi | 1 |
| Angela Urban | Youngstown State University | OH Xi | 4 |
| Corey Vorland | St. Norbert College | WI Delta | 8 |
| Sean Watson | Southwestern University | TX Pi | 9 |
| Alyssia Weaver | Mount Union College | OH Omicron | 9 |
| Allison Wiland | Youngstown State University | OH Xi | 4 |
| Veronica Wills | Southeastern Louisiana University | LA Delta | 8 |
| Moriah Wright | Youngstown State University | OH Xi | 8 |
| Sandi Xhumari | Grand Valley State University | MI Iota | 1 |

### Additional Delegates

| Name | School | Chapter |
|---|---|---|
| Elyse Marie Azorr | Oregon State Univeresity | OR Beta |
| Rongjun Chen | University of North Carolina at Charlotte | NC Theta |
| Michael Donatz | Oregon State University | OR Beta |
| Michelle Krause | University of South Florida | FL Epsilon |
| Matthew James Schmidgall | Western Oregon University | OR Delta |
| Kristal Temple | Western Oregon University | OR Delta |
| Laura Waight | Western Oregon University | OR Delta |

**MAA Session #1**

**Portland Room** **8:30A.M. – 10:25A.M.**

8:30–8:45

**Analysis and Understanding of Identification Numbers Through Non-Commutative Algebra**

Cory Lowe

*Winona State University*

What do grocery stores, credit card companies, and airline agencies all have in common? They all attempt to minimize human errors, caused by inaccurately entered strings of numbers, by incorporating error-detecting systems. A system that is capable of preventing all possible errors is yet to be found, so the users must decide which systems will be the most effective for their individual needs. My presentation will cover the different types of error detecting schemes, show how they work, and reveal how accurate they really are. I will focus on the security of the German Banknotes currency, which incorporates its serial numbers into the dihedral group of order ten, a pre-existing system also used by scientists.

8:50–9:05

**Factorization in Integral Matrix Semigroups**

Rene Ardila

*City College of New York*

Factorization theory is a prominent field of mathematics; however, most previous research in this area lies in the commutative case. Noncommutative factorization theory is a relatively new topic of interest. This talk examines the factorization properties of noncommutative atomic semigroups of matrices, including results on the minimum and maximum length of atomic factorizations, the elasticity and the delta set of the semigroups.

9:10–9:25

**Polynomial Equations over Matrices**

Kaitlyn Hellenbrand

*UW-Eau Claire*

We normally create polynomials that have coefficients in the rational, real or complex numbers. With those coefficients, we know that a polynomial of $n^{th}$ degree will have up to $n$ roots. A more interesting question lies with using matrices as coefficients. Then the question becomes: What is the maximum number of solutions possible for an $n^{th}$ degree polynomial taken over $k \times k$ matrices? This research has shown that if there are a finite number of solutions, then there are at most $kn$ choose $k$ solutions. Furthermore, this maximum is always attainable. Researchers used both a linear algebra and a geometric approach to prove this maximum. It still remains to be shown that it is possible to obtain every number of solutions between 0 and $kn$ choose $k$.

9:30–9:45

**Solvable, More Solvable, Supersolvable**

Alycia Kolat

*Youngstown State University*

A group $G$ is said to be supersolvable if $G$ has a normal series with each of its factors being cyclic. This presentation will introduce and examine supersolvable groups, compare them with solvable groups, and explore different types of supersolvable groups.

9:50–10:05

**Efficient Generation of the Ideals of a Poset**

Lalla Mouatadid
*Vancouver Island University*

Given a partial order $\leq_P$ on a set of elements $E$ , an *ideal* of the partial order is a subset $I$ of $E$ such that, if $x \in I$ and $y \leq_P x$ , then $y \in I$. The problem of generating all the ideals of a given partially ordered set has been investigated since 1978. A *Gray code* is a listing of all instances of a combinatorial object such that successive instances differ in some small prescribed manner; for ideals, for example, we seek a listing such that each ideal differs from its predecessor by adding or removing one or two elements. The most efficient known algorithm for generating ideals runs in time $O(\log n)$ per ideal, where $n = |E|$ (Squire, 1995), but the listing is not a Gray code; Pruesse and Ruskey (1993) have a Gray code algorithm for ideals, but the running time is $O(n)$ per ideal in the worst case. We present some results on classes of posets for which efficient generation of ideals in a Gray code manner is possible.

10:10–10:25

**Dominant Eigenvalues and the Structure of Matrix Spaces**

Tova Lindberg
*Bethany Lutheran College*

The dominant eigenvalues of a matrix are an important tool in applied mathematics, but it turns out that dominant eigenvalues can also be used to study the algebraic structure of spaces of matrices. Even though the eigenvalues of a single matrix really only tell us about that particular matrix, those of polynomial combinations of matrices can tell us more. In particular, the dominant eigenvalues of a matrix in combination with a set of rank-one matrices carry more information. These eigenvalues can be used to extract structural information about the space of the matrices, and in this project, we characterize conditions for which this is the case. Analogous results can be shown for the spectral values of bounded linear operators on infinite-dimensional Banach spaces.

## MAA Session #2

**Eugene Room** **8:30A.M. – 10:25A.M.**

8:30–8:45

### Anatomy, Geometry, and Radio Repairmen: The Mathematics of Flawed Fretted Instruments

Kevin A. Greimel

*Winona State University*

The purpose of this paper is to describe how musical scales can be generated, why fretted string instruments are a unique combination of integers and real numbers, and the mathematical model of sound for standing waves. From this, a model will be developed that will predict the frequency produced at any fret or position along a string of a string instrument. This model will be evaluated using existing geometry of an acoustic guitar and frequencies measured from the same instrument, then three methods for correcting the produced frequencies will be proposed. The first method will simply re-position the frets utilizing the quadratic formula for the simplest case, the second and third methods involve correcting algorithms; one will compare the produced frequency to the predicted value to determine the intended note, then output the desired note, the other will adjust the produced frequency by determining the location on the string and scaling the frequency by a function of the position.

8:50–9:05

### America's New Calling: Modeling the Energy Impact of the Cell Phone Revolution

Stephen Foster

*Southwestern University*

The ongoing cell phone revolution warrants an examination of its energy impacts past, present, and future. Thus, we have developed a model which adheres to two requirements: it can evaluate energy use since 1990; and it is flexible enough to predict future energy needs. Mathematically speaking, our model treats households as state machines and uses actual demographic data to guide state transitions. We produce national projections by simulating multiple households. Our bottom-up approach remains flexible, allowing us to: 1) model energy consumption for the current United States, 2) determine efficient phone adoption schemes in emerging nations, 3) assess the impact of wasteful practices, and 4) predict future energy needs.

9:10–9:25

### Finite Frame Cryptography

Darren Allen

*Southwestern University*

Frame theory is used in many signal processing applications including image compression, reducing unwanted noise, and sending data over the Internet. Very recently, attempts have been made to utilize frames as a piece of cryptographic machinery. We present a brief overview of finite frames and some experimental cryptographic systems involving finite frame theory with an explanation of why these are not particularly effective.

9:30–9:45

**Mathematical Modeling of Structured Textures**

Derek DeSantis

*Cal State Channel Islands*

Textures lie on a spectrum from periodic (e.g. wallpaper groups) to random (e.g. white noise). At either end, the choice of the mathematical model is clear. For textures in between, however, there are many options, each with strengths and weaknesses. This project examines modeling near-periodic (structured) functions as a periodic function together with a warping and uses coefficient analysis to find relationships between the periodic function and warping on one hand, and the structured function on the other.

9:50–10:05

**Modeling of a Hydrogen Induced Radius of Delamination As a Function of Time**

Marek Fikejz

*Gainesville State College*

During the transport of hydrocarbons, dissolved hydrogen can penetrate into the walls of pipelines, frequently causing delaminating of the metal. Hydrogen being accumulated inside the delamination cavity creates pressure which eventually leads to the damage of the pipeline. The focus of this study is the modeling of how the radius of delamination grows with respect to time. The equation of state for the ideal gas is first used; however, this is only accurate for low pressures. This study applies the van der Waals equation, which is valid for high pressures. By substituting the expressions of volume and gas mass into this equation, an integral equation for the delamination radius is derived. Next the integral equation is reduced to the differential equation by taking the derivative of both sides and applying the Fundamental Theorem of Calculus. The separation of variables is then used to solve the differential equation. The analytical solution for the dependence of the radius of growing delamination on time is derived. Since the obtained solution is in an implicit form, the equation is solved using the Matlab Software for specific points of time, making it possible to generate the final graph of the delamination radius versus time. Since this model is derived under an assumption of high pressures, the study further takes into account a non-ideal sink, which exist in the delamination cavity. The two models are then compared and analyzed.

10:10–10:25

**The Optimal Tilt Angle of Solar Panels**

Dylan Richard Poulsen

*University of Puget Sound*

If solar panels can be adjusted continuously, the optimal orientation aligns the face of the solar panel with the sun. Oftentimes, purchasing the equipment necessary for continuous adjustment is too expensive to justify the costs. Therefore less optimal adjustment schedules, such as seasonal adjustment, must be considered. In this talk we derive a model for the energy a solar panel receives daily at variable tilt angles. We then examine the costs and benefits of various adjustment schedules.

## MAA Session #3

**Medford Room** **8:30A.M. – 10:25A.M.**

8:30–8:45

### Edgar Structures on Manifolds

Andrew Magyar
*Ohio Northern University*

An Edgar structure on a manifold is a pair consisting of an affine connection together with a second rank tensor field such that a certain symmetry condition holds. We present some new results on the mutual relationships between quantities associated with an Edgar structure and also on the geometry of the least energy curves of the given tensor field.

8:50–9:05

### Rectilinear Crossing Numbers for Point Sets with Given Convex Hull Layers

Lorena M. Lopez
*California State University, Northridge*

Let $P$ be a set of n points in the plane. Draw all segments joining pairs of points in $P$. We are interested in the number of segment-intersections, or crossings, in such a drawing. For a fixed $n$, the problem of minimizing the number of crossings over all sets of $n$ points in the plane is a famous unsolved problem in Combinatorial Geometry. We classify all sets of n points according to the sizes of their convex layers and consider the minimum number of crossings over sets within the same class. We present our best constructions providing general upper bounds for sets with two layers, and exact values for small $n$. This research was sponsored by CURM.

9:10–9:25

### On the Maximum Number of Isosceles Right Triangles in a Finite Point Set

David Brandon Roberts
*California State Univ., Northridge*

Let $Q$ be a finite set of points in the plane. For any set $P$ of points in the plane, we let $S_Q(P)$ be the number of similar copies of $Q$ contained in $P$. For a fixed $n$, Erdős and Purdy asked to determine the maximum possible value of $S_Q(P)$, denoted by $S_Q(n)$, over all sets $P$ of $n$ points in the plane. Although good bounds have been found for the general problem, not much more is known for specific patterns $Q$. We consider this problem when $Q = \triangle$ is the set of vertices of an isosceles right triangle. We give exact solutions for small values of $n \leq 9$, and show that as $n$ approaches infinity, $S_\triangle(n)$ has quadratic order. Lastly, we provide new upper and lower bounds for the limit of $S_\triangle(n)/n^2$ as $n$ approaches infinity.

9:30–9:45

### Hyperbolic Circles are Circular!

Alma Rosa Gonzalez
*Sonoma State University*

In this talk we will discuss the poincaré model for hyperbolic geometry. We will show that a hyperbolic circle in the poincaré disk is really a Euclidean circle.

9:50–10:05

**On Proofs of Summation Identities**

Samantha Dahlberg and Timothy Ferdinands
*Grand Valley State University and Calvin College*

The problem of finding closed-form expressions for various sums and proving identities among them is among ancient and attractive mathematical problems. One of the most exciting discoveries in the early nineties, due to H. Wilf and D. Zeilberger, was that finding closed-form expressions for various sums and proofs for special class of summation identities can be efficiently and elegantly handled by the computer. In this talk we explore and highlight the Wilf-Zeilberger (WZ) method and show various practical applications of Zeilberger's algorithm. This work was done at the 2009 REU program at Grand Valley State University.

## MAA Session #4

**Salem Room** **8:30A.M. – 10:25A.M.**

8:30–8:45

### Application of Local Regularization for an Inverse Problem of Option Pricing

Ruya Huang and Cynthia Lester
*Linfield College*

We explore the theoretical and numerical application of local regularization methods to an inverse problem rising from financial option pricing. Our purpose is to find the volatility function from noisy call option prices. This is an important problem not only in theory but also for practitioners working in the financial world. However, it has been shown that finding the volatility function from option prices is an ill-posed inverse problem. That is, very small noise in the observed data will lead to huge deviation in the solution (instability). Whenever faced with ill-posed problems due to instability, we need to apply some regularization methods in order to stabilize the problem. However, the existing methods such as Tikhonov regularization, do not take the special structure (causal structure) of this option pricing problem into consideration which leads to nontrivial computational costs. In this paper, we apply local regularization to the option pricing problem. In addition, we discretize the problem and show our results through numerical examples.

8:50–9:05

### The Brouwer Fixed Point Theorem and Supply and Demand

Bryan Michael McCauley
*Winona State University*

The field of economics uses many models to tell how strong the economy is at a given time. One of these models is the supply and demand model. The demand function is an inverse relationship between the price of a product and the quantity of a product. As prices get lower consumers demand more of a certain product. The supply function is a direct relationship between the price of a product and the quantity of a product. When the price of a product is low, producers will produce less because they will not gain much of a profit selling that item at such a low price. The graph of the supply function will have a positive slope and the graph of the demand function will have a negative slope. At the point in the graph where the demand intersects the graph of the supply, the quantity demanded is the same as the quantity supplied at a certain price. This is called the equilibrium price. This supply and demand model has only one product, but what if the economy has multiple products? Will such an equilibrium price still exist? Using the Brouwer Fixed Point Theorem we will try to prove whether or not such an equilibrium point always exists.

9:10–9:25

### The Binomial Asset Pricing Model

David Macfadden
*Augustana College*

The binomial asset pricing model is used to determine the fair price of an option. We'll provide definitions and some simple examples. We will also discuss volatility and how to calculate it. Using our model, we will compare our calculations to real world data.

9:30–9:45

**Competing Prices: Analyzing a Stochastic Interacting Particle System**

Miklos Zoltan Racz
*Budapest University of Technology and Economics*

A market is considered where agents try to sell the same product. As time passes, the agents raise their prices in accordance with rises in the average price. However, those who sell the product at a price above the average will raise their prices at a slower rate than those who sell below the average. What is the speed of the rise of the average price? What is the distribution of the prices around the average price? We introduce a stochastic interacting particle system to model this process and answer these questions. We discuss both analytical and simulation results and show, among other things, that in a special case of the model the stationary distribution is a Type-1 Gumbel distribution, which arises in extreme value statistics.

9:50–10:05

**Probabilistic Forecast Modeling in Operations Management**

Amelia Musselman and Tate Twinam
*Harvey Mudd College and New College of Florida*

Many tactical forecasting applications exist in retail and wholesale distribution. For the most part, traditional methods such as exponential smoothing, Holt's and Winter's methods, and numerous variations of these, produce forecasts of acceptable quality. Given stable demand and sufficient volume, these methods perform well enough to obviate the need for more sophisticated approaches. There are, however, a number of problems in retail forecasting that cannot be adequately solved using these methods. Examples include very slow moving items, intermittent sellers, and unstable seasonal demand. We will present new approaches for solving these problems, in particular how we applied probability theory to develop forecasting models of a predictive, rather than reactive, nature. We will show results of testing our models by validating against industry data and via simulations.

10:10–10:25

**The Minimum Rank Problem for Decomposable Graphs**

Robert Lang and Curtis G. Nelson
*Florida Atlantic University and Brigham Young University*

The problem of determining the minimum rank of a graph has been an active area of research in combinatorial matrix theory over the past decade. Given a simple, undirected graph $G$ on $n$ vertices, the problem is to determine the minimum rank $mr(G)$ (or maximum nullity $M(G)$) over all real symmetric $n \times n$ matrices whose nonzero off-diagonal entries occur in exactly the positions corresponding to the edges of $G$. From elementary linear algebra $mr(G) + M(G) = n$. The primary classes for which $mr(G)$ has been determined thus far are trees, graphs with connectivity equal to 1 or 2, and graphs with small minimum rank or small maximum nullity. The problem is difficult for general graphs and there is no algorithm known for computing minimum rank. A graph parameter called the zero forcing number, gives the exact value of the maximum nullity for trees and is an upper bound for maximum nullity for all graphs. For us a decomposable graph is one whose edges can be covered by a collection of subgraphs (cliques, cycles, complete bipartite graphs, etc.) whose minimum rank is easily determined. Each such decomposition gives an upper bound for the minimum rank of a graph, and the subgraph cover number is the smallest bound obtained over all such covers. If the subgraph cover number and zero forcing number add to $n$, then they are sharp upper bounds, and consequently the minimum rank must equal the subgraph cover number. Several sufficient conditions for this to occur will be presented.

**MAA Session #5**

**Salon B** **8:30A.M. – 10:25A.M.**

8:30–8:45

**Avoiding Two Patterns of Length Three in $S_n \wr C_k$**

Mitch Phillipson

*UW-Eau Claire*

For notation we say $S_n \wr C_k$ is the set of permutations of length $n$ where each number in the permutation is indexed by an integer between 1 and $k$. If $\varphi \in S_m \wr C_r$ and $\psi \in S_n \wr C_k$ we are able to define an order relation, "$<$", and say $\psi$ "contains" $\varphi$ if $\varphi < \psi$. However, it is possible that $\varphi \not< \psi$, in this case we say $\varphi$ *avoids* $\psi$. If two elements, $\varphi, \psi \in S_m \wr C_r$, avoid the same number of elements in $S_n \wr C_k$, for all $n$ and $k$, then we say $\varphi$ and $\psi$ are *Wilf equivalent* or are in the same *Wilf class*. In our project we study Wilf classes generated by avoiding two elements of $S_3 \wr C_2$. In this talk, we detail our findings, including the discovery of at least 74 distinct Wilf classes, we also explain several methods of proving these Wilf classes are actually Wilf classes and discuss several open questions.

8:50–9:05

**One Cake, Four Cuts, Two Hungry People**

Dallas Duckett and Aniya Henry

*Pepperdine University*

We will discuss a problem proposed in the problem section of Math Horizons dealing with cake cutting between two people, Alice and Brian. In the stated problem, Alice cuts the cake first making two pieces, then Brian cuts one of the pieces into two pieces, then Alice cuts a piece into two and then Brian cuts a piece into two resulting in five pieces of cake. In the end, Brian receives the first, third and fifth largest pieces while Alice receives the second and fourth largest pieces. We will discuss Alice's strategy for maximizing her amount of cake given that Brian is also trying to maximize his amount of cake. We will also discuss generalizations of the problem.

9:10–9:25

**Applications of Counting Techniques to Sudoku Variations**

Katherine Varga

*Kent State University*

Sudoku is the latest craze in puzzles, and is played by entering digits from 1 to 9 to complete a partially filled grid so that each digit appears exactly once in each row, column, and block. There are numerous variations with additional restrictions, for example, using inequalities rather than numerical clues. We present the results of our research of Sudoku variations, using permutations and equivalence relations. The work was done at the 2009 REU program at Grand Valley State University.

9:30–9:45

**A Numerical Study of an SIR Model**

John Ensley

*Shippensburg High School*

The SIR model simulates the spread of a disease caused by a new variant of the Rubella virus over a population, in this instance, the U.S. population. In this talk, the speaker will present an SIR model and its numerical solution. Our study varies the value of the overall population at each iteration the numerical technique. We compare these results to the case where overall population kept fixed.

9:50–10:05

**Initial Ideals and Graphs**

Greg Burnham

*Princeton University*

By fixing a term ordering on multivariable monomials, we can define the “initial term” of a multivariable polynomial $P$ to be the largest monomial (under the fixed term ordering) appearing in $P$. Then, given an ideal $J$ in a polynomial ring $S$, we can define the “initial ideal” of $J$ to be the ideal generated by the initial terms of all the elements of $J$. While an ideal in $S$ contains geometric information–it corresponds to the solution set of a system of polynomial equations–the associated initial ideal often contains combinatorial information. For instance, certain ideals have initial ideals that correspond naturally to graphs; the combinatorial properties of these graphs allow us to infer geometric facts about the original ideals. We will discuss several combinatorial properties of graphs arising in this way from initial ideals, and see how they relate back to the geometry of the ideals themselves.

10:10–10:25

**Ideals, Varieties, and Secants**

Rachel Cranfill

*Harvey Mudd College*

If $I$ is an ideal of a polynomial ring in $n$ variables, a point $p$ in affine $n$-space is in the variety of $I$ if $f(p) = 0$ for all $f$ in $I$. We explore the correspondence between ideals and their varieties and present results about the computational properties of varieties and their secant varieties.

## PME Session #1

**Medford Room** **2:00P.M. – 3:55P.M.**

2:00–2:15

### Labelings of Directed Graphs

Sarah Stern
*Southwestern University*

Graph labeling has been widely researched over the last 50 years. Recently graceful and magic labelings for directed graphs have been defined and studied. This talk will focus on some new labelings of directed graphs. Definitions and examples will be given.

2:20–2:35

### Collatz Structures in the Game Go on Graphs

Geoffrey Ehrman
*The University of Akron*

Collatz maps generalize the $3n + 1$ map of the famed $3n + 1$, or Collatz, conjecture. Go is an ancient board game readily generalizable to play on an arbitrary graph. Collatz structures naturally arise in Go on complete graphs; their analysis leads to the solution of Go on several classes of graphs.

2:40–2:55

### On Applications of Generating Functions

Sandi Xhumari
*Grand Valley State University*

A lot of problems turn into Recurrence Relations, where the next term depends on the previous ones. For example, every term in the Fibonacci sequence is defined as the sum of the two previous terms, which is a Recurrence Relation. One of the most powerful tools to solve Recurrence Relations is Generating Functions. In this presentation, I will introduce you to Generating Functions and apply them to some specific problems. Next time you are faced with a Recurrence Relation, you will have a brand new secret weapon up your sleeve!

3:00–3:15

### Generalizing Rook Polynomials to Three and Higher Dimensions

Nicholas Krzywonos
*Grand Valley State University*

A rook polynomial counts the placements of non-attacking rooks on a board. In this talk, we describe generalizations of rook polynomials to "boards" in three and higher dimensions, and the properties of rook polynomials in three dimensions. We also provide results on rook polynomials of generalizations of well-known two-dimensional boards, including the rectangular and triangular boards, and boards of the probléme des rencontres.

3:20–3:35

**Intrinsically Linked Signed Graphs in Projective Space**

Killian Meehan
*SUNY Potsdam*

Define real projective space, $\mathbb{R}P^3$, as the region obtained from the closed 3-ball $D^3$ by identifying the anitpodal points of $\partial D^3$. We examine signed graphs that contain a non-trivial link in every embedding in $\mathbb{R}P^3$. We call such signed graphs intrinsically linked. A graph is signed if each of its edges is labeled positive or negative. When we embed a signed graph in in $\mathbb{R}P^3$, negative edges cross the boundary (i.e., the line at infinity) an odd number of times. We discuss some examples of signed graphs embedded in $\mathbb{R}P^3$ and discuss our attempt to fully characterize the set of minor-minimal (simplest) intrinsically linked signed graphs that are disconnected or have connectivity 1.

3:40–3:55

**Intrinsically Linked Signed Graphs in Projective Space**

Leanne Merrill
*SUNY Potsdam*

Define real projective space, $\mathbb{R}P^3$, as the region obtained from the closed 3-ball $D^3$ by identifying the anitpodal points of $\partial D^3$. We examine signed graphs that contain a non-trivial link in every embedding in $\mathbb{R}P^3$. We call such signed graphs intrinsically linked. A graph is signed if each of its edges is labeled positive or negative. When we embed a signed graph in in $\mathbb{R}P^3$, negative edges cross the boundary (i.e., the line at infinity) an odd number of times. We discuss several examples of intrinsically linked signed graphs with high connectivity. We further discuss our attempt to fully characterize the complete set of minor-minimal intrinsically linked signed graphs.

**PME Session #2**

**Salem Room** **2:00P.M. – 3:55P.M.**

2:00–2:15

**On Generalized Mersenne and Fermat Primes**

Bette Catherine Putnam
*University of Mississippi*

The classical Mersenne and Fermat primes are, respectively, primes of the form $2^k - 1$ and $2^k + 1$. As of September 2008, there are forty-six Mersenne primes known. Fermat primes, of the form $2^k + 1$, seem to be more rare as only five are known to be prime. My work involves generalized Mersenne and Fermat primes. Using Mathematica, I have found tens of thousands of both generalized Mersenne and generalized Fermat primes. It is my hope that these generalizations will prove to be interesting for both theoretical and computational investigation.

2:20–2:35

**Exploring the Fibonacci Sequence Using Combinatorics**

Mark C. Lucas
*Roanoke College*

In Proofs That Count, Art Benjamin introduces a new, combinatorial method for exploring the ubiquitous Fibonacci sequence using a board of length $n$, squares, and dominoes. This talk will explore proofs of known Fibonacci identities using this new combinatorial approach, including an original proof that combines combinatorial and classical techniques.

2:40–2:55

**Gauss and an Asymptotic Formula for the Number of Primes Less than a Given Integer $n$**

William Seck
*Youngstown State University*

It is standard notation to let $\pi(x)$ represent the number of primes that are less than or equal to the real number $x$. In 1796 Adrien-Marie Legendre conjectured, based on a table of known primes that was compiled by Anton Felkel, that

$$\lim_{x\to\infty} \pi(x)\frac{\ln(x)}{x} = 1.$$

Carl Friedrich Gauss independently made this same conjecture. Neither mathematician was able to prove what is now known as *the prime number theorem*, and it was an open question until 1892 when it was independently demonstrated by Jacques Salomon Hadamard and Charles Jean Gustave Nicolas Baron de la Vallee Poussin. In this talk we will present an elementary technique to show why this result is expected.

3:00–3:15

**Concerning the Volume and Surface Area of Hyperspheres in $\mathbb{R}^n$**

Mario Sracic
*Youngstown State University*

The volume of a sphere of radius $R$ in $\mathbb{R}^3$ is $V_3(R) = \frac{4}{3}\pi R^3$ and the surface area of this sphere is

$$SA_3(R) = 4\pi R^2 = D_R\, V_3(R).$$

We consider whether it is true that for all positive integers $n$, the derivative of the volume of a hypersphere in $\mathbb{R}^n$ with respect to its radius gives its surface are. While doing so we discover an interesting inconsistency in standard calculus.

3:20–3:35

**Irreducible Elements in $\mathbb{Z}_n$**

Kian Shenfield
*Rhode Island College*

This paper observes patterns in different rings of integers modulo n, focusing on irreducibility. By looking at different specific rings where n is composite, we can find general relationships between the factors of n, the set of units in n, and equivalence classes under the relation of mutual divisibility.

3:40–3:55

**Solving the Pythagorean Formula Generalized to Polygonal Numbers**

Daniel Franz
*Kenyon College*

Finding when the sum of two squares is again a square is an old problem dating back thousands of years. What happens when other polygonal numbers are substituted for squares? The triangular case will be examined, and certain families of solutions will be presented for the general polygonal case.

**MAA Session #6**

**Portland Room** **2:00P.M. – 3:55P.M.**

2:00–2:15

**Convex Combinations of Minimal Graphs**

Laura Graham

*Brigham Young University*

Minimal surfaces in $\mathbb{R}^3$ are surfaces whose mean (or average) curvature vanishes at each point on the surface. Thus, minimal surfaces look like saddle surfaces and can be modeled by soap films spanning a wire frame. We can parametrize minimal surfaces by using the classical Weierstrass representation. In this talk we will discuss how 1-1 complex-valued harmonic mappings can be used with the Weierstrass representation to parametrize minimal graphs in $\mathbb{R}^3$. Then we will prove conditions under which these minimal graphs can be combined together to form different minimal graphs by using results about complex-valued harmonic mappings from geometric function theory. One application of these results offers a new way to construct minimal graphs over nonconvex polygonal domains resulting in the family of Jenkins-Serrin minimal surfaces.

2:20–2:35

**Level Curves and Extreme Polynomials**

Eddie Niedermeyer

*Gonzaga University*

Let $P$ be a real polynomial of degree $n$. In 2002, Edwards and Gordon showed that if $P$ "has only real zeros, then the number of points of extreme curvature of $P$ is at most $n-1$." We discuss our progress in removing the hypothesis on the zeros of $P$ and discuss the relationship between this problem and an old problem of Polya and Szego.

2:40–2:55

**Metric-Preserving Mappings and a Conjecture of Ulam's**

Patrick Walker

*Youngstown State University*

Consider a metric space and the collection of all metrics on its underlying set that generate the same topology as the given space. Ulam conjectured that one of the metrics in this collection is considered to be the most natural in the following sense: the group of isometries associated with each of the other metrics is isomorphic to a subgroup of the group of isometries associated with this "most natural" metric. Following Bowman and Dalpatadu and alternative proofs I will verify Ulam's conjecture for a class of metrics on $\mathbb{R}$. In this class of examples it is interesting to note that the group of isometries associated with a metric is determined by the range of the function used to define the metric.

3:00–3:15

**What's in a Norm?**

Dillon Ethier

*Clarkson University*

The norm of a complex-valued continuous function is its maximum absolute value. For a given function $f$, knowing its norm doesn't tell you much. However, $f$ can be completely determined by the norms of certain combinations of $f$ with other continuous functions. For example, knowing $\|fh+1\|$ for all continuous functions $h$ allows us to know $f$, whereas knowing $\|fh\|$ for any amount of continuous functions $h$ fails to determine $f$. We will classify for which algebraic combinations the norm allows us to successfully identify a function and also which classes of functions we need to combine it with.

3:20–3:35

**Dancing with Deforming Points**

William Nathan Hack
*Armstrong Atlantic State University*

Maximizing the mutual distance of points inside a convex body is a well-known unsolved problem, and is better known as the equal circle packing problem. For our research, we made a list of point configurations which achieve local maxima of the minimum mutual distance for the square. These lists cultivated the idea of deformation; the deformation takes a local maxima configuration with $k$ points to a local maxima with $k + 1$ points. We will show results obtained by using the idea of deformation. It is our hope this approach will lead to better understanding of the combinatorial problem and to a perceptive proof.

**MAA Session #7**

**Salon B** **2:00P.M. – 3:55P.M.**

2:00–2:15

**The Mathematics Behind Evolutionary Convergence**

Rebecca Rasweiler-Richter

*United States Air Force Academy*

We will look at the mathematics used to explain and model the biological concept of evolutionary convergence. We will explore several different models, in particular Markov chains and the Maximum Likelihood Method, which are used to better understand this concept.

2:20–2:35

**Follow the Food Feeding Function: A Biomathematical Study of Gastric Emptying**

Ariel Kramer

*Goucher College*

As this is a joint undergraduate research project, our research will be presented in two sessions. Ariel Kramer will present in the MAA Student Paper Sessions, and Jennifer Jordan will present in the Pi Mu Epsilon Student Paper Sessions. Through an examination of the mechanisms driving gastric motility, absorption, and transit, and using differential equations, we created a compartmental model of the digestion system. Specifically, we seek to understand the process of gastric emptying by modeling the interactions between ingested solids, liquids, and chyme. To make the model accurate biologically, we introduced randomness into the system; additionally, the nonlinearity and number of the parameters in the model make finding analytical solutions impractical. Thus, we created numerical simulations of the model. As this research is at the crossroads of biology and mathematics, both quantitative and qualitative analyses of the simulations will be discussed.

2:40–2:55

**Analysis of Type 1 Diabetes with Wavelets**

Robert Castellano and Derek Olson

*SUNY-Stony Brook and Drake University*

Type 1 diabetes is a serious disease, and it is estimated that up at least a million Americans are afflicted. This talk will describe work done to apply mathematical tools such as wavelets to blood glucose time series to deepen understanding of this disease. The work was done at the 2009 REU program at Grand Valley State University.

3:00–3:15

**A Mathematical Model for the Source Localization of Brain Signals**

Shubham Debnath

*University of Minnesota-Twin Cities*

Electroencephalography (EEG) is a noninvasive method to measure electrophysiological signals due to spontaneous cortical brain cell activity. In a standard head model, potentials can be calculated using results provided by the EEG signals. A commonly used algorithm, known as the focal underdetermined system solver (FOCUSS), is applied to find the location of these potentials in a model of the brain. By inverse calculation, one can identify the orientation of the source from electrode and sensor information with a high spatial and time resolution. This source localization is very important in medicine for diagnosing epilepsy, sleep disorders, and understanding other neurophysiological diseases, as well as simply learning and studying the brain's activity and function. This presentation will propose an adaptation to the FOCUSS algorithm with an improvement of the regularization parameter; proposed algorithmic steps can be followed to use the modified methods. There will be a description of the mathematical methods necessary in producing source images of electrical signals in the brain. The future research, along with experimental tests and other applications, will also be presented.

3:20–3:35

**Using Optical Flow for Botanical Video Analysis**

Jason Holloway

*Clarkson University*

A vital component of photosynthesis in plants is the absorption of gaseous carbon dioxide ($CO_2$) from the surrounding environment. Photosynthesis can be inferred through fluorescence that varies inversely with photosynthetic activity. The fluorescence is measured as video data, and the fluorescence dynamics can be analyzed using optical flow. Optical flow is a method for generating vector fields that indicate how the fluorescence patches flow across the surface of the leaf. The optical flow is found by minimizing an energy integral whose minimizer is the solution to a pair of coupled partial differential equations. Collectively, the vector fields quantify how the patches change with time, which is a qualitative measure of carbon absorption.

## MAA Session #8

**Portland Room** **4:20P.M. – 6:15P.M.**

4:20–4:35

### More Money, More Problems: Variations on the Coin Game Puzzle

Victoria L. Widowski
*California State University, Monterey Bay*

Consider the following game. Given an even number of coins lined up in a row, two players take turns pulling a single coin from either one of the two ends of the row. The player with the largest sum of money wins. Which player, Player 1 or Player 2, has the winning strategy ( a tie is included as a win for Player 1)? This game is presented in Peter Winkler's *Mathematical Puzzles: A Connoisseur's Collection* but the question was originally posed by Noga Alon. Apparently, this game was used by a high-tech company in Israel to test the mental dexterity of job candidates. The winning strategy for this game is well known. We examine different variations of this game including experimenting with an odd number of coins and multiple rows with various numbers of coins and we determine winning strategies for these games. For example, in a game with an even number of rows and an even number of coins, we show that Player 1 will always have a winning strategy.

4:40–4:55

### Tournaments and Ranking Algorithms

Michael Parker
*University of Utah*

Ranking a field of people based on a difficult (or impossible) to measure quality has always been a challenge. One way to meet this challenge is through having the participants compete against each other in a competitive environment such as a tournament. These tournaments can take on quite a variety of different forms, ranging from a few quick single-elimination rounds to month-long randomly paired championships. In this project, we examine the assumptions behind a few of these tournament structures, as well as measure the accuracy of the rankings produced by these surprisingly complex stochastic processes.

5:00–5:15

### A Mathematical Modification to the Distribution of Byes in Wrestling Championships

Alex David McCullough
*Winona State University*

The pinnacle of collegiate wrestling is the NCAA Division I Wrestling Championships, but to get there, an individual must compete in a regional tournament. Before the brackets are agreed upon, a coach from each team is to rank the top eight wrestlers for each weight class. Generally, each bracket will contain more than eight athletes, meaning several byes must occur. The current method used spreads the byes out at a fast, random manner between the seeds separately from the other weight classes. A problem exists in that these byes must be distributed fairly for both the individual's and team's sake. This presentation will describe a mathematical modification of the existing approach to the distribution of byes and its potential application to the Big Ten Championships. Instead of creating a new system, the proposed modification to the current method has proved to reduce the occurrence of any unfair situation. With the use of the sum of the squares of discrepancies between expected byes and actual byes received, a number can be calculated and judged if a random draw is considered fair. The number is compared with previous years to find a range of acceptance.

5:20–5:35

**Modeling Nonseparable Preferences in Referendum Elections**

Kyle Golenbiewski and Lisa Moats
*Grand Valley State University and Concordia College*

Referendum elections often require voters to cast ballots simultaneously on multiple proposals, some of which may be interrelated. When a voter's preferences on one proposal depend on the known or predicted outcomes of other proposals, the voter's preferences are said to be nonseparable. In this talk, we will explore ways to mathematically model and analyze various forms of nonseparability. This work was completed as part of the 2009 REU program at Grand Valley State University.

**PME Session #3**

**Medford Room** **4:20P.M. – 6:15P.M.**

4:20–4:35

**An Investigation on Triangle Centers**

Kaylin McCue

*Mount Union College*

Within a triangle, there are an endless number of possibilities. This investigation explores the triangle centers that form Eulers Line, the Nine Point Circle, and ultimately the necessary and sufficient conditions which make the Euler Line of a triangle parallel to one of the sides of that triangle.

4:40–4:55

**A Geometric Composition of Isometries**

Scott Eddy

*Youngstown State University*

Results about isometries and their compositions, on the plane and in space, are efficiently obtained using matrices and complex variables. However, these same results can also be obtained geometrically, especially making use of reflections through lines and planes, a point of view which provides further insight into their behavior. In this talk, I will show how to use geometric tools to derive some of the basic results about isometries and their compositions.

5:00–5:15

**Robustness and Efficiency of the Theil-Sen Estimator in Simple and Multiple Regressions**

Cameron Byrum

*University of Mississippi*

The Least Squares method is the most common estimator, but is known to lack efficiency with non-normally distributed error terms and to lack robustness to outliers. The Theil-Sen estimator is based on medians and far more robust. We compare the robustness and efficiency of each in linear and multivariate models.

5:20–5:35

**Statistical Analysis of PGA Golfers: Who's the best golfer?**

Amanda Coughlin

*Roanoke College*

We statistically rate the golfers that participated in the 2008 PGA tournaments based on various aspects of the game including putting, chipping, driving, hitting out of the rough, and more. Using this, we determine which aspect is most important in winning and develop a formula to rate golfers overall performance.

**PME Session #4**

**Salem Room** **4:20P.M. – 6:15P.M.**

4:20–4:35

**Examples of $3 \times 3$ Octonionic Hermitian Matrices with Non-Real Eigenvalues**

Alexander Byers Brummer

*Oregon State University*

There is currently no known method for identifying $3 \times 3$ octonionic Hermitian matrices which admit non-real eigenvalues. We therefore seek to find simple solutions to the generalized characteristic equation presented by Dray, Janesky, and Manogue. We present results of our current work which includes re-deriving the generalized characteristic equation for $2 \times 2$ octonionic Hermitian matrices, finding a class of matrices whose eigenvectors may satisfy certain constraints on their components, and we present a possible method of using known solutions to the corresponding $2 \times 2$ problem to construct solutions to the $3 \times 3$ problem.

4:40–4:55

**Sylow's Theorem**

Allison Wiland

*Youngstown State University*

Ludvig Sylow was a Norwegian mathematician that lived from 1832 to 1918. After studying at Christiana University, he was unable to find a position at a university and so he became a high school teacher in the town of Frederiskshald. He continued to study mathematics and began giving lectures at Christina University. He eventually wrote a paper, *Theoremes sur les groupes de substitutiones*, in which he generalized Cauchy's theorem. Today this generalization is called Sylow's theorem. Using Sylow's Theorem one can classify groups of given orders determine certain properties of groups only based on their orders. In fact, Sylow's theorem is so fundamental that nearly every result in finite group theory since uses Sylows's theorem.

5:00–5:15

**An Analog for a Basis in Finite Groups**

Jason Lutz

*St. John's University*

In linear algebra, a basis of a vector space is a linearly independent spanning set. Here, we will discuss some cases when we can find an analog for a basis in a finite group. This talk is suitable for anyone with a background in undergraduate algebra.

5:20–5:35

**Groups and Counting**

Angela Urban

*Youngstown State University*

Some of the first groups studied were the permutation groups $S_n$ for various $n$. These groups $S_n$, often called symmetric groups, permute the elements of the set of numbers $\{1, 2, 3, \ldots, n\}$. That is, the group $S_n$ acts on the set of numbers $\{1, 2, 3, \ldots, n\}$. It was realized that not only do the groups $S_n$ act on sets, but all groups act on sets. All groups permute the elements of various sets. Shortly after this, a mathematician from London, William Burnside, discovered a formula which gives the number of orbits a group has on a set under such an action. Putting the two ideas together, groups acting onsets and a formula for the number of orbits of such an action, it was quickly difficult to count in the usual or conventional way. In this paper we let certain groups act on certain sets in order to count certain objects.

5:40–5:55

**Laplace's Equation: A Mathematical and Computational Analysis**

Elizabeth Bernat and Kathryn Christian
*University of Mary Washington*

We study mathematically and computationally Laplace's equation. The change of heat energy over a region can be modeled using the law of conservation of energy. The change in temperature for the region may be described by the heat equation. Laplace's equation is the steady-state heat equation which describes heat flow in equilibrium over a region if there are no sources of heat energy generated inside the region. Mathematically, we find an exact solution to Laplace's equation with a nonhomogeneous Dirichlet boundary condition. This solution will enable us to estimate the heat flow over the region in various physical environments. Computationally, we use the finite difference method with SOR iteration to find numerical solutions of Laplace's equation. Finally, we evaluate the performance of the scheme by comparing the exact solution with our numerical results.

**MAA Session #9**

**Eugene Room** **8:30A.M. – 10:30A.M.**

8:30–8:45

**Some Surprising Relations Involving the Fibonacci Numbers**

Jairo Aguayo
*California State University at Fullerton*

In approximately 1170 AD, Italian mathematician Leonardo Fibonacci formulated the famous sequence of numbers 1,1,2,3,5,8,13,....obtained by starting with 1 and 1 and then defining each successive number as the sum of the two previous numbers. Between 1842-1891, French mathematician Francois Edouard Anatole Lucas formulated a sequence that obeys the same relation, but starting with the numbers 1 and 3. These numbers form the Lucas sequence: 1,3,4,7,11,18,29,.In this talk, we will discover recurrence relations for the Fibonacci sequence that are expressed in terms of the Lucas sequence. In fact, we will be able to generate an infinite number of recurrence relations of this type.

8:50–9:05

**Investigating the Computational Efficiency of RSA and its Various Modifications**

My Viet Nguyen and Kyle Marx
*California State University, Fullerton*

We will present C++ programs that can encrypt and decrypt information using the RSA cryptosystem and investigate run times where the enciphering modulus is roughly nine digits long. We will also modify the programs to explore variations of RSA that use a public key integer whose prime decomposition is more complex than a product of two distinct primes. Lastly, this leads us to a brief discussion of potential threats to RSA and a further discussion to alternatives that are being developed to deflect these threats.

9:10–9:25

**On a Fruitful Identity in the Theory of Numbers**

Robert Peter Schneider
*University of Kentucky*

We prove the identity between double summations

$$\sum_{k=1}^{n} f(k) \sum_{d|k} g(d) \;=\; \sum_{j=1}^{n} g(j) \sum_{i=1}^{\left[\frac{n}{j}\right]} f(ij)\;,$$

which we have noticed is implicit in many proofs in the theory of numbers, where a particular change in the order of summation is employed. Several known results involving number theoretic functions such as the Moebius function and the Riemann zeta function follow immediately from this identity, depending on the choices of $f$ and $g$. In addition, a large number of results may be obtained which are infrequently encountered, if not novel. We present brief proofs of both well-known and more exotic identities we have found, and note formal properties to look for in functions $f$ and $g$ such that they might produce nice results when substituted into this fruitful identity.

9:30–9:45

**Some Arithmetic Properties of Overpartition $k$-Tuples**

Robert George Vary
*Penn State University*

Recently, Lovejoy introduced the construct of overpartition pairs which are a natural generalization of overpartitions. Here we generalize that idea to overpartition $k$-tuples and prove several congruences related to them. We denote the number of overpartition $k$-tuples of a positive integer $n$ by $\overline{p}_k(n)$ and prove, for example, that for all $n \geq 0$ , $\overline{p}_{t-1}(tn + r)$ is divisible by $t$, where $t$ is prime and $r$ is a quadratic nonresidue mod $t$.

9:50–10:05

**A $p$-adic Euclidean Algorithm**

Cortney Lager
*Winona State University*

A brief introduction to the $p-$adic numbers will be given. Then we will present a $p$-adic Division Algorithm and a $p$-adic Euclidean Algorithm that parallel the classical algorithms. Lastly we will demonstrate that our methods compute a generalized GCD and a $p$-adic simple continued fraction.

10:10–10:25

**Exploring a Pythagorean Ternary Tree**

Jonathan Weisbrod
*Rowan University*

A right triangle in which all three sides are integers is called a Pythagorean triangle, and the three sides, labeled a, b and c are call a Pythagorean triple (PT). A primitive Pythagorean triple (PPT) occurs when all three numbers have no common factor. Pythagorean triples are usually generated by first selecting a pair of positive integers $m$ and $n$ with $m > n$. Then the sides of the triangle are given by: $a = 2mn$, $b = m^2 - n^2$, $c = m^2 + n^2$. Using a lesser known algorithm of two other coprime positive integers, alpha and beta, such that alpha is an odd square number and beta is twice a square number, we create a ternary tree of the complete set of PPTs without repetition. PPTs which are related share properties and we can connect any PPT with any other PPT with the use of three functions.

**MAA Session #10**

**Salon B** **8:30A.M. – 10:25A.M.**

8:30–8:45

**Musical Madness**

Christianna Hazel Brown
*Metropolitan State College of Denver*

There is an undeniable connection between the art of mathematics and the art of music. This paper will briefly examine this connection through the following topics: 1) the exploration of the fractal geometry that is created from the compositions of J.S. Bach 2) the application of chaos and nonlinear dynamics to 'trumpet-like' instruments and 3) the use of fractal geometry in algorithmic music composition and generation, focusing on the work of Phil Thompson. Thompson's fractal music generator, Gingerbread, is examined to provide further insight.

8:50–9:05

**Chaos in Non-linear Tent Maps: Bifurcation Diagrams, Lyapunov Exponents, and Fractals**

Oumarou Njoya
*Michigan State University*

We investigate the dynamics of the family of maps given by$cx^b$ if $0 \leq x < 0.5$ and $a - ax^b$ if $0.5 \leq x \leq 1$. Here $a, b, c$ are prameters. We construct bifurcation diagrams to characterize the regions that exhibit chaotic behavior. Furthermore we explore the fractal structures that arise in connection with the system.

9:10–9:25

**Creating Fractals of a Given Dimension**

Jacqueline Chalmers
*Augustana College*

By exploring generalizations of the Sierpinski carpet, we will show how to construct a fractal of a given rational dimension between zero and two. We will also show computer generated examples of such fractals.

9:30–9:45

**Understanding the Chinese Remainder Theorem**

Isaak Daniels
*Augustana College*

We will present the Chinese Remainder Theorem. We will do examples of varying difficulty illustrating its use. We will show one example of its use in cryptology.

9:50–10:05

**The Masons vs. The Pythagoreans**

Christine R. Martin and Jamie Jenson
*California State University, Fullerton*

Jamie Jenson and I will be discussing the similarities, differences, and influences of the Masons and the Pythagoreans. To begin we will first dive into the Pythagoreans, talking on their history and their founder, Pythagoras. For the Masons we will also talk about their history and their founder, Hiram Abif. Next we will examine the relationships between these two groups of people and if or how they influenced each other. Through these discussions we will notice the relationship both of these societies had to the ancient Egyptian priests and why both of them thought so highly of geometry. We will see these relationships in the symbolism they both use in ceremonies as well as with ideals in morality and personal growth. Finally, we will review some of the Pythagoreans contributions to the mathematical world and applications that can be used in classrooms today.

**MAA Session #11**

**Salon B** **2:00P.M. – 4:55P.M.**

2:00–2:15

**Eigenvalues of Trees**

Ming Wei Chang

*Augustana College*

Trees are simple graphs without cycles. We'll define eigenvalues of graphs and compute them for some infinite families of trees.

2:20–2:35

**The Relaxed Coloring Game on Certain Classes of Trees**

Lynnette Snyder

*Simpson College*

We consider the $(r, d)$-relaxed coloring game on different classes of graphs. Two players, Alice and Bob, color the vertices of a graph $G$ with $r$ colors. Alice has the first move. A color $\alpha$ is a legal color for a vertex $x$ if $x$ has at most $d$ neighbors colored $\alpha$ , and if $w$ , a neighbor of $x$ colored $\alpha$ , has at most $d - 1$ neighbors colored $\alpha$ . Alice wins if every vertex is colored, while Bob wins if at some point an uncolored vertex has no legal color. We show that Alice has a winning strategy in the $(2, 1)$ -coloring game on stars and extensions of stars.

2:40–2:55

**Steiner Problem: A Focus on Tetrahedrons**

Gina Shero

*Clarion University of Pennsylvania*

The Steiner problem looks at n points in a surface to find the least length path in order to connect all of the points. These problems have been explored quite thoroughly in the Euclidean plane, leading to concrete algorithms for solutions. Recently, there has also been some research to look at Steiner problems on non-planar surfaces. However, very little has been done with closed polygonal surfaces. I will focus on the tetrahedron, providing some insight into Steiner problems in this setting, and the algorithms used to solve these problems.

3:00–3:15

**The Steiner problem in Non-planar Surfaces**

Elena A. Caffarelli

*Canisius College*

The Steiner problem is motivated by the goal of finding the shortest network that connects a set of given points in a surface. The study of Steiner problems often favors the setting of the Euclidean plane due to complexities (such as nonstandard metrics) that arise when non-planar surfaces (such as the tetrahedron) are considered. This talk aims to illuminate some interesting results for the Steiner problem in the latter setting.

3:20–3:35

**The Steiner Problem on Graphs of Linear Piecewise Functions**

Kyra Moon
*Brigham Young University*

The Steiner Problem on a surface is to determine the minimal length tree connecting a given collection of vertices in the surface. In this paper we explore various methods of solving the Steiner problem on surfaces that are the graphs of piecewise linear functions on the plane. In particular, we will study the correlation between the Steiner Problem and coding theory, namely error correction coding.

3:40–3:55

**The Great American Road Trip**

Andrew Johnson
*Mount Union College*

The Great American Road Trip problem requires the solver to find the shortest driving distance through all of America's forty eight continental states. Any circuit through a given amount of points is known mathematically as a Hamilton cycle. This particular problem deals with finding the shortest Hamilton cycle, which is found using a traveling sales person algorithm. A traveling sales person algorithm requires exact vertices to be defined, and the distances between these individual points can be most accurately found using modern Global Positioning System technology. A path with a small number of vertices can be found by hand using one of these algorithms in a few minutes; however a map with this many vertices, which is the case in the Great American Road Trip problem, requires advanced computing technology. The result of this research and experimentation is an approximation of the shortest path through all forty eight continental states.

4:00–4:15

**Exponential Domination of Cyclic Graphs**

Ashley Toth
*Rollins College*

Given a graph with vertex set $V$, a subset $D \subseteq V$ is an exponential dominating set iff

$$\sum_{x \in D} \frac{1}{2^{d(v,x)-1}} \geq 1$$

for every vertex $v \in V$, where $d(v, x)$ is the distance between v and x. The cardinality of the smallest exponential dominating set of a graph $G$ is denoted by $\gamma_e$(G). This discussion concerns the $\gamma_e$ values for the cycle graph $C_n$ and the Cartesian product $C_2 \times C_n$. We show that for all $n \neq 4$, $\gamma_e(C_n) = \lceil \frac{n}{4} \rceil$, and $\gamma_e(C_4) = 2$. For all $n \neq 2$ or 3, $\gamma_e(C_2 \times C_n) = 2\lceil \frac{n}{6} \rceil$ if $n \equiv 3 \bmod 6$, and $\gamma_e(C_2 \times C_n) = \lceil \frac{n}{3} \rceil$ otherwise. (It is obvious that $\gamma_e(C_2 \times C_2) = \gamma_e(C_2 \times C_3) = 2$.) These results are interesting because they may be useful in finding a general formula for $\gamma_e(C_m \times C_n)$.

4:20–4:35

**The Inverse Inertia Problem for Graphs**

Camille Jepsen and Emily McHenry

*Brigham Young University and Xavier University*

Given a graph $G$ on $n$ vertices, let $S(G)$ be the set of all real symmetric $n \times n$ matrices for which $a_{ij} \neq 0$, $i \neq j$, if and only if $ij$ is an edge of $G$. The minimum rank problem for $G$ is to determine the smallest possible rank, $mr(G)$, of a matrix in $S(G)$. It has been an active area of research for a decade. The inverse inertia problem for a graph, a refinement of the minimum rank problem, asks: Given a graph $G$ on $n$ vertices and an ordered triple $(r, s, t)$ of nonnegative integers with $r + s + t = n$, is there a matrix $A \in S(G)$ such that $A$ has $r$ positive eigenvalues, $s$ negative eigenvalues, and $t$ eigenvalues equal to $0$; $(r, s, t)$ is called the inertia of $A$. A necessary, but not sufficient, condition for such an $A$ to exist is that $r + s \geq mr(G)$. The inverse inertia problem has been completely solved for trees in a paper by Barrett, Hall, and Loewy. The paper also contains a formula that allows determination of the set of possible inertias of a graph with a cut vertex in terms of the possible inertia sets of proper subgraphs. Consequently, there is an algorithm to solve the inertia problem for any unicyclic graph or more generally, any cactus. Our results concern instead characterizations of the inertia set of such graphs. As part of our characterization, we exhibit a large class of graphs $G$ with balanced inertia; i.e., there is an $A \in S(G)$ with inertia equal to $(r, s, t)$ such that $r + s = mr(G)$ and $|r - s| \leq 1$.

4:40–4:55

**General Model for Variations of the Even Cycle Problem**

Rachel Pepich

*Illinois State University*

We consider three related problems in graph theory: determining if a directed graph has an even cycle, determining if a two edged-colored graph has an alternating colored even cycle, and determining if a directed graph has an anti-directed even cycle. We show that each of these, and two other variations, are special cases of a more general graph problem. We also show that one of these variations is NP-complete.

**PME Session #5**

**Medford Room** **8:30A.M. – 10:25A.M.**

8:30–8:45

**Infection Dynamics on a Scale-Free Network**

Michael Lind

*Rensselaer Polytechnic Institute*

We model the spread of an infection in a population connected through a scale-free network. The population consists of those susceptible $(S)$, those infected $(I)$, and those who have temporary immunity $(R)$. We have investigated what characteristics of the network result in the long-term survival of the virus. Interesting phenomenon are found, including synchronization of the three-states as well as the requirements necessary for the virus to get a foothold in the population.

8:50–9:05

**Reconstructing Sparse Signals from Random and Incomplete Frequency Samples**

Jon Rogers

*Southwestern University*

Compressive sensing advances a method for simultaneous signal acquisition and compression by exploiting the sparsity of natural signals. A random frequency sample obtained using the Bernoulli model can be used to reconstruct a much larger signal with a very high probability by solving a convex optimization problem.

9:10–9:25

**Edge Effects in the Use of Wavelets for Partial Image Reconstruction**

Henry Schreiner

*Angelo State University*

When reconstructing a portion of an image from its wavelet transform, problems often arise near the edges. We compare the effectiveness of several different remedies, including matrix completion methods and the use of bi-orthogonal filter banks.

9:30–9:45

**Stochastic Modeling in Actuarial and Financial Mathematics**

Jim Manning

*University of South Carolina*

Recent economic and financial events and uncertainties reflect the fact that we live in a stochastic and ever-riskier world, and that mathematical, financial, and analytical skills are critical for identifying, quantifying, understanding, and managing the impact of those risks. This presentation explores mathematical applications in an area of finance.

## PME Session #6

**Salem Room** **8:30A.M. – 10:25A.M.**

8:30–8:45

### A Model for Solar Flux and Atmospheric Density Prediction

Michael O'Connor
*United States Air Force Academy*

Satellites are expensive investments and protecting them requires accurate orbital prediction. Impeding prediction is the lack of a robust atmospheric drag model. This project will model solar flux, a driving factor, and correlate flux with density. Fast Fourier transforms and sinusoids will be addressed, and Kalman filters will be discussed.

8:50–9:05

### Voting Against a Candidate: A Novel System Using Negative Votes

Thomas Eliot
*Willamette University*

This is a novel, non-simple voting system based on the idea of using negative votes to reduce the chances that a single candidate will win. This makes the winner much less likely to be disliked widely.

9:10–9:25

### Image Denoising Via Feature-Based Sparse and Redundant Dictionaries

Josh Koslosky
*Duquesne University*

In recent years the computer vision community has demonstrated that sparse and redundant representations of image patches can be used to denoise images. These representations can be formed using dictionaries that are either fixed (e.g. Discrete Cosine Transform) or learned from the noisy data itself. Finding the best patch representation leads to a constrained optimization problem, which depending on its formulation can be nonconvex. Elad and Aharon propose such a model which learns the dictionary from the noisy data, which they solve using Orthogonal Matching Pursuit and K-SVD (a modification of the Singular Value Decomposition inspired by K-means). In this talk we propose a modification of their algorithm in which dictionaries can be tailored to denoise smooth regions, textured regions, and edges separately. In particular, we discuss several approaches for segmenting an image based on these different geometric properties, and how dictionaries tailored to these properties can improve both the image representation and denoising.

9:30–9:45

### Evaluating Composite Bridge Decks

Terra Fox
*Hope College*

We will discuss our use of the Finite Element Method in the development of a nondestructive evaluation program for Fiber-Reinforced Polymer composite bridge decks.

9:50–10:05

**Authentication Schemes based on Physically Unclonable Functions**

Ilan Shomorony

*Worcester Polytechnic Institute*

We present different hardware authentication schemes based on Physically Unclonable Functions. We analyze the concepts of a secure sketch from an information-theoretic perspective. Then we propose and analyze a new cryptographic protocol for PUF authentication based upon polynomial interpolation using Sudan's list-decoding algorithm.

10:10–10:25

**A Mathematical Perspective on Voting**

Carson Sievert

*St. John's University*

The 2000 presidential election is an example of how voting procedures can yield disputed outcomes. Voting theorists say the phenomenon known as the "spoilers effect" helped Bush win the decisive swing-state. Limiting the possibility of adverse results such as this from occurring in three and four candidate elections is addressed.

**PME Session #7**

**Portland Room** **8:30A.M. – 10:25A.M.**

8:30–8:45

**Symmetry Analysis of the Lane-Emden Equation**

Wyatt A. Brege
*Grand Valley State University*

We will focus on Lie theory and how it can be used to find symmetries of the Lane-Emden equation. This equation has provided a simple, physical description of the density distribution in many a stellar structure. Symmetry results of the equation will be presented.

8:50–9:05

**Zeros of $\zeta(z(c)) - c$ and $\eta(e(c)) - c$ for $c \in [0, 1)$**

Adam Boseman
*University of North Carolina at Greensboro*

Let $\zeta(s)$ be the Riemann zeta function and $z_0 \in \mathbb{C} \setminus \mathbb{R}$ with $\zeta(z_0) = 0$. We investigate the implicit function $z : [0, 1) \to \mathbb{C}$ with $z(0) = z_0$ given by $\zeta(z(c)) - c = 0$ and give right bounds for the zeros of $\zeta(s) - 1$.

9:10–9:25

**Random Juggling: Which State Happens the Most?**

Masaki Ikeda
*Western Oregon University*

Juggling is well known as a very friendly entertainment. Suppose one keeps juggling RANDOMLY for a certain time. We will examine which of the situations of objects caught/thrown happens more likely than others by using Markov chains, as described in a paper by G. S. Warrington.

9:30–9:45

**Coagulation: The Fifth Factor**

Yasmeen Hussain
*University of Utah*

Blood clotting is a complex system which can be modeled with differential equations. Using direct comparison to the results of biological research on Factor V, I have found that the controversial results found by clinical trials are largely unsupported by experiments on mathematical model of coagulation.

9:50–10:05

**A Mathematical Model of Chagas Disease**

Lindsey Kingsland
*Concordia Univeristy, Irvine*

I will present a mathematical model for Chagas disease, a vector-borne parasitic disease that affects mammals, including humans, in Central and South America. I will discuss the steady state solutions of the model and the effects of insecticide spraying and the recovery rate of the vectors when spraying is stopped.

10:10–10:25

**Follow the Food Feeding Function: A Biomathematical Study of Gastric Emptying**

Jennifer Jordan
*Goucher College*

As this is a joint undergraduate research project, our research will be presented in two sessions. Ariel Kramer will present in the MAA Student Paper Sessions, and Jennifer Jordan will present in the Pi Mu Epsilon Student Paper Sessions. Through an examination of the mechanisms driving gastric motility, absorption, and transit, and using differential equations, we created a compartmental model of the digestion system. Specifically, we seek to understand the process of gastric emptying by modeling the interactions between ingested solids, liquids, and chyme. To make the model accurate biologically, we introduced randomness into the system; additionally, the nonlinearity and number of the parameters in the model make finding analytical solutions impractical. Thus, we created numerical simulations of the model. As this research is at the crossroads of biology and mathematics, both quantitative and qualitative analyses of the simulations will be discussed.

**PME Session #8**

**Medford Room** **2:00P.M. – 4:55P.M.**

2:00–2:15

**Genome Exploration**

Kathleen Miller

*St. Norbert College*

Due to high-throughput genomics, massive amounts of data on DNA protein structure and protein sequences are becoming rapidly available - at a faster rate than we can keep up! This data is only as useful as long as it is interpreted. Based on summer laboratory research in bioinformatics, we explore a biological question using statistical and computational models to create algorithms. These algorithms allow for comparison between databases allowing for further interpretation and exploration within genomes.

2:20–2:35

**Mathematical Modeling of Cardiac Myocytes**

Moriah Wright

*Youngstown State University*

Life-threatening cardiac arrhythmias are caused by irregular firing (electrical) activity in cardiac myocytes, muscle cells. Long QT Syndrome is one such condition that increases susceptibility to arrhythmias in which cells have longer action potential durations and EADs (Early After Depolarizations), abnormal increases in membrane potential during the plateau phase of the action potential. We investigate the mechanisms for arrhythmogenic activity by applying dynamical systems techniques and bifurcation analysis to a biophysically based mathematical model of cardiac action potentials that accounts for the numerous types of currents involved as well as calcium dynamics.

2:40–2:55

**Mathematical Modeling of Senktide Response in Pyramidal Neurons**

Joshua Mike

*Youngstown State University*

Senktide is a drug that increases firing activity in prefrontal cortex layer $V$ pyramidal neurons. In order to investigate this response, we developed a biophysically based model incorporating the multiple currents effecting the firing activity of these neurons. The model is based on the literature and consists of a system differential equations. This model was compared to our experimental data in order to determine the currents sensitive to senktide. Additionally, the model was analyzed using dynamical systems techniques to determine the mechanisms of the senktide response.

3:00–3:15

**Using Differential Equations to Model Selenium Metabolism in Bacteria**

Kristi Mraz

*Youngstown State University*

Selenite resistant bacteria removes excess selenium, which is toxic, by reducing it to the elemental form, which is non-toxic. The principle goal is to understand the mechanisms that allow the bacteria to survive when exposed to highly toxic levels of selenite. Using a system of differential equations that model concentrations, we can see how these bacterial cells metabolize selenite. We hypothesize that a selenite resistant strain, S. Maltophilia O2, may use a reduction mechanism during both log and stationary phase.

3:20–3:35

**Bacterial Resistance: When Selenite is Your Kryptonite**

Lisa Curll

*Youngstown State University*

Heavy metal contamination is a serious environmental problem, forcing native organisms like bacteria to adapt resistance. What mechanisms do these cells use to attain survival? Given various growth conditions, a coupled system of differential equations models bacterial growth and reduction of toxic selenite to nontoxic selenium.

3:40–3:55

**The Brain and Mathematical Modeling**

Harold L. Gomes

*City University of New York - Queens College*

The brain is a complex system with many variables that play important roles in computations/information processing. Here, we investigated the role of cell morphology on repetitive firings (voltage-impulses) of neurons. Using mathematical models, we analyzed electrophysiology of six morphological groups. Our results indicate that neuronal geometry can strongly influence electrophysiology.

4:00–4:15

**Modeling Diatom Growth in Trout Lake, Part 2**

Corey Vorland

*St. Norbert College*

Aulacoseira is a freshwater diatom which forms string-like colonies. Aulacoseiras growth is determined by a complex, interconnected relationship between mixing and light availability in the lake. Mixing, generated by turbulent convection, alters the location of Aulacoseira within the depth of the lake, consequently altering its ability to obtain light for growth. Aulacoseiras abundance and colony size have been measured at varying depths in Trout Lake in Northern Wisconsin. In previous work, we built a mathematical model which accounted for growth and sinking of the diatom. However, sinking was only qualitatively included. In this work, the model takes a more quantitative approach to including the diatoms sinking velocity which is not well known in the biological community. This work is in collaboration with Stephanie Schauer, an undergraduate student at St. Norbert College.

4:20–4:35

**Metabolism, Microvilli, and the Manduca sexta Midgut: A Mathematical Model**

Jennifer Garbett

*Kenyon College*

Metabolism involves the use and storage of energy absorbed through food and for unknown reasons scales with body weight consistently across species. Manduca sexta, a type of caterpillar which grows to maturity in only 18 days and exhibits a 10,000-fold increase in weight, is an ideal organism for studying this scaling of metabolism. It has been suggested that the surface area of the caterpillars midgut may play a crucial role in metabolic scaling. I will present a model of the Manduca sexta midgut which reflects the contribution of microvilli (hair-like structures projecting into the midgut which significantly increase surface area) and folding of the midgut to its surface area. I will use this model to investigate changes in midgut surface area resulting from changes in size and density of microvilli over time and midgut section; I will also examine variations in surface area across sections of the midgut caused by differences in the folding pattern exhibited by each section.

4:40–4:55

**A Study of the Solutions to the Family of Differential Equations** $f'(x) = \frac{1}{(fofo...of)(x)}$

Veronica Wills

*Southeastern Louisiana University*

We will study the differential equation $f'(x) = \frac{1}{(fofo...of)(x)}$ where there are $n$ copies of $f$ in the denominator. We begin by finding explicit solutions to our differential equation for $n = 1$ and $n = 2$ We then show that solutions exist for all $n$. We end by discussing the convergence/divergence of the sequence of solutions.

**PME Session #9**

**Salem Room** **2:00P.M. – 4:55P.M.**

2:00–2:15

**Tuning an Instrument Like a Mathematician**

Alyssia Weaver

*Mount Union College*

Are mathematics and music really related? In my presentation, I will be exploring how the set of musical notes form a group in abstract algebra, which can be further divided into subgroups and cosets. In addition, I will be discussing how mathematics can be used to tune instruments.

2:20–2:35

**Chinese Remainder Theorem and the Faro Shuffles**

Brandon McMillen

*Mount Union College*

How does an ancient Chinese theorem relate to shuffling an ordinary deck of cards? Come see how the Chinese Remainder Theorem and a special shuffle can be used to perform a card trick.

2:40–2:55

**Generating Sudoku Puzzles**

Stephanie Schauer

*St. Norbert College*

A (solved) Sudoku puzzle can be viewed as a function $f : (Z_3)^4 \to Z_9$ with certain near one-to-one properties. In this case, for fixed $a$ and $b$, $f(x, y, a, b)$, $f(a, x, y, b)$, and $f(a, b, x, y)$ are injective functions of $(x, y)$. Functions of the form $f(x, y, z, w) = g(x, y) + h(z, w) \bmod 9$ were studied. This form produces filled Sudoku puzzles if and only if two criteria are satisfied. An unsolved puzzle gives you some of the values of $f$; you need to find the rest. Sudoku puzzles were generated using this function.

3:00–3:15

**Summer in Minnesota**

Dania Morales

*Western Oregon University*

In this talk, we will discuss the mathematical findings based on the 2009 Summer Mathematics Program for Undergraduate Women at Carleton College in Minnesota.

3:20–3:35

**The Structures of Series and Sum Ranges in Banach Spaces**

Sean Watson

*Southwestern University*

The famous Riemann theorem states that a conditionally convergent series in $\mathbb{R}$ can be rearranged to converge to any real number. In a finite dimensional Banach space (a space complete with respect to its norm), an analogue of the Riemann theorem, the Levy-Steinitz theorem, will be presented. An introduction to the infinite-dimensional case, examples of when the analogy breaks down, and ongoing research into understanding when the Levy-Steinitz theorem holds will also be discussed.

3:40–3:55

**The Extremality of Bernstein Polynomials**

Neil Biegalle

*Grand Valley State Univeristy*

Extremal problems in the geometry of polynomials concern which polynomials possess certain maximal or minimal geometric properties. We seek to employ results related to polynomial root dragging and root motion to further understand such problems. Of special interest is our investigation into why Bernstein polynomials frequently arise as maximizers.

4:00–4:15

**An Application of the Riemann Zeta Function**

Matthew Alexander

*Youngstown State University*

I will go through the solution to problem 1196 from the the Spring 2009 Pi Mu Epsilon Journal. The problem asks us to find $\sum_{\frac{a}{b}\in\mathbb{Q}^*}\frac{1}{(ab)^2}$ where

$$\mathbb{Q}^* = \{\frac{a}{b} \mid a, b \in \mathbb{Z}, a \neq 0, b > 0,$$

and $gcd(a, b) = 1\}$. The solution will include the notion of a multiplicative function, and a proof of an identity of the Riemann zeta function.

4:20–4:35

**"Really" Counterintuitive**

Justin Laufman

*Youngstown State University*

In earlier centuries, the real line was thought to be easy to understand. However when mathematicians really started to study it, some very surprising results started to appear. One of the results discovered was that the set of rational numbers could be covered by a collection of open intervals the sum of whose lengths could be arbitrarily small–this despite the fact that the rationals are dense. In addition to this, Ëmile Borel discovered a function defined on $[0, 1]$ whose definition defies our intuition. In this talk, we will present some of these counterintuitive results.

4:40–4:55

**Extreme Curvature of Polynomials**

Tarah Jensen

*Grand Valley State University*

Let $P$ be a real polynomial of degree $n$. We are interested in the number of points of extreme curvature. Curvature is defined by $\kappa = \frac{P''}{(1+(P')^2)^(3/2)}$ and to find the points of extreme curvature we look at $\kappa' = 0$. We will discuss our progress in showing that the number of points of extreme curvature is at most $n - 1$. This problem is reminiscent of the $P^2 + P'$ problem.

## J. Sutherland Frame Lectures

| | | |
|---|---|---|
| 2009 | Persi Diaconis | *The Mathematics of Perfect Shuffles* |
| 2008 | John H. Conway | *The Symmetries of Things* |
| 2007 | Donald E. Knuth | *Negafibonacci Numbers and the Hyperbolic Plane* |
| 2006 | Donald Saari | *Ellipses and Circles? To Understand Voting Problems??!* |
| 2005 | Arthur T. Benjamin | *Proofs that Really Count: The Art of Combinatorial Proof* |
| 2004 | Joan P. Hutchinson | *When Five Colors Suffice* |
| 2003 | Robert L. Devaney | *Chaos Games and Fractal Images* |
| 2002 | Frank Morgan | *Soap Bubbles: Open Problems* |
| 2001 | Thomas F. Banchoff | *Twice as Old, Again, and Other Found Problems* |
| 2000 | John H. Ewing | *The Mathematics of Computers* |
| 1999 | V. Frederick Rickey | *The Creation of the Calculus: Who, What, When, Where, Why* |
| 1998 | Joseph A. Gallian | *Breaking Drivers' License Codes* |
| 1997 | Philip D. Straffin, Jr. | *Excursions in the Geometry of Voting* |
| 1996 | J. Kevin Colligan | *Webs, Sieves and Money* |
| 1995 | Marjorie Senechal | *Tilings as Differential Gratings* |
| 1994 | Colin Adams | *Cheating Your Way to the Knot Merit Badge* |
| 1993 | George Andrews | *Ramanujan for Students* |
| 1992 | Underwood Dudley | *Angle Trisectors* |
| 1991 | Henry Pollack | *Some Mathematics of Baseball* |
| 1990 | Ronald L. Graham | *Combinatorics and Computers* |
| 1989 | Jean Cronin Scanlon | *Entrainment of Frequency* |
| 1988 | Doris Schattschneider | *You Too Can Tile the Conway Way* |
| 1987 | Clayton W. Dodge | *Reflections of a Problems Editor* |
| 1986 | Paul Halmos | *Problems I Cannot Solve* |
| 1985 | Ernst Snapper | *The Philosophy of Mathematics* |
| 1984 | John L. Kelley | *The Concept of Plane Area* |
| 1983 | Henry Alder | *How to Discover and Prove Theorems* |
| 1982 | Israel Halperin | *The Changing Face of Mathematics* |
| 1981 | E. P. Miles, Jr. | *The Beauties of Mathematics* |
| 1980 | Richard P. Askey | *Ramanujan and Some Extensions of the Gamma and Beta Functions* |
| 1979 | H. Jerome Keisler | *Infinitesimals: Where They Come From and What They Can Do* |
| 1978 | Herbert E. Robbins | *The Statistics of Incidents and Accidents* |
| 1977 | Ivan Niven | *Techniques of Solving Extremal Problems* |
| 1976 | H. S. M. Coxeter | *The Pappus Configuration and Its Groups* |
| 1975 | J. Sutherland Frame | *Matrix Functions: A Powerful Tool* |

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**MAA Lectures for Students**

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| 2009 | Colm Mulcahy | *Mathemagic with a Deck of Cards on the Interval Between 5.700439718 and 80658175170943878571660636856403766975289505440883277824000000000000* |
| 2008 | Laura Taalman | *Sudoku: Questions, Variations and Research* |
| 2007 | Francis Edward Su | *Splitting the Rent: Fairness Problems, Fixed Points, and Fragmented Polytopes* |
| 2006 | Richard Tapia | *Math at Top Speed: Exploring and Breaking Myths in Drag Racing Folklore* |
| 2005 | Annalisa Crannell & Marc Frantz | *Lights, Camera, Freeze!* |
| 2004 | Mario Martelli | *The Secret of Brunelleschi's Cupola* |
| 2004 | Mark Meerschaert | *Fractional Calculus with Applications* |
| 2003 | Arthur T. Benjamin | *The Art of Mental Calculation* |
| 2003 | Donna L. Beers | *What Drives Mathematics and Where is Mathematics Driving Innovation?* |
| 2002 | Colin Adams | *"Blown Away: What Knot to do When Sailing" by Sir Randolph "Skipper" Bacon III* |
| 2002 | M. Elisabeth Pate-Cornell | *Finding and Fixing Systems' Weaknesses: The Art and Science of Engineering Risk Analysis* |
| 2001 | Rhonda Hatcher | *Ranking College Football Teams* |
| 2001 | Ralph Keeney | *Building and Using Mathematical Models to Guide Decision Making* |
| 2000 | Michael O'Fallon | *Attributable Risk Estimation: A Tale of Mathematical/Statistical Modeling* |
| 2000 | Thomas Banchoff | *Interactive Geometry on the Internet* |
| 1999 | Edward G. Dunne | *Pianos and Continued Fractions* |
| 1999 | Dan Kalman | *A Square Pie for the Simpsons and Other Mathematical Diversions* |
| 1998 | Ross Honsberger | *Some Mathematical Morsels* |
| 1998 | Roger Howe | *Some New and Old Results in Euclidean Geometry* |
| 1997 | Aparna Higgins | *Demonic Graphs and Undergraduate Research* |
| 1997 | Edward Schaefer | *When is an Integer the Product of Two and Three Consecutive Integers?* |
| 1996 | Kenneth Ross | *The Mathematics of Card Shuffling* |
| 1996 | Richard Tapia | *Mathematics Education and National Concerns* |
| 1995 | David Bressoud | *Cauchy, Abel, Dirichlet and the Birth of Real Analysis* |
| 1995 | William Dunham | *Newton's (Original) Method - or - Though This Be Method, Yet There is Madness* |
| 1994 | Gail Nelson | *What is Really in the Cantor Set?* |
| 1994 | Brent Morris | *Magic Tricks, Card Shuffling and Dynamic Computer Memories* |
| 1993 | Richard Guy | *The Unity of Combinatorics* |
| 1993 | Joseph Gallian | *Touring a Torus* |
| 1992 | Peter Hilton | *Another Look at Fibonacci and Lucas Numbers* |
| 1992 | Caroline Mahoney | *Contemporary Problems in Graph Theory* |
| 1991 | Lester Lange | *Desirable Scientific Habits of Mind Learned from George Polya* |